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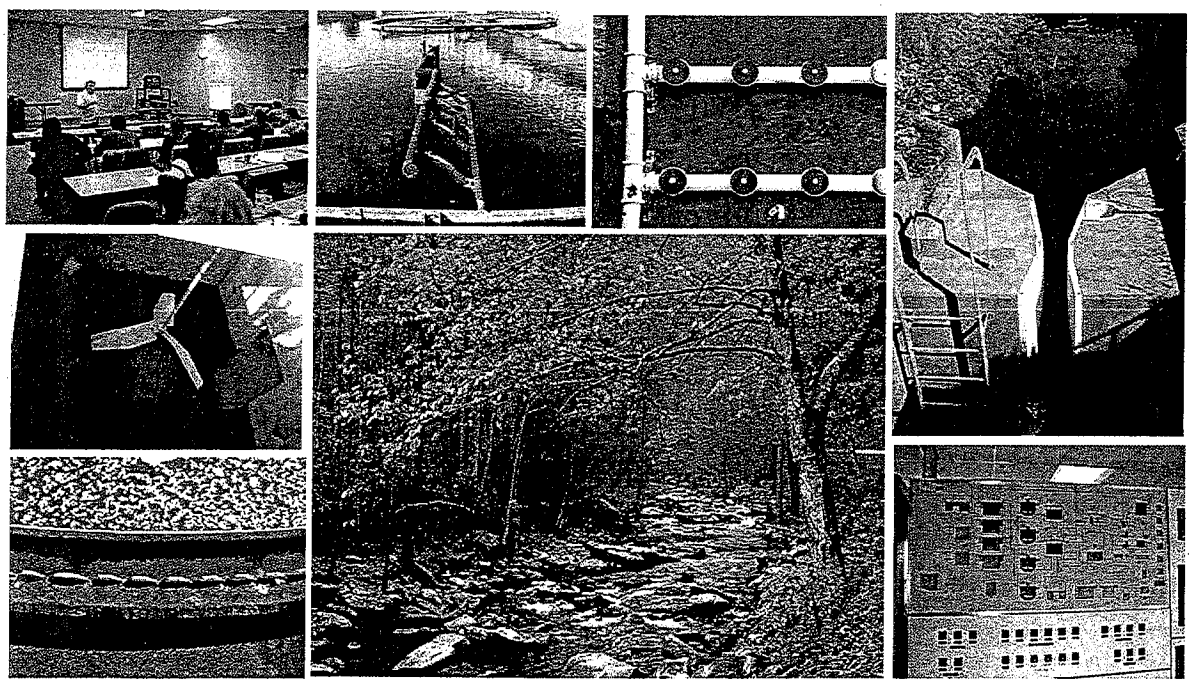
NPDES Compliance Inspection Manual



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Office of Enforcement
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NPDES Compliance Inspection Manual

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U.S. Environmental Protection Agency
Office of Compliance
Office of Enforcement and Compliance Assurance
1200 Pennsylvania Avenue, N.W.
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FOREWORD

The National Pollutant Discharge Elimination System (NPDES) Compliance Inspection Manual has been developed to support personnel that conduct NPDES inspections of wastewater treatment plants, storm water industrial and construction sites, pretreatment facilities, biosolids handling and treatment facilities, Concentrated Animal Feeding Operations (CAFOs), municipal wastewater collection systems (combined and separate from storm water) as well as pollution prevention and multimedia concerns. These procedures are fundamental to the NPDES compliance program and provide inspectors with a method for conducting inspections.

The manual presents standard procedures for inspections. In addition to the manual EPA expects its inspectors to have completed training to develop a good working knowledge of the subject related problems, regulations, control technologies, and Best Management Practices. EPA Order 3500.1, Training and Development for Compliance Inspectors/Field Investigators, establishes the Basic Health and Safety and Program-Specific Curricula for EPA compliance inspectors before they lead or conduct inspections independently. The manual will serve as a reference for the experienced inspector.

Regional and State personnel are encouraged to provide U.S. Environmental Protection Agency (EPA) Headquarters with changes or information that would improve the manual. Comments, information, and suggestions should be addressed to:

Clean Water Team
Compliance Assessment and Media Programs Division (2223A)
Office of Enforcement and Compliance Assurance
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW
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The information contained in this manual is comprehensive and designed to address a wide range of activities. Since each inspection may not involve all activities, the inspector should refer to those parts applicable to the particular inspection.

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The manual is organized into two parts. The first part, covering basic inspection components, consists of seven chapters. The second part includes specific information on different types of inspections.

Basic Inspection Components

- Chapter One, "Introduction," describes the NPDES program and provides general information relating to legal authority and inspector responsibilities.

- Chapter Two, "Inspection Procedures," discusses general procedures common to all NPDES inspections, including pre-inspection preparation, entry, opening conference, documentation, closing conference, and the inspection report.

- Chapters Three through Seven provide the specific technical information necessary to conduct the full range of NPDES compliance inspection activities. Each chapter describes procedures for the major technical activities involved in compliance inspections:

  - Chapter Three, Documentation/Recordkeeping and Reporting
  - Chapter Four, Facility Site Review
  - Chapter Five, Sampling
  - Chapter Six, Flow Measurement
  - Chapter Seven, Laboratory Procedures and Quality Assurance

Specific Information

- Chapter Eight, Toxicity
- Chapter Nine, Pretreatment
- Chapter Ten, Sewage Sludge
- Chapter Eleven, Storm Water
- Chapter Twelve, Combined Sewer Overflows
- Chapter Thirteen, Sanitary Sewer Overflows
- Chapter Fourteen, Pollution Prevention
- Chapter Fifteen, Multi Media Concerns
- Chapter Sixteen, Concentrated Animal Feeding Operations

Within each chapter, tables illustrate the topics discussed in the text. These are located at the end of the chapter subsection in which they are referenced. Additional information and figures are also included in the appendices to the manual. As appropriate, references and checklists are provided at the end of the chapter. The checklists presented in this manual are intended as guidance. They can be used as presented or modified to address the needs of the inspection authority. (More detailed checklists/guidance for any individual inspection type may have also been developed by EPA or State agencies and are presented in the guidance materials specific to that type of inspection.)

It should be noted that the text is written from the perspective of the Federal Clean Water Act requirements. State NPDES inspectors using this manual may find that State rules and procedures on such topics as notice to the permittees vary to some degree from the material found in this manual.

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We would like to thank the considerable efforts and cooperation of the persons who reviewed this document and provided comments.

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DISCLAIMER

The purpose of this guidance is to provide inspectors with an in-depth knowledge of the National Pollutant Discharge Elimination System (NPDES) inspection process. Specifically this manual provides information and references on the components necessary to complete the various types of NPDES inspections. Many of the chapters also include checklists. It is important that an inspector not rely solely on the checklist, but use it as one of the tools when conducting an inspection and evaluating compliance. Finally, the mention of trade names, commercial products, or organizations does not imply endorsement by the U.S. Government.

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C. Revised Fact Sheet: Safety and Health Requirements for EPA Inspectors "http://intranet.epa.gov/oeca/oc/campd/inspector/index.html"

D. EPA's Memorandum on Practices to Follow and Avoid When Requesting Information – "http://intranet.epa.gov/oeca/oc/campd/inspector/index.html"

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F. Final Fact Sheet: The Do's and Don'ts of Using U.S. EPA Credentials "http://intranet.epa.gov/oeca/oc/campd/inspector/index.html"

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LIST OF ABBREVIATIONS

Abbreviation	Full Phrase
AFO	Animal Feeding Operation
APHA	American Public Health Association
API	American Petroleum Institute
APWA	American Public Works Association
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
AU	Animal Unit
BAT	Best Available Technology Economically Achievable
BCT	Best Conventional Pollutant Control Technology
BMP	Best Management Practice
BMR	Baseline Monitoring Report
BOD	Biochemical Oxygen Demand
BPJ	Best Professional Judgement
BPT	Best Practicable Control Technology Currently Available
CAA	Clean Air Act
CAFO	Concentrated Animal Feeding Operation
CBI	Compliance Biomonitoring Inspection
CBI	Confidential Business Information
CEI	Compliance Evaluation Inspection
CEM	Continuous Emission Monitoring
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERI	Center for Environmental Research Information
CFR	*Code of Federal Regulations*
CFSA	Conservation Farm Service Agency
CGP	Construction General Permit
ChV	Chronic Value
CIP	Capital Improvement Project
CIU	Categorical Industrial Users
CMOM	Capacity, Management, Operation, and Maintenance
CNMP	Comprehensive Nutrient Management Plan
COD	Chemical Oxygen Demand
COM	Continuous Opacity Monitoring
CPLR	Cumulative Pollutant Loading Rate
CRC	Cyclic Redundancy Check
CSI	Compliance Sampling Inspection
CSO	Combined Sewer Overflow
CSS	Combined Sewer System
CWA	Clean Water Act
CWAP	Clean Water Action Plan
CWF	Combined Wastestream Formula
CZARA	Coastal Zone Act Reauthorization Amendment
DI	Diagnostic Inspection
DMR	Discharge Monitoring Report
DO	Dissolved Oxygen
DOI	Department of Interior
DOT	Department of Transportation
DSS	Domestic Sewage Study
DWO	Dry Weather Overflow

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EC_{50}	Concentration that causes an effect in 50% of the test organisms
EMS	Emergency Management System
EMSL	Environmental Monitoring Systems Laboratory
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right to Know Act
EQIP	Environmental Quality Incentive Program
ERP	Enforcement Response Plan
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FINDS	Facility Index System
FOIA	Freedom of Information Act
FR	*Federal Register*
FY	Fiscal Year
GC	Gas Chromatography
GC/MS	Gas Chromatography/Mass Spectroscopy
GIS	Geographic Information System
GPS	Global Positioning System
HPLC	High Performance Liquid Chromatography
I&I	Inflow/Infiltration
IC_{25}	Inhibition Concentration
ICDS	Inspection Conclusion Data Sheets
ICIS	Integrated Compliance Information System
ICP	Inductively Coupled Plasma
IATA	International Air Transportation Association
IU	Industrial User
LC	Lethal Concentration
LC	Liquid Chromatography
LC_{50}	Concentration at which 50% of the test organisms die in a specified time period
LD_{50}	Dose at which 50% of the test organisms die in a specific time period
LDR	Land Disposal Restrictions
LOEC	Lowest-Observed-Effect-Concentration
LSI	Legal Support Inspection
LTCP	Long-Term Control Plan
LVE	Low Volume Exemption
MCL	Maximum Contaminant Level
MEP	Maximum Extent Practicable
MGD	Million Gallons per Day
MIT	Mechanical Integrity Testing
MLSS	Mixed Liquor Suspended Solids
MPN	Most Probable Number
MS4	Municipal Separate Storm Sewer System
MSGP	Multi-Sector General Permit
MSSCC	Maryland State Soil Conservation Committee
MSWLF	Municipal Solid Waste Landfill
MWCOG	Metropolitan Washington Council of Governments
MWPP	Municipal Water Pollution Prevention
N/A	Not Applicable
NAAQS	National Ambient Air Quality Standards
NEIC	National Enforcement Investigation Center
NESHAPS	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NIOSH	National Institute for Occupational Safety and Health

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NIST	National Institute of Standards and Technology
NITS	National Institute of Technology and Standardization
NOAA	National Oceanic and Atmospheric Administration
NOC	Notice of Commencement
NOEC	No Observable Effect Concentration
NOI	Notice of Intent
NOT	Notice of Termination
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NRCS	Natural Resources Conservation Service
NRDC	Natural Resources Defense Council
NSPS	New Source Performance Standards
NURP	National Urban Runoff Program
O&M	Operations and Maintenance
OECA	Office of Enforcement and Compliance Assurance
OSHA	Occupational Safety and Health Administration
PAI	Performance Audit Inspection
PC	Pollutant Concentration
PCB	Polychlorinated Biphenyl
PCI	Pretreatment Compliance Inspection
PCS	Permit Compliance System
PFRP	Processes to Further Reduce Pathogens
PIES	Pollution Information Exchange System
PIRT	Pretreatment Implementation Review Task Force
PL	Public Law
PMN	Premanufacture Notification
POTW	Publicly Owned Treatment Works
PPE	Personal Protective Equipment
PPETS	Pretreatment Permits and Enforcement Tracking System
PPIC	Pollution Prevention Information Clearinghouse
PQL	Practical Quantification Limit
PRRS	Porcine Reproductive and Respiratory Syndrome
PSD	Prevention of Significant Deterioration
PSRP	Processes to Significantly Reduce Pathogens
QA	Quality Assurance
QC	Quality Control
QNCR	Quarterly Noncompliance Report
R&D	Research and Development
RBC	Rotating Biological Contactor
RCRA	Resource Conservation and Recovery Act
RI	Reconnaissance Inspection
RMP	Risk Management Plan

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RNC	Reportable Noncompliance
SARA	Superfund Amendments and Reauthorization Act
SCADA	Supervisory Control and Data Acquisition
SCP	Slug Control Plan
SDWA	Safe Drinking Water Act
SFL	Sheet Flow
SHPO	State Historic Preservation Officer
SIC	Standard Industrial Classification
SIP	State Implementation Plan
SIU	Significant Industrial User
SMCRA	Surface Mining Control and Reclamation Act
SNC	Significant Noncompliance
SNUR	Significant New Use Rule
SOUR	Specific Oxygen Uptake Rate
SPCC	Spill Prevention Control and Countermeasure Plan
SS	Suspended Solids
SSO	Sanitary Sewer Overflow
SU	Standard Unit
SW-846	Standard Methods for Evaluating Solid Waste Physical/Chemical Methods
SWPPP	Storm Water Pollution Prevention Plan
TCLP	Toxicity Characteristic Leaching Procedure
TDDP	Treatment, Destruction, and Disposal Facility
THPO	Tribal Historic Preservation Officer
TIE	Toxicity Identification Evaluation
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TME	Test Marketing Exemption
TOC	Total Organic Carbon
TRC	Total Residual Chlorine
TRE	Toxicity Reduction Evaluation
TS	Total Solids
TSCA	Toxic Substances Control Act
TSDF	Treatment, Storage, and Disposal Facility
TSS	Total Suspended Solids
TU	Toxicity Unit
Tu_a	Acute Toxic Unit
Tu_c	Chronic Toxic Unit
TVS	Total Volatile Solids
UA	Urbanized Area
UAA	Use Attainability Analysis
UIC	Underground Inspection Control
USC	United States Code
USDA	United States Department of Agriculture
USDI	United States Department of Interior
USDW	Underground Source of Drinking Water
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

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UST	Underground Storage Tank
VEO	Visible Emission Observation
VOC	Volatile Organic Compound
WEF	Water Environment Federation
WENDB	Water Enforcement Data Base
WET	Whole Effluent Toxicity
WLA	Wastesload Allocation
WPCF	Water Pollution Control Federation
WQA	Water Quality Act
WQBEL	Water Quality-Based Effluent Limit
WQS	Water Quality Standards
WRATT	Waste Reduction Assessment and Technology Transfer
WWTP	Wastewater Treatment Plant
XSI	Toxics Sampling Inspection
ZID	Zone of Dilution

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1. INTRODUCTION

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B. EPA Order 1440.2, Health and Safety Requirements for Employees Engaged in Field Activities
C. Revised Fact Sheet: Safety and Health Requirements for EPA Inspectors

Each of the above documents can be found at "http://intranet.epa.gov/oeca/oc/campd/inspector/index.html"

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1. A. Purpose and Objectives

Three objectives should be met during a routine compliance inspection. According to this section, the inspection should be performed in a manner designed to:

- Determine compliance status with regulations, permit conditions, and other program requirements
- Verify the accuracy of information submitted by permittees
- Verify the adequacy of sampling and monitoring conducted by the permittee.

Other purposes of compliance inspections include:

- Gathering evidence to support enforcement actions
- Obtaining information that supports the permitting process
- Assessing compliance with orders or consent decrees.

Inspection Types

This manual provides guidance applicable to each type of inspection a National Pollutant Discharge Elimination System (NPDES) inspector may be required to conduct at a NPDES permitted facility or an unpermitted facility with discharges. The different types of inspections are described below.

Compliance Evaluation Inspection (CEI)

The CEI is a nonsampling inspection designed to verify permittee compliance with applicable permit self-monitoring requirements, effluent limits, and compliance schedules. Inspectors must review records, make visual observations and evaluate treatment facilities, laboratories, effluents and receiving waters. During the CEI, the inspector must examine both chemical and biological self-monitoring, which form the basis for all other inspection types except the Reconnaissance Inspection.

Compliance Sampling Inspection (CSI)

During the CSI, NPDES permitted or unpermitted facilities, inspectors must take representative samples. Inspectors then verify the accuracy of the permittee's self-monitoring program and reports through chemical and bacteriological analysis; determine compliance with discharge limitations; determine the quantity and quality of effluents; develop permits; and provide evidence for enforcement proceedings where appropriate. In addition, the CSI includes the same objectives and tasks as a CEI.

Performance Audit Inspection (PAI)

The inspector conducts a PAI to evaluate the permittee's self-monitoring program. As with a CEI, the PAI verifies the permittee's reported data and compliance through a records check. However, the PAI provides a more resource-intensive review of the permittee's self-monitoring program and evaluates the permittee's procedures for sample collection, flow measurement, chain-of-custody, laboratory analyses, data compilation, reporting, and other areas related to

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the self-monitoring program. In a CEI, the inspector makes a cursory visual observation of the treatment facility, laboratory, effluents, and receiving waters. In a PAI, the inspector observes the permittee performing the self-monitoring process from sample collection and flow measurement through laboratory analyses, data workup, and reporting. The PAI does not include the collection of samples by the inspector. However, the inspector may require the permittee to analyze performance samples for laboratory evaluation purposes.

Compliance Biomonitoring Inspection (CBI)

This inspection includes the same objectives and tasks as a CSI. A CBI reviews a permittee's toxicity bioassay techniques and records maintenance to evaluate compliance with the biomonitoring terms of the NPDES permit and to determine whether the permittee's effluent is toxic. The CBI also includes the collection of effluent samples by the inspector to conduct acute and chronic toxicity testing to evaluate the biological effect of a permittee's effluent discharge(s) on test organisms.

Toxics Sampling Inspection (XSI)

The XSI has the same objectives as a conventional CSI. However, it places increased emphasis on toxic substances regulated by the NPDES permit. The XSI covers priority pollutants other than heavy metals, phenols, and cyanide, which are typically included in a CSI (if regulated by the NPDES permit). An XSI uses more resources than a CSI because sophisticated techniques are required to sample and analyze toxic pollutants. An XSI may also evaluate raw materials, process operations, and treatment facilities to identify toxic substances requiring controls.

Diagnostic Inspection (DI)

The DI primarily focuses on Publicly Owned Treatment Works (POTWs) that have not achieved permit compliance. POTWs that are having difficulty diagnosing their problems are targeted. The purposes of the DI are to identify the causes of noncompliance, suggest immediate remedies that will help the POTW achieve compliance, and support current or future enforcement action. Once the cause of noncompliance is defined, an administrative order is usually issued that requires the permittee to conduct a detailed analysis and develop a composite correction plan.

Reconnaissance Inspection (RI)

The RI is used to obtain a preliminary overview of a permittee's compliance program. The inspector performs a brief visual inspection of the permittee's treatment facility, effluents, and receiving waters. The RI uses the inspector's experience and judgement to summarize quickly any potential compliance problems. The objective of the RI is to expand inspection coverage without increasing inspection resources. The RI is the briefest and least resource intensive of all NPDES inspections.

Pretreatment Compliance Inspection (PCI)

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The PCI evaluates the POTW's implementation of its approved pretreatment program. It includes a review of the POTW's records on monitoring, inspections, and enforcement activities for its industrial users (IUs). The PCI may be supplemented with IU inspections. An IU inspection is an inspection of any significant IU that discharges to the POTW. The inspection can include sampling or not, depending on the reason for the inspection. If feasible, inspectors should conduct the PCI concurrently with another NPDES inspection of the POTW. Additional guidance is available in EPA's *Guidance for Conducting a Pretreatment Compliance Inspection* (September 1991).

It should be noted that a related type of review procedure, the pretreatment audit, is also performed by Approval Authorities. The pretreatment audit is not treated in depth in this manual because it is not regarded as a true NPDES compliance inspection. The pretreatment audit is defined and discussed in Section 1.2, page 1-1, of EPA's guidance manual *Pretreatment Compliance Inspection and Audit Manual for Approval Authorities* (July 1986) and the *Control Authority Pretreatment Audit Checklist and Instructions* (May 1992).

Follow-up Inspection

The follow-up inspection is a resource intensive inspection conducted when an enforcement problem is identified as a result of a routine inspection or a complaint. For a follow-up inspection, the appropriate resources are assembled to deal effectively with a specific enforcement problem.

Sewage Sludge Inspection

The objectives of a sewage sludge inspection are to determine compliance with Federal 503 sludge regulations for any facility engaged in a regulated sludge or disposal practice and to evaluate the permittee's compliance with sludge monitoring, recordkeeping and reporting, treatment operations, and sampling and laboratory quality assurance. The PCI, CEI, and PAI are the most likely vehicles for evaluating compliance with sludge requirements.

Storm Water Inspection

Storm water inspections are designed to ensure that regulated facilities have a NPDES permit for storm water discharge and a Storm Water Pollution Prevention Plan (SWPPP) and are following the specifications in each. During the inspection, the inspector reviews the permit and the SWPPP and determines whether the SWPPP meets the requirements set forth in the permit. The inspector also reviews records, such as self-inspection reports, to verify that the facility is complying with its permit and the SWPPP and walks the site to verify that the SWPPP is accurate and BMPs are in place and functioning properly.

Combined Sewer Overflow (CSO) Inspection

During a CSO inspection, the inspector evaluates compliance with CSO provisions present in the NPDES permit, an enforcement order, a consent decree, or another enforceable document. The inspector verifies that the permittee is preventing CSOs during dry weather, implementing the nine minimum CSO controls, adhering to a schedule for development, submission, and implementation of a Long-Term CSO Control Plan, eliminating or relocating overflows from sensitive areas, adhering to effluent limitations, and implementing a monitoring program.

Sanitary Sewer Overflow (SSO) Inspection

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During an SSO inspection, the inspector evaluates compliance with SSO provisions present in the NPDES permit, an enforcement order, a consent decree, or another enforceable document. The inspector collects information to verify that the permittee is complying with the NPDES standard/permit conditions (duty to mitigate and proper operation and maintenance) and the required notification procedures. The inspector also determines whether there have been any unpermitted discharges, or discharges from a location other than the discharge point specified in the permit, to waters of the United States.

Concentrated Animal Feeding Operation (CAFO) Inspection

The objective of this inspection is to evaluate a CAFO's compliance with permit requirements, permit conditions, applicable regulations, and other requirements. The three types of CAFO inspections are the Status Determination Inspection, the Permit Compliance Inspection, and the Settlement Agreement Inspection. The type of information that the inspector gathers depends on the type of CAFO inspection being conducted.

Summary

The inspector should plan all activities and coordinate with the appropriate compliance personnel in their office before the inspection. The type of inspection may serve as a basis for deciding what activities will be conducted onsite and for determining what additional information is to be gathered or verified during the inspection. Compliance personnel should choose the type of inspection to be conducted based on the compliance status of the facility, the information needed from the facility, and the type of facility involved. Note that some types of NPDES inspections may encompass several elements of the primary inspection types (e.g., a storm water inspection may encompass elements from both a CSI and a PAI).

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1. B. Legal Authority for NPDES Inspections

The Federal Water Pollution Control Act of 1972, as amended by the Clean Water Act (CWA or the Act) of 1977 and the Water Quality Act of 1987, gives EPA the authority to regulate the discharge of pollutants to waters of the United States. The Act provides broadly defined authority to establish the NPDES Permit Program, define pollution control technologies, establish effluent limitations, obtain information through reporting and compliance inspections, and take enforcement actions (both civil and criminal) when violations of the Act occur. Table 1-1 provides a listing of applicable NPDES statute and regulations.

Inspection Authority

Under Section 402 of the Act, point source dischargers of pollutants (e.g., municipal wastewater treatment plants, industries, animal feedlots, aquatic animal production facilities, and mining operations) facilities must apply and receive a permit that set specific limits and operating conditions to be met by the permittee. Section 308 authorizes inspections and monitoring to determine whether the facility is meeting the NPDES permit conditions. This section provides for two types of monitoring:

- Self-monitoring, where the facility must monitor itself
- Monitoring by EPA or the State, a process whereby the agency evaluates the self-monitoring and/or conducts its own monitoring.

According to the CWA, EPA may conduct an inspection, including storm water, sludge, combined sewer overflows, sanitary sewer overflows, concentrated animal feeding operations, or pretreatment, wherever there is an existing NPDES permit or where a discharge exists or is likely to exist and no permit has been issued.

State Program Authority

Much of the compliance with the NPDES program is monitored by the State. Sections 308 and 402 of the Act allow for the delegation of Federal program authority to States to conduct NPDES permit compliance monitoring, permit issuance, and permit enforcement; but EPA does not relinquish its control authority even when a program has been authorized to the State. EPA Regional Administrators and some State water pollution control agencies have signed formal cooperative agreements that ensure timely, accurate monitoring of compliance with permit conditions. States may implement requirements and regulations that are more stringent than those under the CWA.

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Table 1-1

NPDES-Related Statutes and Regulations

Topic	Reference	
	CWA[1]	40 *CFR*[2]
Inspection Authority	§308	122.41(i), 123.26
Self-Monitoring and Recordkeeping Authority	§308	122.41(h), (j), and (l), 122.48
Confidential Information	§308(b)	2.201, 2.215, 2.302, 122.7
Emergency Authority	§504	123.27
Employee Protection	§507	———
Permits	§402	122, 123.25
EPA Permitting Procedures	§402	124
Technical Requirements	§§301, 304, 307	129, 133, 136
Best Management Practices (BMP)	§304(e)	125
Spill Prevention Control and	§311	112
Countermeasure (SPCC) Plan Waivers	§301	125, 230
Effluent Guidelines	§304	405-471
Pretreatment Standards	§§307, 402(m)	122.21, 403, and 405-471
Biosolids	§405	60, 61, 123, 258, 501, and 503

[1] Clean Water Act
[2] Code of Federal Regulations, Revised as of July 1, 2002

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1. C. Responsibilities of the EPA NPDES Inspector

The primary role of a NPDES inspector is to gather information that can be used to determine the reliability of the permittee's self-monitoring data and evaluate compliance with permit conditions, applicable regulations, and other requirements. The NPDES inspector also plays an important role in case development and support. To fulfill these roles, inspectors are required to know and use policies and procedures for effective inspection and evidence collection; accepted safety practices; and quality assurance standards.

Indian Country Inspections

Each regional inspector should understand and apply the *EPA Policy for the Administration of Environmental Programs on Indian Reservations* (Indian Policy - November 8, 1984) www.epa.gov/indian/1984.htm and their region's policies and procedures when conducting inspections in Indian country. If the facility is in Indian country, the inspector should research this. If a facility is owned or managed by a tribal government or owned and managed by a private party, EPA generally will notify tribal governments in advance of visiting a reservation and EPA will inform the tribal government of the results each inspection. If advance notice is not possible due to circumstances beyond the control of the EPA inspector or if the visit involves an unannounced inspection, the tribal government should be contacted as soon as possible. EPA should address out-of-compliance facilities that are located in Indian country (and/or owned or managed by a tribal government) in a manner consistent with the Indian Policy, the *Guidance on the Enforcement Principles Outlined in the 1984 Indian Policy*, (January 17, 2001), The enforcement guidance is located at www.epa.gov/compliance/planning/tribal/index.html. Regions should also be familiar with the American Indian Environmental Office's website www.epa.gov/indian. EPA Indian program contacts are located at www.epa.gov/indian/miss.htm. They can help identify facilities in Indian country. Please be aware that while it is often very difficult to identify these facilities, EPA should still follow the applicable guidance vis-a-vis working with tribes.

Legal Responsibilities

Inspectors must conduct all inspection activities within the legal framework established by the Act, including:

- Presenting proper credentials
- Properly handling confidential business information.

Inspectors also must be familiar with the conditions of the specific permit, CWA, and regulations.

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Procedural Responsibilities

Inspectors must be familiar with general inspection procedures and evidence collection techniques to ensure adequate inspections and to avoid endangering potential legal proceedings on procedural grounds.

Inspection Procedures

Inspectors should observe standard procedures for conducting each inspection element. The elements of the inspection process listed in Table 1-2 are common to most NPDES compliance inspections. They are grouped by the major inspection activities:

- Pre-Inspection Preparation
- Entry
- Opening Conference
- Facility Inspection
- Closing Conference
- Inspection Report.

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Table 1-2

Inspector's Responsibilities

Pre-Inspection Preparation.

- Establish purpose and scope of inspection.
- Review background information and EPA/State records, including permit and permittee compliance file.
- Develop plan for inspection.
- Prepare documents and equipment, including appropriate safety equipment.
- Coordinate schedule with laboratory if samples are to be collected.
- Coordinate schedule with other appropriate regulatory authorities.
- Contact party responsible for sample transportation, for packing/shipping requirements.
- Ensure state/tribe is notified of pending inspection.

Entry. Establish legal entry to facility.

- Identify self and present official credentials to the responsible official.
- If denied of entry call supervisor/ORC.

Opening Conference. Orient facility officials to inspection plan.

- Discuss inspection objectives and scope.
- Establish working relationship with facility officials.

Facility Inspection. Document compliance/noncompliance with permit conditions; collect evidence including photographs.

- Conduct visual inspection of facility.
- Review facility records.
- Inspect monitoring location, equipment, and operations.
- Collect samples, if appropriate.
- Review laboratory records for QA/QC.
- Review laboratory procedures to verify analytical methodology and use of approved methods.
- Document inspection activities.

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Closing Conference. Conclude inspection.

- Collect additional or missing information.
- Clarify questions with facility officials.
- Prepare necessary receipts.
- Review inspection findings and inform officials of follow-up procedures.
- Issue deficiency notice, if appropriate.

Inspection Report. Organize inspection findings in a report with field notes, file, photographs, and other relevant information.

- Complete NPDES Compliance Inspection Report Form 3560.
- Prepare narrative report, checklists, and documentary information as appropriate.
- Sign and date the report

Evidence Collection

Inspectors must be familiar with general evidence-gathering techniques. Because the Government's case in a civil, criminal, or administrative enforcement action depends on the evidence gathered, inspectors must keep detailed records of each inspection. These notes and documentation will be used for preparing the inspection report, determining the appropriate enforcement response, and giving testimony in an enforcement case.

In particular, inspectors must know how to:

- Substantiate facts with items of evidence, including samples, photographs, document copies, statements from witnesses, and personal observations.
- Evaluate what evidence should be collected (routine inspections).
- Follow chain-of-custody procedures
- Collect and preserve evidence consistent with Chapter 5 – Sampling.
- Write clear, objective, and informative inspection reports

Inspection procedures are discussed in detail in Chapter Two of this manual.

Training Responsibilities

EPA Order 3500.1 establishes consistent EPA-wide training and development programs for employees leading environmental compliance inspections/field investigations to ensure that they have working knowledge of regulatory requirements, inspection methodology, and health and safety measures. Those who lead environmental compliance inspections/field investigations must be properly trained to perform these functions in a legally and technically sound manner. This Order applies to all Environmental Protection Agency (EPA) personnel who lead or oversee compliance inspections/field investigations on a full or part-time basis under any of EPA's statutes, and supervisors of compliance inspectors/field investigators. Training required by the Order consists of three parts: Occupational Health and Safety

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Curriculum, Basic Inspector Curriculum, and Program-Specific Curriculum. (See Appendix A)

Safety Responsibilities

The inspection of wastewater and other environmental pollution control facilities always poses a certain degree of health and safety risk. To avoid unnecessary risks, the inspector should be familiar with all safety obligations and practices. The safety equipment and procedures required for an inspector will be based on either standard safety procedures or the facility response to the 308 (inspection notification) Letter. Inspectors should do the following:

- Use safety equipment in accordance with available guidance and labeling instructions.
- Maintain safety equipment in good condition and proper working order.
- Dress appropriately for the particular activity and wear appropriate protective clothing. For example, appropriate protective gloves should be worn during sample collection to protect the inspector and to prevent the potential for sample contamination. Disposable gloves are preferred to assure that no cross contamination occurs between sampling points.
- Use any safety equipment customary in the establishment being inspected (e.g., hard hat or safety glasses).
- Never enter confined spaces unless properly trained, equipped, and permitted (if applicable).

For any safety-related questions not covered in this manual, the inspector should comply with the facility's current approved safety requirements for greater detail if one is available. An inspector should look at Appendix B which contains the website: "http://intranet.epa.gov/oeca/oc/campd/inspector/index.html" to locate EPA's Order 1440.2, Health and Safety Requirements for Employees Engaged in Field Activities. Also, Appendix C contains a fact sheet on safety and health requirements for EPA inspectors.

Professional Responsibilities

Inspectors are expected to perform their duties with the highest degree of professionalism. Procedures and requirements ensuring ethical actions have been established through many years of Government inspection experience. The procedures and standards of conduct listed below have evolved for the protection of the individual and EPA, as well as industry.

- All inspections are to be conducted within the framework of the United States Constitution and with due regard for individual rights regardless of race, sex, religion, or national origin.
- EPA inspectors are to conduct themselves at all times in accordance with the regulations prescribing employee responsibilities and conduct.
- The facts of an inspection are to be noted and reported completely, accurately, and

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objectively.

- In the course of an inspection, any act or failure to act motivated by reason of private gain is illegal. Actions that could be construed as such should be scrupulously avoided.

- A continuing effort should be made to improve professional knowledge and technical skill in the inspection field.

Professional Attitude

The inspector is a representative of EPA and is often the initial or only contact between EPA and the permittees. In dealing with facility representatives and employees, inspectors must be professional, tactful, courteous, and diplomatic. A firm but responsive attitude will encourage cooperation and initiate good working relations. Inspectors should always speak respectfully of any product, manufacturer, or person.

Attire

Inspectors should dress appropriately, including wearing protective clothing or equipment for the activity in which they are engaged.

Gifts, Favors, Luncheons

Inspectors may not accept favors, benefits, or job offers under circumstances that might be construed as influencing the performance of governmental duties. It is prudent to avoid even the appearance of compromising federal ethics statutes and regulations. If offered a bribe, the inspector must not accept money or goods. Since this act may violate federal laws, regulations and may also violate criminal statute, report the incident in detail as soon as possible to a supervisor and the Deputy Ethics Officials (DEO). A list of the DEOs is at intranet.epa.gov/ogc/ethics.htm - first left radio-button. If it appears that a federal criminal statute was violated, report this right away to the EPA's Office of the Inspector General. (OIG information is at www.epa.gov/oigeatrth/whoswho.htm)

The EPA website on ethics at intranet.epa.gov/ogc/ethics.htm contains extensive information on conflicts of interest, gifts and luncheons. It is recommended that each inspector go to the Resource Library section and review information in the Conflict of Interest (especially the 2002 Ethics Conference Materials), Gifts and Travel sections.

Note also that it is prudent for EPA inspectors to decline business luncheons while on EPA business. The inspector must pay his/her own fees for meals. When in doubt about a possible issue, contact a Deputy Ethics Official to clarify what can and cannot be accepted and report any possible infraction of the ethics statutes and rules. (See page 20, *U.S. EPA Guidance on Ethics and Conflict of Interest*, February 1984, and 5 *CFR* 2635, Standards of Ethical Conduct for Employees of the Executive Branch, January 1, 2001.)

Requests for Information

EPA has an "open-door" policy on releasing information to the public. This policy is to make information concerning EPA and its work freely and equally available to all interested

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individuals, groups, and organizations. In fact, EPA employees have both a legal and traditional responsibility for making useful educational and safety information available to the public. This policy, however, does not extend to information about a suspected violation, evidence of possible misconduct, or confidential business information. The disclosure of information is discussed further in Chapter Two, Disclosure of Official Information.

Quality Assurance Responsibilities

The inspector must assume primary responsibility for ensuring the quality and accuracy of the compliance inspection and the integrity of samples collected. While other organizational elements play an important role in quality assurance, it is the inspector who must ensure that all data introduced into an inspection file are complete, accurate, and representative of existing conditions. To help the inspector meet this responsibility, Regional Offices have established quality assurance plans that identify individual responsibilities and document detailed procedures.

The objective of a quality assurance plan is to establish standards that will guarantee that inspection and analytical data meet the requirements of all users. Many elements of quality assurance plans are incorporated directly into the basic inspection procedures and may not be specifically identified as quality assurance techniques.

The inspector must be aware that following established inspection procedures are critical to the inspection program. These procedures have been developed to reflect the following quality assurance elements:

- Valid data collection
- Approved standard methods
- Control of service, equipment, and supplies
- Standard data handling and reporting.

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1. D. References

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2. INSPECTION PROCEDURES

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I. EPA's Memorandum on Deficiency Notice Guidance
J. NPDES Compliance Inspection Report Form 3560-3

Related Website

U.S. EPA's Office of Compliance Inspector Website:
http://intranet.epa.gov/oeca/oc/campd/inspector/index.html

2. A. Pre-Inspection Preparation

Pre-planning is necessary to ensure that the inspection is focused properly and is conducted smoothly and efficiently. It involves:

- Review of facility background information
- Development of an inspection plan
- Notification of the facility, if applicable
- Notification to the State of Federal inspection
- Preparation of Equipment

Review of Facility Background Information

Collection and analysis of available background information on the candidate facility are essential to the effective planning and overall success of a compliance inspection. Materials from available files, company web sites, and other information sources will enable inspectors to familiarize themselves with facility operations; conduct a timely inspection; minimize inconvenience to the facility by not requesting data previously provided; conduct a thorough and efficient inspection; clarify technical and legal issues before entry; and develop a sound and factual inspection report. The types of information that may be available for review are listed below. The inspector must determine the amount of background information necessary for the inspection and in collecting this information, should focus on the characteristics unique to the permittee: design, historical practices, legal requirements, etc.

General Facility Information

- Maps showing facility location, plumbing including wastewater discharge pipes, sampling points, overflow and bypass points, and geographic features
- Plant layout and process flow diagram
- Names, titles, and telephone numbers of responsible facility officials
- Any special entry requirements
- Any safety requirements
- Description of processing operations and wastewater discharges
- Production levels—past, present, and future
- Hydrological data
- Geology/hydro-geology of the area
- Changes in facility conditions since previous inspection/permit application
- Available aerial photographs.

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Requirements, Regulations, and Limitations

- Copies of existing permits, regulations, requirements, and restrictions placed on permittee discharges
- Monitoring and reporting requirements and available monitoring stations
- Special exemptions and waivers, if any
- Receiving stream water quality standards
- Information concerning sludge, air, solid, and hazardous waste treatment and disposal.

Facility Compliance and Enforcement History

- Previous inspection reports
- Correspondence among facility, local, State, and Federal agencies
- Complaints and reports, follow-up studies, findings, and remedial action
- Documentation on past compliance violations, exceedences, status of requested regulatory corrective action, if any
- Enforcement actions such as compliance schedules and consent orders
- Status of current and pending litigation against facility
- Self-monitoring data and reports
- Previous Environmental Protection Agency (EPA), State, or consultant studies and reports
- Previous deficiency notices issued to facility
- Laboratory capabilities and analytical methods used by the facility
- Name(s) of contract laboratories, if applicable
- Previous Discharge Monitoring Report (DMR)—Quality Assurance (QA) files and reports
- Permit Compliance System (PCS) information
- Reports from special studies (e.g., stream monitoring, internal audits) or compliance schedules.

Pollution Control and Treatment Systems

- Description and design data for pollution control system and process operation, if available

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- Sources and characterization of discharge
- Type and amount of wastes discharged
- Spill prevention contingency plans, if available
- Available routes for bypasses or diversions, and spill containment facilities
- Pollution control units, treatment methods, and monitoring systems.

Pretreatment Information

- Information concerning compliance schedule to install technologies (industrial facilities) or develop a pretreatment program (Publicly Owned Treatment Works [POTWs])
- Pretreatment reports as required by the National Pollutant Discharge Elimination System (NPDES) permit and the General Pretreatment Regulations, regional, State, or local requirements
- The POTW's enforcement response plan and sewer use ordinance, including local discharge limits
- Information concerning industrial discharges to POTWs, such as:
  - Industrial monitoring and reporting requirements
  - POTW monitoring and inspection program
  - Waste contribution to the POTW
  - Compliance status of industry with pretreatment requirements
  - POTW enforcement initiatives.

Chapter Nine of this manual discusses pretreatment program requirements in greater detail.

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Sources of Facility Background Information

Previous Inspections

Previous inspection reports can provide general facility information, as well as problems or concerns noted in previous inspections. Inspectors who have visited the facility for NPDES, pretreatment, or other regulatory programs may also provide information on the facility.

Laws and Regulations

The Clean Water Act (CWA) and related NPDES regulations establish procedures, controls, and other requirements applicable to a facility. In addition, State's may have additional regulations, and sometimes even local ordinances, are applicable to the same facility. Refer to Table 1-2 for a list of applicable NPDES-related Federal statutes and regulations.

Permits and Permit Applications

Permits provide information on the limitations, requirements, and restrictions applicable to discharges; compliance schedules; and monitoring, analytical, and reporting requirements. Permit applications provide technical information on facility size, layout, and location of pollutant sources; treatment and control practices; contingency plans and emergency procedures; and pollutant characterization—types, amounts, applicability of effluent guidelines, and points/ locations of discharge. Permit applications for air, solid, and hazardous waste treatment and disposal permits may provide additional information to the inspector that is not available elsewhere.

Regional and State Files and Personnel

Files or Regional and State personnel often can provide correspondence; facility self-monitoring data; inspection reports, Quarterly Noncompliance Reports (QNCRs), and DMR QA reports; and permits and permit applications applicable to individual facilities. They can provide compliance, enforcement, and litigation history; special exemptions and waivers applied for and granted or denied; citizen complaints and action taken; process operational problems/solutions; pollution problems/solutions; laboratory capabilities or inabilities; and other proposed or historical remedial actions. This information can provide design and operation data, recommendations for process controls, identification of pollutant sources, treatment/control systems improvement, and remedial measures.

Technical Reports, Documents, and References

These information sources provide generic information on waste loads and characterization, industrial process operations, and pertinent specific data on available treatment/control techniques, such as their advantages or disadvantages and limits of application and pollutant removal efficiencies. Such sources include Development Documents for Effluent Standards and Guidelines.

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Company Data Sources

Many companies maintain individual web sites that contain valuable information regarding the company's financial status, significant purchases and sales, new business ventures, etc.

Other Statutory Requirements

Facility files maintained by EPA and the State pursuant to other statutes (e.g., Toxic Substances Control Act [TSCA]; Resource Conservation and Recovery Act [RCRA]; Comprehensive Environmental Response, Compensation and Liability Act [CERCLA]; Federal Insecticide, Fungicide and Rodenticide Act [FIFRA]; Clean Air Act [CAA]) may also contain information useful to the NPDES inspection.

Development of an Inspection Plan

Plans are helpful tools for organizing and conducting compliance inspections. A plan is recommended to effectively conduct a compliance inspection. After reviewing the available background information, the inspector prepares a comprehensive plan to define inspection objectives, tasks and procedures, resources required to fulfill the objectives, inspection schedule, and when findings and conclusions on the work will be reported. At least the following items need to be considered:

- Objectives
  - What is the purpose of the inspection?
  - What is to be accomplished?
- Tasks
  - What tasks are to be conducted?
  - What information must be collected?
  - What records will be reviewed?
- Procedures
  - What procedures are to be used?
  - Will the inspection require special procedures?
- Resources
  - What personnel will be required?
  - What equipment will be required?

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- Schedule
  - What will be the time requirements and order of inspection activities?
  - What will be the milestones?

- Coordination
  - What coordination with laboratories or other regulatory agencies will be required?

An outline of tentative inspection objectives, meetings to be held, and records that will be reviewed can be prepared and presented to the facility officials during the opening conference.

Notification of the Facility

With regard to the EPA-administered NPDES program, the permittee is sometimes notified by a Section 308 Letter or "308 Letter" that the facility is scheduled for an inspection. (Appendix E is an example of a typical 308 Letter.) The signature authority for a 308 Letter may be delegated to a section chief. The 308 Letter advises the permittee that an inspection is imminent and usually requests information regarding onsite safety regulations to avoid problems concerning safety equipment at the time of inspection. This information may include such items as names, addresses, and updated process information. The 308 Letter may specify the exact date of inspection, if coordination with the permittee is required. The 308 Letter also is used to inform the permittee of the right to assert a claim of confidentiality. EPA conducts both announced and unannounced inspections. Depending upon the specific circumstances the permittee may or may not be notified prior to the inspection in writing or by telephone. Each region uses different criteria to determine whether to announce inspections.

State Notification of Federal Inspection

The inspector must be certain that the appropriate State regulatory agency is notified in a timely manner of inspections to be conducted in its jurisdiction. The State should be notified of all Federal inspections unless disclosing inspection information would jeopardize an unannounced inspection. This responsibility may vary depending on the region.

Preparation of Equipment and Supplies

If sampling is to be performed, part of the pre-inspection process may involve preparing sampling equipment and the development of a Quality Assurance Project Plan (QAPP). The type of equipment may vary according to the facility inspected and the type of inspection. Table 2-1 includes a list of field sampling equipment that may be needed. All equipment must be checked, calibrated, and tested before use. The inspector also must ensure that all materials necessary to complete an inspection are taken to the inspection site. The inspector or

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designated person is responsible for maintaining the equipment properly, in accordance with operating instructions.

Safety equipment and procedures required for a facility will be based on the response to the 308 Letter or standard safety procedures. Safety requirements must be met, not only for safety reasons, but to ensure that the inspector is not denied entry to the facility or parts of it. See Table 2-1 for list of protective clothing and safety equipment.

Photocopies of appropriate checklists to be used during the inspection should be obtained during the pre-inspection preparation.

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Table 2-1

List of Field Sampling Equipment

Field Equipment	
Documents and Recordkeeping Tools • Credentials • File • Checklists • Log book • Shipping labels • Analysis request forms • Waterproof pen • Calculator • QAPP & Sampling plan	Protective Clothing[1] • Hard hat • Hearing protection • Safety shoes • Gloves • Coveralls • Reflective safety vest • Safety glasses/goggles • Rainwear
Sampling Materials • Automatic samplers • Tubing • Sample containers, including extras • Batteries/extension cords • Sample bottle labels/sample seals • Plastic security tape • Chain-of-custody forms • Dissolved oxygen meters • pH meter • TRC meter • pH buffer • Deionized water • Chart paper • Thermometer • Coolers/ice • Preservatives	Safety Equipment[1] • First-aid kit • Meters (oxygen content, explosivity, and toxic gas) • Safety harness and retrieval system • Ventilation equipment • Respirator • Filter cartridges • Self-contained breathing apparatus (if appropriate)
Sample Transportation Materials • Bubble pack material • Filament tape • Airbill/bill of lading	Tools • Multi-tooled jack knife (Swiss Army type) • Electrical and duct tape • Tape measure • Hand-held range finder and level • Camera/film, digital camera, video camera • Flashlight • Screwdriver • Adjustable wrench and vise grips • Bucket (plastic or stainless steel, as appropriate) • Nylon cord • GPS • Laptop computer • Cell phone
Flow Measurement Devices • Measurement devices (e.g., flumes, weirs, portable ultrasound or bubble systems) • Flow discharge tables • Level • Ruler • Stopwatch or watch with second hand	

[1] List of Protective Clothing and Safety Equipment is not limited to only Sampling Inspections.

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2. B. Offsite Surveillance

Considerations

Often many potential concerns can be identified prior to entering the facility, such as illegal discharges, stressed vegetation, spills, smoke, or illegal dumping. Offsite surveillance also provides an opportunity for the inspector to determine the direction North, which can be used to reference photos, locations, violations, etc., and allows the inspector to determine the layout of the facility and make judgements about how to prioritize the inspection.

Specific questions the inspector should answer when conducting offsite surveillance include:

1. Is the offsite surveillance conducted from a public right-of-way?
2. Where is the direction North?
   - A brief sketch of the layout and orientation (as viewed from the public right-of-way) should be noted.
3. What are some obvious concerns visible from public right-of-way (e.g., containers, loading areas, tanks, obvious discharges, improper disposal)?

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2. C. Entry

Entry Procedures

Authority

The authority for entry into a wastewater facility is found in section 308(a)(4)(B) of the CWA which states:

> the Administrator or his authorized representative . . . upon presentation of his credentials (i) shall have a right of entry to, upon, or through any premises in which an effluent source is located or in which any records are required to be maintained . . . and (ii) may at reasonable times have access to and copy any records, inspect any monitoring equipment or method . . . and sample any effluents which the owner or operator of such source is required to sample. . . .

In addition, NPDES permits contain inspection authority provisions.

Arrival

Arrival at the facility and the facility inspection should occur during normal working hours. The facility owner or agent in charge should be located as soon as the inspector arrives on the premises. Prior to entering a facility, inspectors should observe it as thoroughly as possible from public grounds.

Credentials

When the proper facility officials have been located, the inspector must introduce himself or herself as an EPA inspector and present the proper EPA credentials. These credentials indicate that the holder is a lawful representative of the regulatory agency and is authorized to perform NPDES inspections. The credentials must be presented whether or not identification is requested.

If the facility officials question the inspector's credentials after the credentials have been reviewed, the officials may telephone the appropriate State or EPA Regional Office for verification of the inspector's identification. Credentials should never leave the sight of the inspector or be photo-copied. For more detailed information on the use of EPA Credentials, please refer to the fact sheet "The Do's and Don'ts of Using EPA Credentials"(Appendix F).

Consent

Consent to inspect the premises must be given by the owner or operator at the time of the inspection. As long as the inspector is allowed to enter, entry is considered voluntary and consensual, unless the inspector is expressly told to leave the premises. Expressed consent is not necessary; absence of an expressed denial constitutes consent.

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Reluctance to Give Consent

The receptiveness of facility officials toward inspectors is likely to vary among facilities. Most inspections will proceed without difficulty. In other cases, officials may be reluctant to give entry consent because of misunderstood responsibilities, inconvenience to a firm's schedule, or other reasons that may be overcome by diplomacy and discussion. If consent to enter is denied, the inspector should follow denial of entry procedures (see p.2-13).

Whenever there is a difficulty in gaining consent to enter, inspectors should tactfully probe the reasons and work with officials to overcome the problems. Care should be taken, however, to avoid threats of any kind, inflammatory discussions, or deepening of misunderstandings. If the situation is beyond the authority or ability of the inspector to manage, the inspector's supervisor/ Office of Regional Counsel should be contacted for guidance.

Claims of Confidentiality

The inspector should explain the permittee's right to claim material as confidential and that the inspector may examine areas related to effluent production or storage even if the permittee has asserted claims of confidentiality. Confidential information is discussed in greater detail later in this chapter.

Waivers, Releases, and Sign-In Logs

When the facility provides a blank sign-in sheet, log, or visitor register, it is acceptable for inspectors to sign it. However, EPA employees must not sign any type of "waiver" or "visitor release" that would relieve the facility of responsibility for injury or that would limit the rights of EPA to use data obtained from the facility. The inspector may cross-out and initial any wording that is unacceptable due to its restrictive nature.

If such a waiver or release is presented, the inspectors should politely explain that they cannot sign and request a blank sign-in sheet. If the inspectors are refused entry because they do not sign the release, they should leave and immediately report all pertinent facts to the appropriate supervisor and/or legal staff. All events surrounding the refused entry should be fully documented. Problems should be discussed cordially and professionally.

Problems With Entry or Consent

Because a facility may consider an inspection to be an adversarial proceeding, the legal authority, techniques, and competency of inspectors may be challenged. Facility officials also may display antagonism toward EPA personnel. In all cases, inspectors must cordially explain the authorities and the protocols followed. If explanations are not satisfactory or disagreements cannot be resolved, the inspectors should leave and obtain further direction from his EPA supervisor or legal staff. Professionalism and politeness must prevail at all times. Appendix G contains EPA's Memorandum on Entry Procedures – "Conduct Inspections After the Barlow's Decision."

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Entry Procedures

EPA developed the following inspection procedures as a result of the 1978 U.S. Supreme Court decision in Marshall v. Barlow's, Inc.

- Ensure that all credentials and notices are presented properly to the facility owner or agent in charge.
- If entry is not granted, ask why. Ask the reason for the denial to see if obstacles (such as misunderstandings) can be cleared. If resolution is beyond the authority of the inspector, he or she may suggest that the officials seek advice from their attorneys to clarify EPA's inspection authority under Section 308 of the CWA.
- If entry is still denied, the inspector should withdraw from the premises and contact his or her supervisor or Regional Counsel. The supervisor will confer with attorneys to discuss the desirability of obtaining an administrative warrant.
- All observations pertaining to the denial are to be carefully noted in the field notebook and inspection report. Include such information as the facility name and exact address, name and title of person(s) approached, name and title of the person(s) who refused entry, date and time of denial, detailed reasons for denial, facility appearance, and any reasonable suspicions of regulatory violations. All such information will be important should a warrant be sought.

Important Considerations

Under no circumstances should the inspector discuss potential penalties or do anything that may be construed as coercive or threatening.

Inspectors should use discretion and avoid potentially threatening or inflammatory situations. If a threatening confrontation occurs, the inspector should document it and then report it immediately to the supervisor or staff attorney. If feasible, statements from witnesses should be obtained and included in the documentation.

Withdrawal of Consent During Inspection

If the facility representative asks the inspector to leave the premises after the inspection has begun, the inspector should leave as quickly as possible following the procedures discussed previously for denial of entry. All activities and evidence obtained before the withdrawal of consent are valid. The inspector should ensure that all personal and government equipment is removed from the facility.

Denial of Access to Some Areas of the Facility

If, during the course of the inspection, access to some parts of the facility is denied, the inspector should make a notation of the circumstances surrounding the denial of access and of

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the portion of the inspection that could not be completed. He or she then should proceed with the rest of the inspection. After leaving the facility, the inspector should contact his or her supervisor or staff attorney at the Regional Office to determine whether a warrant should be obtained to complete the inspection.

Warrants

The inspector may be instructed by EPA attorneys, under certain circumstances, to conduct an inspection under search warrant. A warrant is a judicial authorization for appropriate persons to enter specifically described locations to inspect specific functions. A pre-inspection warrant possibly could be obtained where there is reason to believe that entry will be denied when the inspector arrives at the facility or when the inspector anticipates violations that could be hidden during the time required to obtain a search warrant. This would be done only in unusual circumstances.

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2. D. Opening Conference

Once credentials have been presented and legal entry has been established, the inspector can proceed to outline inspection plans with facility officials. At the opening conference, the inspector provides names of the inspectors, the purpose of the inspection, authorities under which the inspection is being conducted, and procedures to be followed. EPA encourages cooperation between the inspectors and the facility officials in order to facilitate assignments and ensure the success of the inspection.

Considerations

Inspection Objectives

An outline of inspection objectives will inform facility officials of the purpose and scope of the inspection and may help avoid misunderstandings.

Order of Inspection

A discussion of the order in which the inspection will be conducted will help eliminate wasted time by allowing officials time to make records available and start up intermittent operations.

Meeting Schedules

A schedule of meetings with key personnel will allow facility officials adequate time to spend with the inspector.

List of Records

A list of facility records that will need to be reviewed as part of the inspection should be provided to facility officials. (i.e., permit, discharge monitoring report, chain-of-custody form, sampling data, operation and maintenance records, training records, lab data sheets, and other records can be requested depending on the inspections type being performed.) This will allow the officials adequate time to gather the records and make them available for the inspector.

Accompaniment

It is important that a facility official accompany the inspector during the inspection not only to answer questions and describe the plant and its principal operating characteristics, but also for safety and liability considerations. Discussion of such needs with facility officials will provide them the opportunity to allocate personnel for this purpose. It is also advisable that the inspector talk to the personnel actually responsible for performing sample collection and analysis to gather specific information on these procedures.

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Permit Verification

The inspector should verify pertinent information included in the permit, such as facility name and address, receiving waters, and discharge points. The inspector should also validate (or obtain) accurate outfall locational data (i.e., the precise latitude and longitude of each outfall).

Safety Requirements

Inspector should be prepared with the appropriate safety equipment which may include hard hat, safety shoes, safety glasses, etc.) The inspector should reaffirm which Occupational Safety and Health Administration (OSHA) and facility safety regulations will be involved in the inspection and should determine whether his safety equipment is adequate.

Closing Conference

A post-inspection meeting should be scheduled with appropriate officials to provide a final opportunity to gather information, answer questions, present findings and deficiencies, and complete administrative duties.

New Requirements

The inspector should discuss and answer questions pertaining to any new rules and regulations that might affect the facility. If the inspector is aware of proposed rules that might affect the facility, he or she may wish to encourage facility officials to obtain a copy.

Split Samples

Facility officials should be informed during the opening conference of their right to receive a split or duplicate of any physical sample collected for laboratory analysis if sufficient sample volume is collected. Officials should indicate at this point their desire to receive split and duplicate samples so that arrangements can be made to secure the samples during inspection. Duplicate samples will be collected at all sites suspected of potential violations and offered to the permittee.

Photography

Photography is an essential tool used to assist the inspector in preparing a thorough and accurate inspection report, to present evidence in enforcement proceedings, and to document conditions found at a site. The Federal Water Pollution Control Act (FWPCA) gives the inspector the authority to collect and copy records including photographic images during an inspection. During special circumstances such as Confidential Business Information (CBI) claims, the inspector may take the photographs, but he/she must handle the photographs following all CBI procedures. If there are other circumstances such as national security issues, the inspector should try to collect the evidence needed without taking photographs. The inspector must inform the site representative that he or she will be taking photographs as a routine part of their inspection.

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If the facility representative expresses reservations about allowing the inspector to take photographs, these concerns should be discussed to seek a mutually acceptable solution. This can be as simple as agreeing to avoid photographing sensitive items which are irrelevant to the inspection, and/or allowing the representative to look through the camera's viewfinder prior to taking the photograph. With digital and video photography it is possible to immediately show the representative your image with the option to delete it if deemed unacceptable. As a general rule, it is considered a denial of entry when a facility imposes any photographic restrictions which limit the inspector from properly performing the inspection.

Under no circumstances should the inspector discuss potential penalties or do anything that may be construed as coercive or threatening. If the inspector is unable to reach an acceptable solution, then he or she should withdraw from the premises and immediately contact his or her supervisor for assistance.

If entry is denied, it is legal for the inspector to photograph areas of the facility exposed to public view.

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2. E. Documentation

Providing documentary support of discrepancies discovered in an inspection is an inspector's basic responsibility. Documentation serves to "freeze" the actual conditions existing at the time of inspection so that evidence can be examined objectively by compliance personnel.

Documentation is a general term referring to all printed information and mechanical media produced, copied, or taken by an inspector to provide evidence of suspected violations. Forms of documentation include the field notebook, statements, photographs, videotapes, drawings, maps, printed matter, mechanical recordings, and copies of records.

Inspector's Field Notebook

The core of all documentation relating to an inspection is the field notebook, which provides accurate and inclusive documentation of all inspection activities. A bound notebook should be used, and entries should be made in permanent ink. The notebook will form the basis for written reports and should contain only facts and pertinent observations.

Note the date and time of arrivals and departures each day. Language should be objective, factual, and free of personal feelings or terminology that might prove inappropriate. Cross out and initial any errors in the notebook. The field notebook should never leave the inspector's possession during the inspection. Do not allow a facility to copy the field notebook. Notebooks become an important part of the evidence package and are admissible in court. The field notebook is a part of government records and is not to be considered the inspector's personal record. Hold notebooks indefinitely pending disposition instructions. There have been instances, although not frequent, where an inspector needed to look back at their field note some 10 to 20 years later for related enforcement work.

Inspection Notes

An inspector may need to testify in an enforcement proceeding. Therefore, it is imperative that each inspector keep detailed records of inspections, investigations, samples collected, and related inspection functions. Types of information that should be entered into the field notebook include the following:

Observations

Record all conditions, practices, and other observations that will be useful in preparing the inspection report or that will validate evidence. Note weather conditions such as rain/snowfall events prior to and during the inspection. These data will assist the inspector in determining whether inflow/infiltration (I&I) is a problem with the facility.

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Documents and Photographs

Photographs taken during an inspection are used to supplement the testimony of the inspector as a witness during a court proceeding. The photographs are not intended to refute testimony but rather to aid the witness in recalling actual conditions onsite. All documents taken or prepared by the inspector such as the completed checklists for the inspection report should be noted and related to specific inspection activities. The inspector should adequately document each photograph so that its content can be properly identified with the site, date, and who took the photograph. This can be recorded in the inspector's field notebook or a separate photo log. Some cameras have a photo specific data which allow this information to be permanently imprinted on the photograph. Video cameras and some digital cameras allow this information to be voice recorded with the photograph. All the statements in this section, regarding digital camera use, should be checked with the EPA's Policy on the Use of Digital Cameras for Inspections (Appendix H).

Unusual Conditions and Problems

Note describe in detail unusual conditions and problems.

General Information

List names and titles of facility personnel and the activities they perform should be listed along with statements they have made and other general information. Record weather conditions. Information about a facility's recordkeeping procedures may also be useful in later inspections.

Samples

For the analysis of a sample to be admissible as evidence, a logical and documented connection must be shown between samples taken and analytical results reported. This connection is shown by using a chain-of-custody form that identifies and accompanies a sample between the time it is collected and the time it is analyzed. Sampling techniques and procedures are discussed in Chapter Five, "Sampling."

Statements

Inspectors may attempt to obtain a formal statement from a person who has personal, firsthand knowledge of facts pertinent to a potential violation. Request the person making the statement to sign and date the statement or a certification that the document reflects an accurate summary of what they said.

The principal objective of obtaining a statement is to record in writing, clearly and concisely, relevant factual information.

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Procedures and Considerations

- Determine the need for a statement. Will it provide useful information? Is the person making the statement qualified to do so by personal knowledge?
- Ascertain all the facts. Make sure all information is factual and firsthand. Record statements that are relevant and that the person can verify in court. Avoid taking statements that cannot be personally verified.
- In preparing a statement, use simple narrative style; avoid stilted language.
  - Narrate the facts in the words of the person making the statement.
  - Use the first-person singular ("I am manager of . . .").
  - Present the facts in chronological order (unless the situation calls for another arrangement).
- Positively identify the person making the statement (name, address, position).
- Show why the person is qualified to make the statement.
- Present the pertinent facts.
- Have the person read the statement and make any necessary corrections before signing. If necessary, read the statement to the person in the presence of a witness.
  - All mistakes that are corrected must be initialed by the person making the statement.
- Ask the person making the statement to write a brief concluding paragraph indicating that he or she read and understood the statement. This safeguard will counter a later claim that the person did not know what he or she was signing.
- Have the person making the statement sign it.
- If he or she refuses to sign the statement, elicit an acknowledgment that it is true and correct. Ask for a statement in his or her own hand ("I have read this statement and it is true, but I am not signing it because . . ."). Failing that, declare at the bottom of the statement that the facts were recorded as revealed and that the person read the statement and avowed it to be true. Attempt to have any witness to the statement sign the statement including the witness' name and address.
- Provide a copy of the statement to the signer if requested.

Photographs

The documentary value of photographs ranks high as admissible evidence. Clear photographs of relevant subjects provide an objective record of conditions at the time of inspection. If

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possible, keep "sensitive" operations out of the photographed background. Photographs showing confidential operations or information must be handled as confidential information.

When a situation dictates the use of photographs, the inspector should obtain the permittee's approval before taking them. The inspector should be tactful in handling any concerns or objections a permittee may have about the use of a camera. In some cases, the inspector may explain to the permittee's representative that wastestreams, receiving waters, and wastewater treatment facilities are public information, not trade secrets. In the event the permittee's representative still refuses to allow photographs, and the inspector believes the photographs will have a substantial impact on future enforcement proceedings, the inspector supervisor or Regional attorneys should be consulted for further instructions.

The primary objective of inspection photography is to create an image which accurately documents their observations and can be used to testify that the image is a "true and accurate representation of what he or she saw on that date." To accomplish this goal, the inspector needs to be familiar with their camera so that the image not only is captured but is properly exposed and in-focus.

There are myriad choices of cameras and image recording media to pick from. The highest quality photographs are typically from 35mm single-lens reflex cameras, but most non bottom-of-the-line point-and-shoot range finder type cameras produce acceptable images. Disposable film cameras and instant print (e.g., Polaroid) may give poorer quality images but may be used photo is representative of what the inspector saw. Color film is the standard type of film used, but there may be situations where slide film is preferred. Good quality prints can also be made from slide film.

Digital cameras offer the advantage of immediate viewing of the image to assure proper composition and exposure. As mentioned above, they can also be shown to the facility representative to mitigate their photographic concerns. Digital photography presents unique issues which are addressed in the EPA's Policy on the Use of Digital Cameras for inspections (See Appendix H).

Equipment

A single-lens reflex camera will take high-quality photographs, enable the inspector to use a variety of film speeds, and allow the use of appropriate lenses. Fully automatic 35-mm and pocket cameras can also be used for routine inspections to record the conditions of the facility during the inspection.

All photographs should be made with color print film because additional equipment, such as a projector and screen, is not needed to review them. Also, the negatives from color print film are easily duplicated and the prints can be enlarged and distributed as needed.

A digital camera may be used in conjunction with or instead of a single-lens reflex camera. Digital images require no processing or printing. Digital photographers have the advantage of reviewing images immediately and verifying the results, and if the digital images are not satisfactory, new images may be taken without the substantial delay entailed in processing and printing of traditional photographic images.
When final the digital camera policy will be located at the US EPA's Office of Compliance Inspector web site: http://intranet.epa.gov/oeca/oc/campd/inspector/index.html

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Scale, Location, and Direction Depending on the situation, there are normally three types of photographs which can be taken: 1) the establishing shot, 2) the subject, and 3) the detail shot. The "establishing shot" or wide angle shot is a photograph taken from a distance which shows the subject in relation to permanent landmarks that can be used for reference in establishing the location of the subject. The "subject" shot emphasizes a specific object or event. The "detail" shot or close-up is typically a particular area of interest within the subject, such as a nameplate or leaky valve. It may be helpful to include an object of known size for scale reference such as a notebook or pen.

Safety

In areas where there is a danger of explosion, flash photographs should not be taken. If there is a danger of electrical shock, photographs should be taken from a distance known to be safe.

Videotapes

For some inspections, video cameras can be more effective in documenting your findings. Video cameras not only can document motion relative to a violation, but record sound, have extreme zoom capabilities, and can operate in very low light conditions. When recording sound, inspectors must be aware that all comments are recorded.

Drawings and Maps

Schematic drawings, maps, charts, and other graphic records can be useful in supporting violation documentation. They can provide graphic clarification of site location relative to the overall facility, relative height and size of objects, and other information which, in combination with samples, photographs, and other documentation, can produce an accurate, complete evidence package.

Drawings and maps should be simple and free of extraneous details. Include basic measurements and compass points to provide a scale for interpretation. Identify drawings and maps by source, inspector's initials, and date.

Printed Matter

Brochures, literature, labels, and other printed matter may provide important information regarding a facility's conditions and operations.

Collect these materials as documentation if, they are relevant. Identify all printed matter with date, inspector's initials, and origin.

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Mechanical Recordings

Properly date and sign printouts of electronic records so they can be entered as evidence. Charts, graphs, and other hard copy documents produced from computer output should be treated as documentation and handled accordingly.

Copies of Records

The inspector may store records in a variety of information retrieval systems, including written or printed materials, computer or electronic systems, or visual systems such as microfilm and microfiche.

Obtaining Copies of Necessary Records

When copies of records are necessary for an inspection report consider, storage and retrieval methods.

Written or printed records generally can be photocopied onsite. Portable photocopy machines may be available to inspectors through the Regional Office. When necessary, inspectors should get authorized in advance via procurement request, travel authorization, or phone call to the appropriate EPA authority. Each inspector should find who is their approval official. Authorization will allow the inspector to pay a facility a "reasonable" price for use of copying equipment. If the facility does not have a photocopier and a portable photocopier is not available, a photocopy machine is usually accessible at a nearby site (e.g., post office, convenience store). However, inspectors must obtain permission from the permittee prior to taking records offsite for copying.

- At a minimum, all copies made for or by the inspector should be initialed and dated for identification purposes. (See identification details below.)

- When photocopying is impossible or impractical, closeup photographs or videotape or hand copying may be taken to provide suitable copies.

- Computer or electronic records may require the generation of hard copies for inspection purposes. Arrangements should be made during the opening conference, if possible, for these copies.

  - Photographs of computer screens may provide adequate copies of records if other means do not exist.

- Visual systems (microfilm, microfiche) may have photocopying capacity built into the viewing machine, which can be used to generate copies. Photographs of the viewing screen may provide adequate copies if hard copies cannot be generated.

Identification Procedures Immediate and adequate identification of records reviewed is essential to ensure the identification of records throughout the EPA custody process and their

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admissibility in court. When inspectors are called to testify, they must be able to identify each particular document and state its source and the reason for its collection if asked.

The inspector should initial, date, number, and enter the facility's name on each record, and log these items into the field notebook.

Initialing/Dating

Each inspector should develop a unique system for initialing (or coding) and dating records and copies of records so that he or she can easily verify their validity. This can be done by initialing each document in a similar position, or by another method, at the time of collection. All record identification notations should be made on the back of the document. The inspector must be able to identify positively that he or she so marked the document.

Numbering

As necessary to keep proper track each document or set of documents substantiating a suspected violation(s) should be assigned an identifying number unique to that document. The number should be recorded on each document and in the field notebook.

Logging

Documents obtained during the inspection should be entered in the field notebook by a logging or coding system. The system should include the identifying number, date, and other relevant information:

- The reason for copying the material (i.e., the nature of the suspected violation or discrepancy)
- The source of the record (i.e., type of file, individual who supplied record)
- The manner of collection (i.e., photocopy, other arrangements).

General Considerations

- Return originals to the proper person or to their correct location.
- Group related records together.
- Handle Confidential business records according to the special confidential provisions discussed below.

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Routine Records

The inspector may find it convenient to make copies of records, such as laboratory analysis sheets and data summaries, to refresh his or her memory when preparing the inspection report. It is not always necessary to follow the formal identification and logging requirements when such records are obtained for general information purposes or to aid in the preparation of routine inspection reports.

Confidential Information

Confidentiality

When conducting compliance inspections, an inspector may have to deal with claims of confidentiality as authorized under Section 308 of the CWA and as defined under 40 CFR Part 2. This section of the statute is designed to protect confidential business information from unauthorized disclosure. Confidential business information includes information considered to be trade secrets (including chemical identity, processes, or formulation) that could damage a company's competitive position if they became publically known.

Any business being inspected has the right to claim all or any part of the information gathered during that inspection, other than effluent data, as confidential. See CWA section 308(b); 40 C.F.R. § 2.302(e). In fact, as a mater of policy, EPA notifies the business of its right to assert a claim of confidentiality at the time of 308 letter Frequently, the 308 letter is used for this notification. After the business has responded to the 308 letter and, in that response, has asserted whatever claims of business confidentiality for eligible information it intends to make, EPA generally will be aware of any potential confidentiality problems.

The affected business may assert a daim of confidentiality at any time, according to 40 CFR 2.203(c). The business can make such a claim at the time of the inspection or at any time subsequent to the inspection. This claim must be in writing and signed by a responsible company official. While the business is entitled to make a claim of confidentiality on all information which an inspector requests or has access to while onsite (other than effluent data), claims of confidentiality are subject to review by the EPA's Office of General Counsel or Office of Regional Counsel and the business may be asked to substantiate its claims. See 40 C.F.R. § 2.204(e). If a claim of confidentiality for certain information is received by EPA after the information itself is received by EPA, EPA will make such efforts as are administratively practicable to associate the late claim with copies of the previously submitted information in EPA's files. See 40 C.F.R. § 2.203(c). However, EPA cannot assure that such efforts will be effective, in light of the possibility of prior disclosure or widespread prior dissemination of the information.

When a business makes the confidentiality claim, the Regional office normally will not determine the validity of that claim under 40 CFR Part 2 until there is a request for the information from a third party or if EPA believes that the information should be included in the public record in connection with a proceeding. The exact procedures for making and handling CBI determinations are contained in 40 CFR Part 2. Until such a time as that determination is made, the information shall be treated as confidential information.

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In some cases, entry to a facility may be denied based on the claim by a permittee that there is confidential information at the facility. In such cases, the inspector should recite the relevant subsections of 308 so they are clearly understood by all parties involved. The inspector should then explain the provisions of 40 CFR Part 2 concerning confidentiality. For example, the inspector could suggest that the protected material or process be segregated from other disclosable information or processes. The inspector should also have in his/her possession a copy of both the 308 letter which was sent to the business and the business' response. If the facility representative still refuses entry, the inspector should not contest the issue but should treat the matter in the same manner as any denial of entry and immediately notify the appropriate EPA enforcement office for instructions.

Types of Information Excluded from Confidential Treatment

In order to understand claims of confidentiality, an inspector should know the types of information considered confidential. These types of information are defined in 40 CFR Part 2. The regulations specifically exclude certain types of information from confidential treatment. In particular, this "public information" includes the NPDES permit application and all "effluent data" as defined in 40 CFR 2.302(a)(2)(i). According to this definition, effluent data include all information necessary to determine the identity, amount, frequency, concentration, temperature, and other characteristics (to the extent related to water quality) of:

- Any pollutant which has been discharged by the source (or any pollutant resulting from any discharge from the source) or any combination of the foregoing

- The pollutant which, under an applicable standard or limitation, the source was authorized to discharge (including, to the extent necessary for such purpose, a description of the manner or rate of operation of the source).

Effluent data may also include a general description of the location and/or nature of the source to the extent necessary to distinguish it from other sources (e.g., a description of the device, installation, or operation constituting the source). For additional clarification about confidentiality, EPA Regional policy on the issue should be consulted.

Secrecy Agreements and Nondisclosure

Inspectors, whether EPA, the State, or EPA contractors conducting NPDES compliance inspections, shall not sign any pledge of secrecy or confidentiality agreements or any agreement which would limit the Agency*s ability to disclose information received while inspecting a facility. Section 308 does not specify that a secrecy agreement must be executed as a condition of entry. Unauthorized disclosure of confidential information by EPA or State employees and authorized contractors is prohibited by law [33 U.S.C. 1318(b)]. In addition, all contractor inspectors must sign a statement that they will be personally bound by 40 CFR Part 2 and not disclose trade secrets.

It is not appropriate for the compliance inspector to determine whether a permittee's claim of confidentiality is justified. Once such a claim is made, the information must not be disclosed and must be kept confidential until a determination is made by the appropriate EPA legal office. EPA employees who violate these requirements may be subject to dismissal,

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suspension, or fines. Criminal action may be taken against EPA employees and authorized contractors who disclose confidential business information.

Trade Secrets and Confidential Business Information Section 308(b)(2) of the CWA in Title 40, *Code of Federal Regulations*, Part 2 (40 *CFR* Part 2) protects and defines trade secrets and confidential business information from public disclosure.

Section 308(a)(4) of the CWA states that an inspector may sample an effluent, request information, have access to the location of the effluent, and inspect any monitoring equipment. The information that is collected is available to the public. If a permittee does not want inspection information to be available to the public, he or she must request that EPA consider the information confidential. Confidential information includes trade secrets, such as chemical identity, processes, or formulae. The permittee must show that the information, if made available, would divulge trade secrets. The information then may be classified confidential, but still may be disclosed to authorized representatives of EPA.

Therefore, a business is entitled to a claim of confidentiality for all information that an inspector requests or has access to; however, a business may not refuse to release information requested by the inspector under the authority of Section 308 of the Act on the grounds that the information is considered confidential or a trade secret. The claim of confidentiality relates only to the public availability of such data and cannot be used to deny facility access to inspectors performing duties under Section 308 of the Act. A claim of confidentiality may be made at the time of the inspection or at any time subsequent to the inspection. Claims must be made in writing and signed by a responsible company official. Information claimed as confidential can be later reviewed to determine whether the claim is valid.

Handling Confidential Business Information

Routine security measures will help ensure that reasonable precautions are taken to prevent unauthorized persons from viewing confidential information. When practical circumstances prohibit the inspector from following the procedures exactly, he or she should take steps to protect the information. He or she should mark all confidential information received as such and placed in a locked filing cabinet or a safe immediately after the inspection is completed. Maintain a chain-of-custody record for all confidential information. Since confidential information requires special handling procedures, it may be useful to keep it in a separate notebook in a secure/locked location. By doing this, only the confidential material, and not the entire notebook of inspection findings, would have to be kept in a locked filing cabinet.

While Traveling. The inspector may be on the road for several days while conducting inspections. The inspector is responsible for ensuring that the information collected is handled securely.

- Documents and field notes are considered secure if they are in the physical possession of the inspector and are not visible to others while in use.

- Keep inspection documents which contain sensitive information in a locked briefcase. If it is impractical to carry the briefcase store the briefcase in a locked area, such as the trunk of a motor vehicle.

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- Place physical samples in locked containers and store in a locked portion of a motor vehicle. The chain-of-custody procedures provide further protection for ensuring the integrity of the sample.

In the Office. Indicate who is authorized to have access, only personnel authorized by the Regional Administrator, Division Director, or Branch Chief. An access log should be maintained for all transactions. Do not copy information marked "trade secret" and/or "confidential" unless there is written authority from the Regional Administrator, Division Director, or Branch Chief. Requests for access to confidential information by any member of the public, or by an employee of a Federal, State, or local agency, must be handled according to the procedures contained in the Freedom of Information Act regulations (40 *CFR* Part 2). All such requests should be referred to the responsible Regional organizational unit.

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2. F. Closing Conference

To achieve the most effective results from compliance inspections, the inspector should communicate results promptly to the facility management and/or operating personnel. The inspector should limit the discussion to preliminary findings of inspection. If appropriate, the inspector may compare findings with the permittee's NPDES permit requirements, consent decrees, administrative orders, and other enforcement actions.

Facility officials are usually anxious to discuss the findings of an inspection before the inspector(s) leave. Inspectors should hold a closing meeting or conference for the presentation and discussion of preliminary inspection findings. The closing conference provides an opportunity to describe deficiencies found and identify areas of concern (e.g., unpermitted discharge, parts of a SWPPP missing; inspections not being done; silt fence not installed; discharge to a storm drain, etc...). During this meeting or conference, inspectors can answer final questions, prepare necessary receipts, provide information about the NPDES program, and request the compilation of data that were not available at the time of the inspection. It also presents an opportunity to deliver compliance assistance materials and/or information in accordance with the National Policy on the Role of the EPA Inspector in Providing Compliance Assistance During Inspections, June, 2003. Inspectors should be prepared to discuss follow-up procedures, such as how results of the inspection will be used and what further communications the region, state, tribe, or locality may have with the facility. Inspectors should conduct closing conferences in accordance with any applicable guidelines or SOPs established by the EPA Regional Administrator, State Commissioner, Tribal Official or Local Director.

Precautions and Guidelines

Although a discussion of the inspection results is important, certain precautions are essential:

- The inspector should follow the guidelines described in the National Policy on the Role of the EPA Inspector in Providing Compliance Assistance During Inspections, June, 2003.

These guidelines are subject to standard operating procedures developed by the Administrator/delegated party or State Director regarding permittee contacts in the Region/State.

Deficiency Notice

The inspector may issue a Deficiency Notice that specifies existing or potential problems in a permittee's self-monitoring program. Issuing a Deficiency Notice onsite or after the site inspection provides a swift and simple method for improving the quality of data from NPDES self-monitoring activities. An example Deficiency Notice and EPA's Memorandum on Deficiency Notice Guidance are provided in Appendix I. Notices allow the inspector to formally assign responsibility to the permittee and to track each step of the compliance/enforcement process. The Deficiency Notice also helps the permittee to comply with the self-monitoring requirements of the permit.

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This tool should be used in conjunction with any type of NPDES compliance inspection during which the inspector identifies problems with the permittee's self-monitoring activities. It is to be used by the inspector only to alert permittees to deficiencies in their self-monitoring activities. The enforcement office of the regulatory authority, not the inspector, handles effluent violations.

Inspectors can issue the Deficiency Notice to a permittee immediately following a compliance inspection, or after the site visit is completed, if they discover any permit deficiencies in the following seven categories that the Notice addresses:

- Monitoring location
- Flow measurement
- Sample collection/holding time
- Sample preservation
- Test procedures, Section 304(h), 40 *CFR* Part 136
- Recordkeeping
- Other self-monitoring deficiencies.

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2. G. Inspection Report

The adequacy of compliance follow-up to correct problems or deficiencies noted during the inspection greatly depends on the report prepared by the inspector. The sections of this chapter detail procedures for collecting and substantiating the information used to prepare this report. Once collected, however, the inspector should organize and arrange the material so that compliance personnel can make maximum use of the evidence or inspection information. The information presented in this section provides general guidelines for organizing evidence and preparing an inspection report.

Objective of the NPDES Inspection Report

The objective of a NPDES inspection report is to organize and coordinate all inspection information and evidence into a comprehensive, usable document. To meet this objective, information in an inspection report must be presented in a clear, well-organized manner. The information should be objective and factual; the report must not speculate on the ultimate result of the inspection findings. Of particular importance are the following:

- Include only accurate information in the report. It should be factual and based on sound inspection practices. Observations should be the verifiable result of firsthand knowledge. Compliance personnel must be able to depend on the accuracy of all information.

- Information in an inspection report should be relevant to the subject of the report. Irrelevant facts and data will clutter a report and may reduce its clarity and usefulness. Avoid personal comments and opinions.

- Substantiated suspected violation(s) be by as much factual, relevant information as is feasible to gather. Organize all information pertinent to the subject into a complete package. Reference documentary support (e.g., photographs, statements, sample documentation) accompanying the report should be referenced clearly so that anyone reading the report will get a complete, clear overview of the situation. The more comprehensive the evidence is, the better and easier to determine compliance or noncompliance.

Effectively Communicate and Document an Alleged Violation in the Inspection Report

This is especially critical when the findings and observations support that a potential violation occurred. The following includes procedures and examples of how to effectively communicate potential violations.

1. First, state the requirement in the actual language of the statute, permit, or regulation and then describe and present the evidence that shows how the facility failed to meet the requirement. Each potential violation should be made obvious to the reader by thoroughly and clearly describing all documents, photographs, statements, and other evidence in the inspection report. This should include the inspector's own observations. For example:

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I. ***Failure to Meet Missouri State Operating Permit (MSOP) Conditions -*** *The Missouri MSOP, MO0023456, issued to the City of Pollutionville, at Section C. Special Conditions, Subsection 6. General Criteria, contains the following requirement: "a) Waters shall be free from substances in sufficient amounts to cause formation of putrescent, unsightly or harmful bottom deposits or prevent full maintenance of beneficial uses." On January 5, 2002, at the WWTP's outfall 32 (see map - attachments 3), I observed the receiving water body, Greenfoot Stream, to have approximately 4-5 inches of sludge deposit on the bottom 9 (see photos #10-14, approximation of depth made with 12" ruler) as well as significant blood worm populations (photos #15-16, estimate of blood worm population based on counting the number of blood worms per square foot of water surface to a depth of about one foot). Greenfoot Stream is on the Missouri 303(d) list for nutrient content. Mr. Smith, the plant operator, signed a statement that the plant had been losing solids to the stream for four months due to an increased organic load from Acme Meat Packing Co. (see attachment 5)....*

II. ***NOV #4 - Failure to Close Hazardous Waste Satellite Accumulation Container -*** *While in the aerosol fill area (see map - attachment 3), I observed one full 55-gallon satellite accumulation container that was open (photo 1). I verified that the drum was full by looking inside of it. Mr. Helpful, the Aerosol Can Fill Operator, said that he used the container to collect spent line flushing solvent. He said the solvent consisted of Mecos laquer thinner and that the thinner was used to wash the paint out of the fill equipment (MSDS - attachment 9). I asked Mr. Helpful if he considered the spent laquer thinner a hazardous waste. He said yes, that he managed it as F003/F005 hazardous waste. Containers holding hazardous waste are required to be closed per 40 CFR 262.34(a)(1(l) ref. 40 CFR 265.173(a).*

2. Use a separate, indented paragraph to highlight each violation along with an obvious font change. As in the above example, each violation was in **bold face type** and *italicized.* Other formats may be used as long as each violation is made clearly obvious to the reader.

3. The inspector should write the report as soon as possible after returning from the field. As noted earlier, excessive delays or reports not written "near-in-time" to the inspection can seriously compromise EPA's ability to conduct timely enforcement.

Each inspector should use the following techniques to ensure a well-documented inspection report:

1. Write the report as soon as possible upon return from the field.
2. Write the report in the first person and in a "compare and contrast" style, i.e., each violation identified should be stated in a manner where the facts are presented and then compared, against the statute, permit or regulatory requirement.
3. Use simple, direct language, and short sentences.
4. Identify, by name and relationship to the facility, who said what and when.
5. Clearly identify all potential violations observed during the inspection or evaluated prior to the report write-up.
6. Reference the applicable statute, permit, or regulation for each potential violation identified. If the inspection is conducted in a state that is authorized to implement the regulation, then the applicable state law or regulation should be co-referenced.

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7. Provide a complete and detailed description of all materials gathered to support the alleged violation, e.g., all photographs, maps, diagrams, etc.
8. Identify, number, and reference all attachments in the text of the field report.
9. Use consistent word choice, e.g., if a particular device is called a "Waste-o-matic," use the term "Waste-o-Matic" throughout the report to describe that particular device.
10. Do not use negative inferences. For example, avoid saying "...the only drums found were...," which is not first person and implies that no other drums were at the facility. Simply state what was observed, e.g., "During the inspection, I observed five drums which were..."
11. Do not use vague and ambiguous terms or statements. For example, avoid using words like *indicated, implied, suggested, several, many, some,* or *it was determined.*
12. Do not use absolute terms like *all, always,* or *every,* unless the findings and observations have been fully verified and documented (be as precise and accurate as possible.
13. Do not repeat or use information obtained from previous inspection reports that was not verified during the inspection.
14. Describe all actions (including time frames) that the facility said they would complete as a result of the inspection.

Elements of a Report

Although specific information requirements for an inspection report will vary, most reports will contain the same basic elements:

- NPDES Compliance Inspection Report Form
- Supplementary narrative information
- Copies of completed checklists
- Documentary support
- Inspection Conclusion Data Sheet

NPDES Compliance Inspection Report Form

The inspector is responsible for reporting all compliance inspection activities by completing the current NPDES Compliance Inspection Report Form 3560-3 as soon as possible after the inspection. A copy of the form is included as Appendix J. The EPA should forward the inspection report form (Form 3560-3) to the regulatory authority no later than 30 days after completion of the inspection. Copies should be sent to the permittee in a timely manner (generally within 30 days of inspection date) except when formal enforcement procedures are underway. In this instance, the case attorney will direct any disclosure of data.

Supplementary Narrative Information

Supplementary narrative information could be a memorandum in the case of routine inspections or a narrative report when major violations are detected. When a narrative report is necessary to fully describe a compliance inspection, the contents of the report should focus on supporting or explaining the information provided in the Compliance Inspection Report Form.

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The narrative report should be a concise, factual summary of observations and activities, organized logically and legibly, and supported by specific references to accompanying documentary support.

A work plan will simplify preparation and will help ensure that information is organized in a usable form. Basic steps in writing the narrative report include the following:

Reviewing the Information

The first step in preparing the narrative is to collect all information gathered during the inspection. Review the inspector's field notebook in detail. Review all evidence for relevance and completeness. A telephone call or, in unusual circumstances, a follow-up visit may be needed to obtain additional or supplementary information. Record any phone call relating to the inspection in the inspector's log book with date and time.

Organizing the Material

Organize the information according to need, present it logically and comprehensively. Organize the narrative so that it is easily understood.

Referencing Accompanying Material

Reference all documentary support accompanying a narrative report clearly so that the reader will be able to easily locate the items. The "Documentation" section in this chapter provides details on document identification. The inspector should check all documentary support for clarity before writing the report.

Writing the Narrative Report

Once all the material is collected the reviewing, organizing, and referencing, the narrative can be written. The purpose of the narrative is to factually record the procedures used in, and findings resulting from, the evidence-gathering process. The inspector should refer to routine procedures and practices used during the inspection, but should detail facts relating to potential violations and discrepancies. The field notebook is a guide for preparing the narrative report.

If the inspector has followed the steps presented in this manual, the report will develop logically from the organizational framework of the inspection. In preparing the narrative, the inspector should make simplicity paramount.

- Write simply; avoid stilted language.
- Use the active, not passive, voice: (e.g., "He said that . . ." rather than "It was said that...").
- Keep paragraphs brief and to the point.
- Avoid repetition.

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- Proofread the narrative carefully.

Copies of Completed Checklists

Refer to comprehensive checklists in the technical chapters of this manual and in the appendices. When appropriate use these checklists to collect information during the inspection, the Region may modify these to specific concerns. Include copies of all completed checklists in the inspection report.

Documentary Support

Include all documentation produced or collected by the inspector to provide evidence of suspected violations in the inspection report. The "Documentation" section in this chapter provides details on obtaining and organizing this material.

The Permit Compliance System (PCS)/Integrated Compliance Information System (ICIS)

The inspection office should ensure that all data listed in Section A of the NPDES Compliance Inspection Report Form 3560-3 are entered into the PCS, which is used for national tracking of NPDES permit information. EPA does not credit the inspection until it is coded/entered into PCS. Therefore, timely completion of reports and data entry into PCS is essential to effectively follow up a compliance inspection. Make every effort to ensure that data are entered no later than 30 days after the inspection is completed.

Inspection Conclusion Data Sheet (ICDS)

In FY 2002, EPA began collecting information on EPA NPDES compliance inspection outcomes using a manual ICDS form. Regional inspectors completed these forms and sent to Headquarters. The information on the forms was then entered into a national ICDS database. In FY 2003, Office of Enforcement and Compliance Assurance (OECA) launched the Integrated Compliance Information System (ICIS) Phase I to electronically capture compliance and enforcement information, including ICDS data. ICIS Phase I includes data fields for entering both general inspection information (for example, facility name, address, SIC code, media) and ICDS information (for example, deficiencies, actions taken, and compliance assistance provided). Appendix BB contains the Compliance Monitoring Screens required and directions to follow to enter both types of information. Regions must decide whether EPA inspectors or central data entry personnel will be responsible for entering the data into ICIS. If EPA inspectors enter the data, no manual ICDS form will be needed since the information to fill out the form should be included in the inspector's notes. If central data entry personnel enter the data, EPA inspectors will have to complete the manual ICDS form and forward it to their first-line supervisor for review prior to data entry into ICIS.

Integrated Compliance Information System (ICIS)

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The Integrated Compliance Information System (ICIS) supports the information needs of the National Enforcement and Compliance program as well as the unique needs of the NPDES program. ICIS will integrate data that is currently located in more than a dozen separate data systems. The web-based system will eventually enable individuals from states, communities, facilities, and EPA to access integrated enforcement and compliance data from any desktop connected to the Internet. EPA's ability to target the most critical environmental problems will improve as the system integrates data from all media.

ICIS features include:

- Desktop access
- Internet access
- Integrated data
- Real time entry and retrieval of data
- Powerful reporting capabilities
- User friendly.

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3. DOCUMENTATION/ RECORDKEEPING AND REPORTING

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D. Digitized Video Clip - Records & Reports . . . . . (CD-Rom Insert in binder)

Associated Appendices

K. Sample Discharge Monitoring Report Form

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3. A. Inspection Authority and Objectives

Authority and Objectives

Statutory Recordkeeping Authority:	Clean Water Act (CWA) §308 and §402
Regulatory Requirements:	40 *Code of Federal Regulations (CFR)* Parts 122, 136, 401, 403, 405-471, and 503, as applicable
Inspection Authority:	CWA §308

The National Pollutant Discharge Elimination System (NPDES) permit system requires permittees to maintain records and report periodically on the amount and nature of discharged effluent waste components. The permit stipulates recordkeeping and reporting conditions. Evaluations are conducted at selected permitted facilities to determine compliance with permit requirements. The procedures listed below should be used for these routine inspections. If suspected violations are disclosed during the routine evaluation, a more intensive investigation should be conducted.

A review of facility records should determine that recordkeeping requirements are being met. The following questions should be answered in particular:

- Is facility verifying data being collected as required by the permit?
- Is all required information available?
- Is the information current?
- Is the information being maintained for the required time period?
- Do the records reviewed indicate areas needing further investigation?
- Are the records organized?
- Do the records show compliance?

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3. B. Evaluation Procedures

Verification, Recordkeeping, and Reporting Evaluation Procedures

During the facility site inspection, the inspector should verify the following requirements of the permit:

- That the number and location of discharges are as described in the permit
- That all discharges, if permitted are in accordance with the general provisions of the permit, such as no noxious odors, no visible entrained solids in discharge, no deposits at or downstream of the outfall, no color change in the receiving stream, and no fish or vegetation kills near the outfalls.

The inspector should review the permit to determine recordkeeping and reporting requirements. Throughout the inspection, the inspector should compare facility's operations with the permit to verify that required permit activities are correct, current, and complete. Obtain some of the information needed to verify the permit during the opening conference and compare with the facility permit. This information includes:

- Correct name and address of facility
- Correct name and location of receiving waters
- Number and location of discharge points, if any
- Principal products and production rates (where appropriate).

The inspector should check for records that will verify that notification has been made to the Environmental Protection Agency (EPA) or to the State when: (1) discharges differ from those stated in the permit, (2) a discharge violates the permit, and (3) a bypass has occurred. The inspector should also check to ensure that the facility maintains the appropriate records for a minimum of 3 years (or 5 years for sewage sludge). These records may include the following:

- Sampling and Analysis Data
  - Dates, times, and locations of sampling
  - Sample types collected
  - Analytical methods and techniques
  - Results of analyses
  - Dates and times of analyses
  - Name(s) of analytical and sampling personnel.
- Monitoring Records
  - Discharge Monitoring Reports (DMRs), including information on flow, pH, Dissolved Oxygen (DO), etc., as required by permit. A blank DMR form is included in Appendix K.
  - Original charts from continuous monitoring instrumentation.
  - It is important for the inspector to verify the validity of the data on the DMRs. Provide this verification by tracking the raw data from the laboratory bench sheets or other

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databases to the final reported DMR entries.

- Laboratory Records

  - Calibration and maintenance of equipment
  - Calculations (i.e., on bench sheets or books)
  - Quality Assurance/Quality Control (QA/QC) analysis data
  - Laboratory Standard Operating Procedures (SOPs)
  - Results of DMRQA studies.

- Facility Operating Records

  - Daily operating log
  - Summary of all laboratory tests run and other required measurements, including reference test method used (general reference to Standard Methods or 40 *CFR* Part 136 methods is not adequate)
  - Chemicals used (pounds of chlorine per day, etc.)
  - Weather conditions (temperature, precipitation, etc.)
  - Equipment maintenance completed and scheduled
  - Spare parts inventory
  - Flowmeter and pH meter calibration records.

- Treatment Plant Records (required as part of the Federal Construction Grants program)

  - Plant Operations and Maintenance (O&M) Manual
  - Percent removal records
  - "As built" engineering drawings
  - Copy of construction specifications
  - Equipment supplier manual
  - Data cards on all equipment.

- Management Records

  - Average monthly operating records
  - Annual reports
  - Emergency conditions (power failures, bypass, and chlorine failure reports, etc.).

- Pretreatment Records

  - Publicly Owned Treatment Works (POTW) and industrial monitoring and reporting requirements
  - Industrial user discharge data
  - Compliance status records
  - POTW enforcement initiatives.

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- Risk Management Plan (RMP)
- Storm Water Pollution Prevention Plan (SWPPP)
- Spill Prevention Control and Countermeasure (SPCC) Plan

  When required, a properly completed RMP, SWPPP, and/or SPCC Plan should be available. The inspector also may gather information on the SPCC and forward this information to the appropriate program office for follow-up action plans.

- Best Management Practices (where required)

  Two types of Best Management Practice (BMP) plans are included in NPDES permits:

  - BMP plans to minimize or prevent release of significant amounts of any toxic or hazardous pollutants to public waters. The plans may discuss general operations and maintenance of the plant, good housekeeping procedures on the facility grounds, and other plans and procedures specific to best management of the facility.
  - Site-specific BMP plans to address particular toxic or hazardous chemicals or other conditions particular to the facility. Site-specific BMP may include procedures, monitoring requirements, construction of barriers such as dikes and berms, or other appropriate measures for solving specific problems.

In addition, inspectors should ensure that sludge records to verify compliance with 40 *CFR* Part 503 are maintained for a minimum of 5 years. Facility needs to keep records to be reviewed (such as sludge records and laboratory records) onsite for the inspector.

The inspector should document all inspection activities (see Chapter Two, Section D). Inadequacies, discrepancies, or other problems disclosed during this review may warrant more intensive investigation.

The inspector should validate (or obtain) accurate outfall locational data during the inspection. Locational data includes the precise latitude and longitude of each outfall (including metadata such as source, datum, precision, etc.). This EPA requires the information as part of the EPA permit applications, for all outfalls in modernized PCS. Locational data are becoming increasingly critical for Agency-wide geospatical applications, including everything from mapping to prioritizing enforcement and permitting efforts.

Compliance Schedule Status Review

If the permit contains a compliance schedule or if the facility is under an enforcement action with a compliance schedule, the inspector should determine:

- Whether the permittee is conforming to the compliance schedule and, if not, whether final requirements will be achieved on time
- The accuracy of reports relating to compliance schedules
- The length of delay associated with a particular construction violation

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- Whether any schedule violations are beyond the control of the discharger
- Whether requests for permit modifications are valid.

If the permit contains a compliance schedule address the schedule in detail only if the need becomes apparent during records review and preparation of the inspection plan. Actions to look at should included beginning new construction, contract and equipment orders, authorization and financing arrangements, and/or attainment of operational status. The specific compliance schedule actions are described below.

Construction Progress

The inspector must know whether contracts for labor and material have been fulfilled and whether the permittee or the permittee's engineering consultant is monitoring progress. These aspects are extremely important, particularly in plants where numerous contracts are likely for labor and equipment.

If the permittee or the engineering consultant reports that construction or acquisition of equipment is behind schedule, the inspector should:

- Ask to see the permittee's or the resident engineer's progress report and determine whether the report indicates that the final compliance schedule required by the permit can be met.
- If the report indicates that the final date will not be met, advise the permittee that the compliance schedule of the NPDES permit requires the permittee to notify the permit-issuing authority promptly of any possible delay in achieving compliance and of measures taken to minimize the delay.
- Inquire whether the facility superintendent or chief operator and operating personnel are receiving adequate training concerning the operational aspects of the new treatment unit while construction is under way. They must be prepared to perform the essential operating functions when the facility is placed in service.

Construction Contracts and Equipment Orders

The inspector should review the appropriate documents to determine whether the permittee has obtained the necessary approval to begin construction. The inspector should note the start and completion dates (or scheduled delivery dates in service or equipment contracts).

Authorization and Financing

If construction is incomplete, the inspector should determine whether the permittee has the authority and financial capability (mortgage commitments, corporate resolution, etc.) to complete the required structures.

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Attainment of Operational Status

If construction has been completed but the facility is not yet operational, the inspector should determine whether the facility is using appropriate procedures to ensure attainment of working status at the earliest possible time. The inspector should verify the following:

- Adequate self-monitoring procedures that the facility has initiated. It is especially important that the result of operational and effluent quality monitoring be reviewed to determine whether progress is being made toward optimum efficiency in each treatment unit and in the entire plant.
- Adequate recordkeeping procedures.
- Adequate work schedules and assignments. (For municipal facilities, the O&M Manual should provide essential guidance.)

POTW Pretreatment Requirements Review

The inspector must collect specific information to evaluate compliance with pretreatment requirements. A summary using the following procedures below and for more detail see Chapter Nine, "Pretreatment."

As part of the inspection, the inspector must collect information about the POTW's compliance with its approved pretreatment program and applicable regulations as well as the compliance status of its industrial users with categorical pretreatment standards or locally developed discharge limitations. The inspector should review POTW records to determine the following:

- Whether all the contributing industries, including the number of significant industrial users are accounted.
- Whether all industries are properly identified and classified.
- Whether industries have submitted required reports and notifications to the POTW. These include baseline monitoring reports, 90-day compliance reports, periodic compliance reports, notifications of changed discharge, potential problem discharges, violation and resampling, and hazardous waste discharge.
- Whether the number of contributing industries are in compliance with applicable standards.
- Whether permits containing all required elements have been issued to significant industrial users in a timely manner.
- Whether inspections and sampling (including evaluation of the need for slug control plans) of significant industrial users are conducted at the required frequency.
- Whether the POTW has notified all affected users of classification and applicable

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standards and requirements, including Resource Conservation and Recovery Act (RCRA) obligations.

- Whether appropriate enforcement actions have been taken against all noncompliant industries and whether the names of all users in significant noncompliance are published at least annually.

- Whether contributing industries with compliance schedules are meeting applicable schedule deadlines and compliance schedule reporting requirements.

In-depth Investigations

When necessary conduct an in-depth inspection of a permittee's records and reports to substantiate a suspected violation, to verify self-monitoring data to use as corroborative evidence in an enforcement action, or to confirm apparent sampling, analysis, or reporting discrepancies discovered during the limited inspection. Discrepancies warrant an in-depth review if, for example:

- Suspect the discharge does not meet required standards and no definite operational problems have been established.

- Suspect grossly inaccurate self-reporting data with recordkeeping procedures and/or the filing of reports.

- Suspect the cursory review indicates omissions or laxity in the preparation of records.

- Suspect evidence of falsification of records

- Suspect laboratory review of analytical data indicates errors in QC or data management.

Confer with supervisor for more guidance and assistance as needed in performing an in-depth investigation.

In-depth Investigation Procedures

The following procedures should guide the inspector in conducting an in-depth investigation:

- Determine Investigation Objective. What is the specific purpose of the investigation?

- Determine Information Needed. What specific data will substantiate a violation or respond to the investigation objective?

- Determine Data Source. What records will contain these required data?

- Review Inspection Authority. Authority to inspect under Section 308 is limited to those records required by the permit/regulations.

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- Inspect Direct and Indirect Data Sources. Examine records likely to provide the required data directly. In the absence of direct data, use indirect sources of information can be used to develop a network of information relevant to the data being sought.

- Take Statements From Qualified Facility Personnel. See Chapter Two, Section D, for procedures.

- Prepare Documentation. Copy and identify all records relevant to the information being sought; see Chapter Two, Section D, for specific procedures.

- Follow Confidentiality Procedures. Any record inspected may be claimed by the facility as confidential. Treated such records in accordance with EPA procedures; see Chapter Two, Section D, the discussion on Confidential Business Information.

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3. C. Verification, Recordkeeping, and Reporting Evaluation Checklist

VERIFICATION, RECORDKEEPING, AND REPORTING EVALUATION CHECKLIST

A. PERMIT VERIFICATION

Mailing Address:

Brief Facility Description:

Yes	No	N/A	1.	Inspection observations verify information contained in permit.
Yes	No	N/A	2.	Current copy of permit is onsite.
Yes	No	N/A	3.	Name and mailing address of permittee are correct.
Yes	No	N/A	4.	Facility is as described in permit.
Yes	No	N/A	5.	Notification was given to EPA/State of new, different, or increased discharges.
Yes	No	N/A	6.	Facility maintains accurate records of influent volume, when appropriate.
Yes	No	N/A	7.	Number and location of discharge points are as described in permit.
Yes	No	N/A	8.	Records accurately identify name and location of receiving waters.
Yes	No	N/A	9.	All discharges are permitted.
Yes	No	N/A	10.	The facility used Federal Construction Grant funds to build the plant.

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VERIFICATION, RECORDKEEPING, AND REPORTING EVALUATION CHECKLIST (Continued)

B. RECORDKEEPING AND REPORTING EVALUATION

Yes	No	N/A	1. Maintain records and reports as required by permit.
Yes	No	N/A	2. All required information is available, complete, and current.
Yes	No	N/A	3. Information is maintained for 3 years (or 5 years for sewage sludge).
Yes	No	N/A	4. If the facility monitors more frequently than required by permit (using approved methods), these are results reported.
			5. Analytical results are consistent with data reported on DMRs.
Yes	No	N/A	a. The data moves accurately from the bench sheets to the DMRs
Yes	No	N/A	b. The calculations are performed properly (including loading, averages, etc.)
			6. Sampling and analyses data are adequate and include:
Yes	No	N/A	a. Dates, times, and location of sampling
Yes	No	N/A	b. Name of individual performing sampling
Yes	No	N/A	c. Analytical methods and techniques
Yes	No	N/A	d. Results of analyses and calibration
Yes	No	N/A	e. Dates of analyses
Yes	No	N/A	f. Name of person performing analyses
Yes	No	N/A	g. Instantaneous flow at grab sample stations.
			7. Monitoring records are adequate and include:
Yes	No	N/A	a. Flow, pH, DO, etc., as required by permit
Yes	No	N/A	b. Monitoring charts kept for 3 years (or 5 years for sewage sludge)
Yes	No	N/A	c. Flowmeter calibration records kept.
Yes	No	N/A	d. Locational data (latitude and longitude of each outfall)
Yes	No	N/A	8. Laboratory equipment calibration and maintenance records are adequate.
Yes	No	N/A	9. Plant records* are adequate and include:
Yes	No	N/A	a. O&M Manual
Yes	No	N/A	b. "As-built" engineering drawings
Yes	No	N/A	c. Schedules and dates of equipment maintenance repairs
Yes	No	N/A	d. Equipment supplies manual
Yes	No	N/A	e. Equipment data cards.
Yes	No	N/A	* Required only for facilities built with Federal Construction Grant funds.
			10. Pretreatment records are adequate and contain inventory of industrial waste contributors, including:
Yes	No	N/A	a. Monitoring data
Yes	No	N/A	b. Inspection reports
Yes	No	N/A	c. Compliance status records
Yes	No	N/A	d. Enforcement actions.

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VERIFICATION, RECORDKEEPING, AND REPORTING EVALUATION CHECKLIST (Continued)

C. COMPLIANCE SCHEDULE STATUS REVIEW

Yes	No	N/A	1. Permittee is meeting compliance schedule.
Yes	No	N/A	2. Permittee has obtained necessary approvals to begin construction.
Yes	No	N/A	3. Financing arrangements are complete.
Yes	No	N/A	4. Executed contracts for engineering services.
Yes	No	N/A	5. Completed design plans and specifications.
Yes	No	N/A	6. Construction has begun.
Yes	No	N/A	7. Construction is on schedule.
Yes	No	N/A	8. Equipment acquisition is on schedule.
Yes	No	N/A	9. Facility has completed construction.
Yes	No	N/A	10. Startup has begun.
Yes	No	N/A	11. Permittee has requested an extension of time.
Yes	No	N/A	12. Permittee has met compliance schedule.

D. POTW PRETREATMENT REQUIREMENTS REVIEW

Yes	No	N/A	THE FACILITY IS SUBJECT TO PRETREATMENT REQUIREMENTS
			1. Status of POTW pretreatment program
Yes	No	N/A	a. EPA approved the POTW pretreatment program. (If not, is approval in progress?)
Yes	No	N/A	b. The POTW is in compliance with the pretreatment program compliance schedule. (If not, note why, what is due, and intent of the POTW to remedy.)
			2. Status of Compliance with Categorical Pretreatment Standards.
			a. Number POTW industrial users, Federal or State, subject to pretreatment standards?
Yes	No	N/A	b. Are these industries aware of their responsibility to comply with applicable standards?
Yes	No	N/A	c. Has the facility submitted baseline monitoring reports (403.12) for these industries?
Yes	No	N/A	i. Have categorical industries in noncompliance (on BMR reports) submitted compliance schedules?
			ii. How many categorical industries on compliance schedules are meeting the schedule deadlines?
Yes	No	N/A	d. If the compliance deadline has passed, have all industries submitted 90-day compliance reports?
Yes	No	N/A	e. Are all categorical industries submitting the required semiannual report?

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VERIFICATION, RECORDKEEPING, AND REPORTING EVALUATION CHECKLIST (Continued)

Yes	No	N/A	f.	Are all new industrial discharges in compliance with new source pretreatment standards?
Yes	No	N/A	g.	Has the POTW submitted an annual pretreatment report?
Yes	No	N/A	h.	Has the POTW taken enforcement action against noncomplying industrial users?
Yes	No	N/A	i.	Is the POTW conducting inspections of industrial contributors?
Yes	No	N/A	3.	Are the industrial users subject to Prohibited Limits (403.5) and Local Limits more stringent than EPA in compliance? (If not, explain why, including need for revision of limits.)

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4. FACILITY SITE REVIEW

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4. A. Objectives

In performing a facility site review, an inspector examines process treatment units, sampling and flow monitoring equipment, outfalls, and the receiving stream. In particular, the inspector focuses on areas of the permittee's premises where pollutants are generated, pumped, conveyed, treated, stored, or disposed of. The proper conduct of a facility site review requires that the inspector understand fully the wastewater treatment processes used at the facility and how each process fits into the overall treatment scheme. A General Wastewater Treatment Plant Flow Diagram is included at the end of this chapter. (See Figure 4-1.)

The objectives of a facility site review are to:

- Assess the conditions of the facility's current treatment processes and operations
- Evaluate the permittee's operation and maintenance activities
- Check the completeness and accuracy of the permittee's performance/compliance records
- Determine whether the treatment units are achieving the required treatment efficiencies.

During the overall review of the facility, the compliance inspector becomes more knowledgeable about the facility being inspected, reviews areas that may indicate problems with effluent limitations, and evaluates overall performance of the treatment facility. The information in this chapter is comprehensive and is based on performing an inspection at a Publicly Owned Treatment Works (POTW). Inspectors should use only the information applicable to a particular situation. This chapter includes a Facility Site Review Checklist for the inspector's use at the end of this chapter.

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4. B. Physical Inspection of the Facility

During the "walk-through" of the facility, the inspector should pay attention to the operational factors listed below. The inspector needs to carefully document the physical inspection. The inspector should look at and record the following:

- Influent characteristics, including:
  - Appearance (color, odor, etc.)
  - Combined sewer loads
  - Infiltration/inflow
  - Industrial contributions
  - Diurnal/seasonal loading variations
- Process control
- Unit operations including supply of treatment chemicals
- Equipment condition
- Maintenance and operation staff
- Safety controls and equipment
- Effluent characteristics, including:
  - Appearance of discharge
  - Receiving stream appearance including any staining. deposits, or eutrophication
  - Evidence of toxicity of the discharge
- Other conditions particular to the plant.

The Environmental Protection Agency's (EPA's) *Field Manual for Performance Evaluation and Trouble Shooting at Municipal Wastewater Facilities* (USEPA 1978), published by the Municipal Operations Branch of EPA, is a good reference for operational characteristics of plants.

The physical inspection may lead the inspector to determine:

- Whether a major facility design problem may require an engineering solution

- Whether problems can be solved through proper operation and maintenance of the treatment facilities

- Whether periodic equipment malfunctions the facility needs to address by complete overhaul or replacement of equipment.

If a facility design problem exists, one of the recommendations will be that the facility develop engineering solutions. The inspector may evaluate the operation and maintenance procedures from the viewpoint of what can be done to simplify the solution. When the inspection findings indicate that specific practices of the facility contribute to or cause problems, the inspector should detail the problems. When possible, the inspector should use the information to evaluate the operation and maintenance procedures.

When conducting the walk-through, the inspector should be aware of and look for physical conditions that indicate past, existing, or potential problems. The presence of these conditions will give the inspector an idea of the types of problems present, the parts of the treatment

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process causing the problems, and the potential solution to existing problems. Conditions to look for in the plant generally and in specific processes are listed in the following sections.

General Conditions in Overall Plant

General Indicators

- Excessive scum buildup; grease, foam, or floating sludge in clarifiers
- Hydraulic overload caused by storms, discharges of cooling water, or undersized facility or process
- Noxious odors in wet wells and grit chambers and around aerobic and anaerobic biological units, scum removal devices, and sludge handling and treatment facilities
- Evidence of severe corrosion at the treatment plant and in the collection system
- Discoloration of the ground or a strong chemical smell may indicate past spills at the plant; further investigation of spills may be warranted
- Vital treatment units out of service for repairs. Determine when the units went out of service, the type of failure, and when they will be put back in service
- Excessive noise from process or treatment equipment
- Any unusual equipment intended to correct operation problems (e.g., special pumps, floating aerators in diffused air systems, chemical feeders, temporary construction or structures, or any improvised system)
- Ruptures in chemical feed lines.

Flow Indicators

- Surcharging of influent lines, overflow weirs, and other structures
- Hydraulicly overloaded process or equipment
- Flow through bypass channels
- Overflows at alternative discharge points, channels, or other areas
- Excessive septage dumping by septic tank pumpers
- Flow from unknown source or origin
- Open-ended pipes that appear to originate in a process or storage area and periodically contain flows to the ground or to surface water. Although these pipes have been disconnected from a closed system or otherwise removed from service, they can still be connected to a discharge source
- Flow charts indicating acute Infiltration and Inflow (I/I) problems following rain events.

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Unusual Wastes Indicators

- Collected screenings, slurries, sludges, waste piles, or by-products of treatment. Their disposal, including runoff of any water, must be such that none enters navigable waters or their tributaries.
- Improper or lack of recycling of filtrates and supernatants from sludge dewatering and treatment.
- Improper storage of chemicals and hazardous substances with particular attention to the proper diking of chemicals and hazardous substances and segregation of incompatible chemicals. Generally, spill containment should be such that the dike could contain the contents of the largest tank.
- Spills or mishandling of chemicals.

Preliminary Treatment at the Headquarters

Screening

- Excessive screen clogging
- Excessive buildup of debris against screen
- Oil and grease buildup
- Improper disposal of screenings
- Excessive odors
- Pass thru of grease and debris that shows up in the final effluent or "pass through."

Shredding/Grinding

- Bypass of shredding/grinding equipment
- Equipment removed or inoperable.

Grit Removal

- Grit chamber clogged or subject to odors
- Less than typical grit accumulation
- Excessive organic content of grit
- Wear of grit removal/handling equipment
- Excessive odors in grit removal area.

Influent Pumping

- Inadequate pumping capacity during periods of high influent flow
- Not operable pumps.

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Flow Equalization

- Equalization tank never empty
- Excessive odors
- Inoperable aerators, if aerated
- Ability to bypass directly to surface water.

Primary Clarifier

General Indicators

- Excessive gas bubbles or grease on surface
- Black and odorous wastewater
- Poor removal of suspended solids in primary clarifier
- Excessive buildup of solids in center well of circular clarifier
- Unlevel discharge weirs
- Fouling of overflow weirs
- Evidence of short circuiting
- Ineffective scum rake
- Scum overflow or lack of adequate scum disposal, full scum pit
- Excessive floating sludge and/or scum
- Excessive sludge on bottom, inadequate sludge removal
- Noisy sludge scraper drive
- Broken sludge scraper equipment
- Poor maintenance of sludge pumps (leaking) or pump gallery.

Secondary Biological Treatment Units

Trickling Filter/Activated Biofilters

- Filter ponding (indicating clogged media)
- Collapsed media
- Leak at center column of filter's distribution arms
- Uneven distribution of flow on filter surface
- Uneven or discolored growth
- Excessive sloughing of growth
- Odor
- Clogging of trickling filter's distribution arm orifices
- Restricted rotation of distribution arms
- Filter flies, worms, or snails
- Ice buildup on trickling filter media or distribution arms
- Inappropriate recirculation rate.

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Rotating Biological Contactors

- Odor
- Development of white biomass on rotating biological contactor (RBC) media
- Excessive sloughing of growth
- Excessive breakage of rotating disks or shafts in RBC units
- Shaft, bearing, drive gear, or motor failure
- Solids accumulation in RBC units.

Activated Sludge Tanks

- Excessive breakage of paddles on brush aerators
- Shaft, bearing, drive gear, or motor failure on disk or brush aerators
- Dead spots in aeration tanks
- Failure of surface aerators .
- Inoperative air compressors
- Air rising unevenly
- Excessive air leaks in compressed air piping
- Dark mixed liquor in aeration tank (grey or black)
- Dark foam or bad odor on aeration tanks
- Stable dark tan foam on aeration tanks that sprays cannot break up
- Thick billows of white, sudsy foam on aeration tank
- Low Dissolved Oxygen (DO, < 1.0 mg/l) in aeration tank (except in areas used for denitrification)
- Inadequate amount of return activated sludge rates
- Improper MLSS concentration (not using basin to hold excess solids inventory).

Stabilization Ponds/Lagoons

- Trees growing on the bank, or within the root zone distance from the bank.
- Erosion of stabilization pond bank or dike
- Excessive foliage or animal burrows in pond bank or dike
- Excessive weeds in stabilization ponds
- Foaming and spray in aerated lagoon
- Dead fish or aquatic organisms
- Buildup of solids around influent pipe
- Excessive scum on surface.

Secondary Clarifier

General Indicators

- Excessive gas bubbles on surface
- Fouling of overflow weirs
- Unlevel overflow weirs
- Evidence of short circuiting

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- Excessive buildup of solids in center well of circular clarifier
- Deflocculation in clarifier
- Pin floc in overflow
- Ineffective scum rake
- Floating sludge on surface; rising sludge or bulking sludge
- Billowing sludge
- Excessively high sludge blanket
- Clogged sludge withdrawal ports on secondary clarifier for either sludge wasting or sludge return
- Unequal sludge blanket levels in parallel units
- Inappropriate return and wasting rates
- Poor maintenance of sludge pumps (leaking) or pump gallery.

Advanced Physical Treatment Units

Filtration

- Filter surface clogging
- Short filter run
- Air displacement of gravel media
- Formation of mud balls in filter media
- Air binding of filter media
- Loss of filter media during backwashing
- Recycled filter backwash water in excess of 5 percent
- Excessive effluent turbidity.

Microscreening

- Erratic rotation of microscreen drums
- Plugging
- Drive system noisy or overheating
- Backwash in excess of 5% of flow treated.

Activated Carbon Adsorption

- Excessive biological growth resulting in strong odor
- pH above 9.0 Standard Units (S.U.)
- Plugged carbon pores
- Presence of carbon fines (dust) in effluent
- Excessive carbon regeneration.

Nitrification

- Hydraulic overload
- Inadequate pH control/chemical addition

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- Pin floc in final effluent
- Sludge rising because of gasification in secondary clarifier.

Denitrification

- Temperature below 15°C
- pH below 6.0 S.U. or above 8.0 S.U.
- Excessive methanol or other chemical additions
- Septic sludge conditions.

Ammonia Stripping

- Excessive hydraulic loading rate
- Tower packing coated with calcium carbonate
- pH below 10.8 S.U.
- Inadequate tower packing depth
- Air temperature below 65°F.

Disinfection

Chlorination

- Sludge buildup in contact chamber
- Gas bubbles
- Inadequate retention time
- Floating scum and/or solids
- Evidence of short circuiting
- Inadequate ventilation of chlorine feeding room and storage area
- High temperatures in chlorination rooms
- Improper operation of automatic feed or feedback control
- Excessive foaming downstream
- Evidence of toxicity downstream (dead fish, other dead organisms)
- Improper chlorine feed, storage, and reserve supply
- Leak detection equipment is tied into the plant alarm system
- SCBAs available on-site
- Proper training in use of SCBA
- Lack emergency SOP and/or RMP (Risk Management Plan)
- No chlorine repair kit available.

Dechlorination

- Improper storage of sulfur dioxide cylinders
- Inadequate ventilation of sulfur dioxide feeding room
- Automatic sulfur dioxide feed or feedback control not operating properly
- Depressed DO after dechlorination

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- Improper storage and mixture of sodium metabisulfite containers
- Reduced efficiency of activated carbon dechlorination units because of organic and inorganic compound interference
- No SCBAs available on-site
- Improper training in use of SCBA
- No emergency SOP and/or RMP.

Ultraviolet (UV)

- Quartz sleeves not kept clean
- Bulbs are not all operational
- Effluent has high turbidity
- Fecal coliform tests show inadequate bacterial kill.

Sludge Handling

General Indicators

- The facility does not waste sludge
- Inadequate sludge removal from clarifiers or thickeners
- Poor dewatering characteristics of thermal treated sludge
- Thickened sludge too thin
- Fouling of overflow weirs on gravity thickeners
- Air flotation skimmer blade binding on beaching plate
- Substantial down time of sludge treatment units
- Sludge disposal inadequate to keep treatment system in balance - storing excess sludge inventory within other treatment units such as activated sludge basin, or clarifiers due to inadequate sludge wasting capabilities
- Mass balance inappropriate (ratio of sludge wasted should be 0.65-0.85 lbs of sludge per lb of Biochemical Oxygen Demand (BOD) removed)
- Sludge decant or return flows high in solids
- Odors
- Improper loading rates
- Lack of adequate process control (unit removal efficiencies, DO, sludge age, F/M ratio, etc.).

Sludge Anaerobic Digestion

- Inoperative mechanical or gas mixers
- Inoperative sludge heater or low temperature
- Floating cover of digester tilting
- Inadequate gas production
- Inoperative gas burner
- Supernatant exuding a sour odor from either primary or secondary digester
- Excessive suspended solids in supernatant
- Supernatant recycle overloading the Wastewater Treatment Plant (WWTP)
- pH problems.

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Sludge Aerobic Digestion

- Excessive foaming in tank
- Objectionable odor in aerobically digested sludge
- Insufficient dissolved oxygen in digester
- Digester overloaded
- Clogging of diffusers in digester
- Mechanical aerator failure in digester
- Inadequate supernatant removal from sludge lagoons
- Solids accumulation in tank.

Sludge Dewatering

Drying beds

- Poor sludge distribution on drying beds
- Vegetation in drying beds (unless reed design)
- Dry sludge remaining in drying beds (storage)
- Inadequate drying time on drying beds
- Some unused drying beds
- Dry sludge stacked around drying beds where runoff may enter navigable waters
- Filtrate from sludge drying beds returned to front of plant
- Inadequate sludge wasting capabilities as indicated by all beds being full, and maintaining a high solids inventory within the treatment units.

Centrifuge

- Excessive solids in fluid phase of sample after centrifugation
- Inadequate dryness of centrifugal sludge cake
- Excessive vibration or other mechanical problems.

Filter Press

- High level of solids in filtrate from filter presses or vacuum filters
- Thin filter cake caused by poor dewatering
- Vacuum filter cloth binding
- Low vacuum on filter
- Improperly cleaned vacuum filter media
- Sludge buildup on belts and/or rollers of filter press
- Excessive moisture in belt filter press sludge cake
- Difficult cake discharge from filter presses
- Filter cake sticks to solids-conveying equipment of filter press
- Frequent media binding of plate filter press
- Sludge blowing out of filter press
- Insufficient run time of sludge dewatering equipment.

Sludge Stabilization

Lagoon

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- Objectionable odor from sludge lagoon
- Damage to dikes around sludge drying lagoons
- Unlined sludge lagoons
- Sludge lagoons full, overflowing sludge back to plant or to natural drainage
- Deep rooted vegetation on dikes or berms.

Composting

- Piles that give off foul odor
- Inoperable blower
- Temperature does not reach 122-140°F (50-60°C)
- Uncontrolled storm water runoff.

Heat Drying/Pelletizing

- Excess moisture in sludge feed
- Insufficient air flow or drying temperature achieved
- Inadequate drying of final product (excess moisture in final product)
- Excess odors associated with treatment area
- Excess odors associated with treated product.

Alkaline Stabilization

- Insufficient amount of lime (or other alkaline additive) used to ensure pH is raised sufficiently
- Inadequate mixing provided to ensure good contact of lime (or other alkaline additive) with sludge solids
- pH problems
- Excess odors associated with treatment area
- Excess odors associated with treated product
- Excessive lime dust around treatment equipment.

Incineration

- Objectionable odors associated with treatment area
- Evidence of excessive dust (ash) around unit
- Visible smoke or dust exhaust from unit
- Lack of compliance with air permit parameters
- Spilling or leaking sludge from dewatered sludge transfer equipment.

Sludge Disposal

- Sludge constituents not analyzed before disposal
- Sludge not transported in appropriate and approved vehicle
- Surface runoff of sludge at land application site
- Liquid sludge (i.e., less than 10 percent solids) applied to landfill site
- Sludge fails paint filter test
- Inadequate coverage of sludge in subsurface plow injection system
- Objectionable odors generated at land application site

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- Slow drying of soil-sludge mixture in subsurface injection system
- Sludge pooling at land application sites
- Flies breeding, vectors, and/or odors at landfill site
- Inadequate burial of sludge at landfill site
- Excessive erosion at sludge sites
- Sludge disposed of in nonpermitted sites
- Disposal not in accordance with Federal, State, or local regulations
- Sludge lagoons full and overflowing
- Inadequate runoff control at landfill or land application sites.

Polishing Ponds or Tanks

- Objectionable odor, excessive foam, floating solids, or oil sheens in polishing ponds or tanks
- Solids or scum accumulations in tank or at side of pond
- Evidence of bypassed polishing ponds or tanks.

Plant Effluent

- Excessive suspended solids, turbidity, foam, grease, scum, color, and other macroscopic particulate matter present
- Potential toxicity (dead fish, dead plants at discharge)
- Stained sediments in receiving waters
- Sludge in the receiving water, anaerobic sediments, and blood worms
- Low dissolved oxygen content
- Eutrophication.

Flow Measurement

- Improper placement of flow measurement device
- Flow totalizer not calibrated
- Buildup of solids in flume or weir
- Broken or cracked flume or weir
- Improperly functioning magnetic flowmeter
- Clogged or broken stilling wells
- Weir plate edge corroded or damaged, not sharp edged (< 1/8"), or not level
- System not capable of measuring maximum flow
- Sizing of system adequate to handle flow range
- Flow measurement error greater than ± 10%
- Flow measurement that includes all wastewater discharged and does not include wastestreams that are recirculated back to the treatment plant.

Chemical Treatment Units

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- Evident heavy corrosion
- No portion-measuring device at feed unit
- pH measuring not evident at pH adjustment tank
- Chemicals left open when they should be closed
- Chemicals outdated
- Chemical containers stored improperly or hazardously
- Inappropriately stored, moved, or handled chemical tank cars (trucks or train)
- Spilled dry chemicals on floor between storage area and feed units
- Improperly disposed of empty chemical containers
- Large containers handled improperly, container transfer equipment not maintained
- No appropriate sized berms or dikes at liquid chemical feed units
- Inadequate supply of chemicals
- Chemical dust covering feed unit area or storage and transfer areas
- Use of an inappropriate coagulant
- Improperly stored or handled glass carboys (acid storage).

Standby Power and Alarms

- Emergency generator with no automatic switch-over
- Generator not regularly checked and exercised
- No separate electrical substation feed line
- Portable generators with quick connects
- Portion of plant operated by the standby power
- Treatment units and headworks equipped with alarms to notify operations staff of unit failure or loss of power
- SCADA (Supervisory Control and Data Available)
  - Only large facilities tend to have this equipment
  - SCADA to monitor and operate lift station in the collection system.

General Housekeeping

- Facility control panel in disrepair or not in use
- Wastewater pipelines not clearly distinguished from product pipelines
- Spills or leaks in dry areas not remediated in a timely manner.

Production Changes

Industries frequently make production changes because of advances in technology and availability of new products. Therefore, during the tour of an industrial facility, the inspector also should inquire about the following:

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- Whether a permittee has last made any changes to:
  - Production processes
  - Raw materials
  - Amount of intermediate and/or finished product
  - Water use
  - Water reuse or recycling
  - Waste treatment processes
  - Other such changes
- Whether the permittee has modified any production process that would change the pollutant types or loadings
- Whether the regulatory agency (EPA, State, or local municipality as appropriate) was notified of such changes
- What changes will need to be reflected in any National Pollutant Discharge Elimination System (NPDES) or local permit modifications.

The inspector should verify any changes and include the results of the findings and other pertinent information in the Compliance Inspection Report. Changes in the loading to Publicly Owned Treatment Works (POTWs) by the addition of a significant industrial discharger or large population growth also should be ascertained and reported.

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4. C. Operation and Maintenance Evaluation

Operation Evaluation

Operating factors affecting plant performance range from qualitative factors such as the skills and aptitudes of operators (e.g., process knowledge and general aptitude), to physical deficiencies in laboratory equipment or a lack of flexibility in process equipment. The evaluation of operation functions must focus on wastewater treatment, sludge treatment/ disposal, and laboratory analysis. The evaluation should be based on the following topics:

- Policies and procedures
- Organization
- Staffing and training
- Planning
- Management controls.

Table 4-1 presents the basic review questions that an inspector should ask in evaluating operation functions. Although each of the preceding evaluation topics must be covered in the review of operation functions, the four areas discussed in the following paragraphs should particularly concern the inspector:

Policies and Procedures

Written operating procedures and standard reference texts enable the operator to achieve efficient plant operation. The operations manual prepared for the facility is the most important reference that an inspector should review when evaluating plant policies and procedures. Other reference materials relating to operations that should be available to the operator include manufacturers' literature, publications by professional organizations (e.g., the Water Environment Federation), and EPA publications.

Staffing and Training

Even the best engineered facility cannot perform to its potential without a sufficient number of capable and qualified staff. The inspector must consider the abilities and limitations of the operating staff. Most States have some type of certification program for operators. The inspector may inquire about how many of the staff have been trained and to what degree staff are certified. Staff interviews may include the individual in charge of the overall operation, the chief operator, specific unit process operators, and laboratory staff. The inspector should ascertain the hours the facility is manned and unmanned. If the facility is regularly unmanned, the inspector should inquire about unit alarms, in the event of equipment failure or loss of power, alarm telemerty or autodialers, facility response procedures and whether there have been any unit bypasses as a result of the plant being unmanned.

A010600

Table 4-1

Operation and Maintenance Function Evaluation Questions

Policies and Procedures

- Is there a formal or informal set of policies for facility operations?
- Do policies address:
  - Compliance with permit?
  - Maintaining process controls?
  - Quality control?
  - Preventive maintenance?
- Is there a set of standard procedures to implement these policies?
- Are the procedures written or informal?
- Do the procedures consider the following areas?

  - Safety
  - Emergency
  - Laboratory
  - Process control
  - Operating procedures
  - Monitoring
  - Labor relations
  - Energy conservation
  - Treatment chemical supply
  - Collection system
  - Pumping stations
  - Treatment process
  - Sludge disposal
  - Equipment record system
  - Maintenance planning and scheduling
  - Work orders
  - Inventory management

- Are the procedures followed?

Organization

- Is there an Organizational Plan (or Chart) for operations?
- Does the Plan include:
  - Delegation of responsibility and authority
  - Job descriptions
  - Interaction with other functions (such as maintenance)?
- Is the Plan formal or informal?
- Does staff have access to and understand the Plan?
- Does the facility follow the Plan?
- Is the Plan consistent with policies and procedures?
- Is the Plan flexible? Can it handle emergency situations?

A010601

Table 4-1

Operations and Maintenance Function Evaluation Questions (Continued)

- Does the Plan clearly define lines of authority and responsibility in the following subfunctional areas?

  - Laboratory
  - Process control
  - Instruments
  - Sludge disposal
  - Collection system
  - Pumping stations
  - Monitoring practices
  - Mechanical
  - Electrical
  - Buildings and grounds
  - Automotive
  - Supplies and spare parts

Staffing

- Is there an adequate number of staff to achieve policies and procedures?
- Are staff members adequately qualified for their duties and responsibilities by demonstrating the following:

  - Certification
  - Qualifications
  - Ability
  - Job performance
  - Understanding of treatment processes

- Is staff used effectively to support plant activities?
- Has the potential for borrowing personnel been considered?
- Are training procedures followed for:

  - Orientation of new staff?
  - Training new operators?
  - Training new supervisors?
  - Continuing training of existing staff?
  - Cross training staff between plant jobs needing more staff/support?

- Which of the following training procedures are used?

  - Formal classroom
  - Home study
  - On-the-job training
  - Participation in professional organization

A010602

Table 4-1

Operations and Maintenance Function Evaluation Questions (Continued)

- Does the training program provide specific instruction for the following operations and maintenance activities?

  - Safety
  - Laboratory procedures
  - Treatment processes
  - Instrumentation
  - Equipment troubleshooting
  - Handling personnel problems
  - Monitoring practices
  - Emergency procedures
  - Mechanical
  - Electrical
  - Automotive
  - Building maintenance
  - Inventory control

- Does management encourage staff motivation?
- Does management support its first-line supervisors?
- Is staff motivation maintained through any of the following tools?

  - Encouragement for training
  - Job recognition
  - Promotional opportunities
  - Salary incentives
  - Job security
  - Working environment

Operations

- How does the facility establish operating schedules?
- Do schedules attempt to attain optimum staff utilization?
- Are line supervisors included in manpower scheduling?
- Are staff involved in and/or informed of manpower planning?
- Is there sufficient long-term planning for staff replacement and system changes?
- Are there procedures in manpower staffing for emergency situations?
- How are process control changes initiated?
- How do process control changes interact with management controls?
- How are laboratory results used in process control?
- Are there emergency plans for treatment control?
- Is there an effective energy management plan? Is the plan used?
- To what extent are operations personnel involved in the budget process?

A010603

Table 4-1

Operations and Maintenance Function Evaluation Questions (Continued)

- Do budgets adequately identify and justify the cost components of operations?
- Are future budgets based on current and anticipated operating conditions?
- Do operating and capital budget limits constrain operations?
- Can budget line items be adjusted to reflect actual operating conditions?

Maintenance

- Are maintenance activities planned? Is the planning formal or informal?
- Does the facility have sufficient management controls to affect realistic planning and scheduling? If the controls exist, are they used?
- Are operating variables exploited to simplify maintenance efforts?
- To what extent are the supply and spare part inventories planned in conjunction with maintenance activities?
- Have minimum and maximum levels been established for all inventory items?
- Does the facility have a maintenance emergency plan?
- Is the maintenance emergency plan current? Is the staff knowledgeable about emergency procedures?
- Does a plan exist for returning to the preventive maintenance mode following an emergency?
- Are preventive maintenance tasks scheduled in accordance with manufacturers' recommendations?
- Is adequate time allowed for corrective maintenance?
- Are basic maintenance practices (preventive and corrective) and frequencies reviewed for cost-effectiveness?
- Do the management controls provide sufficient information for accurate budget preparation?
- Does the maintenance department receive feedback on cost performance to facilitate future budget preparation?
- To what extent are maintenance personnel involved in the budget process?

A010604

Table 4-1

Operations and Maintenance Function Evaluation Questions (Continued)

- Do budgets adequately identify and justify the cost components of maintenance?
- Are future budgets based on current and anticipated operating and maintenance conditions?
- Do maintenance and capital budget limits constrain preventive maintenance (equipment replacement and improvements)?
- Does the maintenance department receive adequate feedback on cost performance?
- Can budget line items be adjusted to reflect actual maintenance conditions?

Management Controls

- Are current versions of the following documents maintained?

  - Operating reports
  - Work schedules
  - Activity reports
  - Performance reports (labor, supplies, energy)
  - Expenditure reports (labor, supplies, energy)
  - Cost analysis reports
  - Emergency and complaint calls
  - Process control data, including effluent quality

- Do the reports contain sufficient information to support their intended purpose?
- Are the reports usable and accepted by the staff?
- Are the reports being completed as required?
- Are the reports consistent among themselves?
- Are the reports used directly in process control?
- Are the reports reviewed and discussed with operating staff?
- What type of summary reports are required?
- To whom are reports distributed and when?

A010605

Table 4-1

Operations and Maintenance Function Evaluation Questions (Continued)

Management Controls (Maintenance)

- Does a maintenance record system exist? Does it include the following?

  - As-built drawings
  - Shop drawings
  - Construction specifications
  - Capital and equipment inventory
  - Maintenance history (preventive and corrective)
  - Maintenance costs
  - Equipment manuals

- Does the facility keep a current base record system kept current as part of daily maintenance practices?

- Does the facility have a work order system for scheduling maintenance? Is it explicit or implicit?

- Which of the following do work orders contain?

  - Date

  - Location

  - Work requirements

  - Assigned personnel

  - Work order number

  - Nature of problem

  - Time requirements

  - Space for reporting work performed, required parts and supplies, time required, and cost summary

  - Responsible staff member and supervisory signature requirements

- When emergency work must be performed without a work order, is one completed afterward?

- Are work orders usable and acceptable by staff as essential to the maintenance program? Are they actually completed?

- Is work order information transferred to a maintenance record system?

- Does a catalog or index system exist for controlling items in inventory?

- Are withdrawal tickets used for obtaining supplies from inventory?

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Table 4-1

Operations and Maintenance Function Evaluation Questions (Continued)

- Do the tickets contain cost information and interact well with inventory controls and the work order system?
- Is the cost and activity information from work orders aggregated to provide management reports? Is this information also used for budget preparation?
- Is the maintenance performance discussed regularly with staff?
- How is the cost of contract maintenance or the use of specialized assistance recorded?
- Are safeguards and penalties adequate to prevent maintenance cards from being returned without the work being done?
- Is the preventive maintenance record checked after an emergency equipment failure?

Health and Safety

At all times, the facility should follow safe operating procedures. Employees must be trained in emergency shut-down, fire control, and spill response procedures, as well as in the use of safety equipment, safe sampling techniques, and safe handling of chemicals and wastes. Employees should not enter confined spaces unless properly trained and equipped. Managers must be aware of the Occupational Safety and Health Administration (OSHA) Right-to-Know laws regarding potentially dangerous chemicals in the workplace. This law specifically requires a written hazard communication program, labeling of chemicals, and the availability of material safety data sheets to employees upon request.

Management Controls

Monitoring practices are a good indicator of both the emphasis placed on operations and the operator's understanding of process controls. Factors affecting a facility's monitoring capabilities are:

- The sampling program
- Performance testing
- Analytical capabilities
- Recordkeeping practices.

An effective process control program is essential to a treatment facility's optimal performance. However, process control cannot be easily quantified by the inspector. In most cases, the inspector must rely on discussions with the plant superintendent and/or operators to supplement available records and the technical evaluation. The key considerations for effective process controls are:

- Process control data
- Process knowledge of the operators
- The basis for the control practices
- Implementation of the control practices

A010607

- Past performance
- Operator emphasis on controls
- Recordkeeping.

Maintenance Evaluation

Facility maintenance directly affects the ability of the facility to run efficiently and to comply with its NPDES permit. The two types of facility maintenance are preventive maintenance and corrective maintenance:

- Preventive maintenance
  - Reduces facility operating costs by eliminating breakdowns and the need for corrective maintenance
  - Improves the facility's reliability by minimizing the time equipment is out of service
  - Increases the useful life of equipment, thus avoiding costly premature replacement
  - Avoids possible compliance violations.
- Corrective maintenance
  - Returns malfunctioning equipment to operation
  - Avoids or minimizes possible violations.

Evaluation of the maintenance function must focus on the ability to maintain process equipment, supply of treatment chemicals, vehicles, and building and grounds. Although each of the five evaluation topics (policies and procedures, organization, staffing, planning, and management controls) must be covered for each facility inspected, the principal areas of concern in the operations evaluation are the same in the maintenance function:

- Staffing and training
- Planning and scheduling
- Management control—records systems and inventory control.

Only well-trained, competent plant staff can be expected to perform adequate physical inspections, repairs, and preventive maintenance. Wastewater facility maintenance is complex and requires a variety of skills. An ongoing training program is essential because many of these skills are not readily available.

Maintenance planning and scheduling are essential to effective corrective and preventive maintenance. The maintenance supervisor must prepare work schedules listing job priorities, work assignments, available personnel, and timing.

A detailed records system is the basis of any maintenance program. Records are used to establish maintenance histories on equipment, diagnose problems, and anticipate—and thereby avoid—equipment failure, making records an effective tool for preventive maintenance.

A central inventory of spare parts, equipment, and supplies must be maintained and controlled. The basis for the inventory should be the equipment manufacturer's recommendations, supplemented by specific, historical experience with maintenance problems and requirements. Inventoried supplies must be kept at levels sufficient to avoid process interruptions.

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A maintenance cost control system should be an integral part of every wastewater facility. Budgets must be developed from past cost records and usually are categorized according to preventive maintenance, corrective maintenance, and projected and actual major repair requirements. Annual costs must be compared to the budget periodically to control maintenance expenditures. Evaluating costs this way serves to control expenditures and provides a baseline for future budgets.

The basic concerns that need to be addressed and evaluated during the inspector's maintenance program review are presented in Table 4-1. These questions may help identify the causes of a facility's operation and maintenance problems.

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4. D. References and Facility Site Review Checklist

References

U.S. Environmental Protection Agency. 1973. *Maintenance Management Systems for Municipal Wastewater Facilities.* EPA 430/9-74-004.

U.S. Environmental Protection Agency. 1978. *Field Manual for Performance Evaluation and Troubleshooting at Municipal Wastewater Treatment Facilities.* MO No. 16, EPA 430/9-78-001.

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Water Environment Federation (WEF). 1992. *Wastewater Treatment Plant Design.* MOP No. 8, WEF, 1992.

Water Pollution Control Federation (WPCF). 1990. *Operation of Wastewater Treatment Plants.* MOP No. 11, WPCF, 1990.

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FACILITY SITE REVIEW CHECKLIST

A. OPERATION AND MAINTENANCE EVALUATION

Yes No N/A	1. Facility properly operates and maintains treatment units
Yes No N/A	2. Facility has standby power or other equivalent provision.
Yes No N/A	3. Adequate alarm system for power or equipment failures is available.
	4. Sludge disposal procedures are appropriate:
Yes No N/A	a. Disposal of sludge according to regulations
Yes No N/A	b. State approval for sludge disposal received.
Yes No N/A	5. All treatment units, other than backup units, are in service.
Yes No N/A	6. Facility follows procedures for facility operation and maintenance.
Yes No N/A	7. Sufficient sludge is disposed of to maintain treatment process equilibrium.
Yes No N/A	8. Organizational Plan (chart) for operation and maintenance is provided.
Yes No N/A	9. Plan establishes operating schedules.
Yes No N/A	10. Facility has written emergency plan for treatment control.
	11. Maintenance record system exists and includes:
Yes No N/A	a. As-built drawings
Yes No N/A	b. Shop drawings
Yes No N/A	c. Construction specifications
Yes No N/A	d. Maintenance history
Yes No N/A	e. Maintenance costs
Yes No N/A	f. Repair history
Yes No N/A	g. Records of equipment repair and timely return to service.
Yes No N/A	12. Adequate number of qualified operators on-hand.
Yes No N/A	13. Facility has established procedures for training new operators.
Yes No N/A	14. Facility maintains adequate spare parts and supplies inventory.
Yes No N/A	15. Facility keeps instruction files for operation and maintenance of each item of major equipment.
Yes No N/A	16. Operation and maintenance manual is available.
Yes No N/A	17. Regulatory agency is notified of any bypassing. (Dates _____)
Yes No N/A	18. a. Hydraulic overflows and/or organic overloads are experienced.
Yes No N/A	b. Untreated bypass discharge occurs during power failure.
Yes No N/A	c. Untreated overflows occurred since last inspection. Reason: _____
Yes No N/A	d. Flows were observed in overflow or bypass channels.
Yes No N/A	e. Checking for overflows is performed routinely.
Yes No N/A	f. Overflows are reported to EPA or to the appropriate State agency as specified in the permit.

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FACILITY SITE REVIEW CHECKLIST
(Continued)

B. SAFETY EVALUATION

Yes	No	N/A	1.	Facility uses undiked/unbermed oil/chemical storage tanks.
Yes	No	N/A	2.	Facility maintains up-to-date equipment repair records.
Yes	No	N/A	3.	Dated tags show out-of-service equipment a. Proper facility/unit lock-out and tag-out procedures are being followed.
Yes	No	N/A	4.	Facility schedules/performs routine and preventive maintenance on time.
Yes	No	N/A	5.	Facility provides personal protective clothing (safety helmets, ear protectors, goggles, gloves, rubber boots with steel toes, eye washes in labs).
			6.	Safety devices are readily available:
Yes	No	N/A		a. Fire extinguishers
Yes	No	N/A		b. Oxygen deficiency/explosive gas indicator
Yes	No	N/A		c. Self-contained breathing apparatus near entrance to chlorine room
Yes	No	N/A		d. Safety harness
Yes	No	N/A		e. First aid kits
Yes	No	N/A		f. Ladders to enter manholes or wetwells (fiberglass or wooden for electrical work)
Yes	No	N/A		g. Traffic control cones
Yes	No	N/A		h. Safety buoy at activated sludge plants
Yes	No	N/A		i. Life preservers for lagoons
Yes	No	N/A		j. Fiberglass or wooden ladder for electrical work
Yes	No	N/A		k. Portable crane/hoist.
Yes	No	N/A	7.	Plant has general safety structures such as rails around or covers over tanks, pits, or wells.
Yes	No	N/A	8.	Emergency phone numbers are listed, including EPA and State.
Yes	No	N/A	9.	Plant is generally clean, free from open trash areas.
Yes	No	N/A	10.	Facility has available portable hoists, for equipment removal.
Yes	No	N/A	11.	All plant personnel are immunized for typhoid, tetanus, and hepatitis B.
Yes	No	N/A	12.	No cross connections exist between a potable water supply and nonpotable source.
Yes	No	N/A	13.	Gas/explosion controls such as pressure-vacuum relief values, no smoking signs, explosimeters, and drip traps are present near anaerobic digesters, enclosed screening or degritting chambers, and sludge-piping or gas-piping structures.
Yes	No	N/A	14.	Facility has enclosed and identified all electrical circuitry.

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FACILITY SITE REVIEW CHECKLIST
(Continued)

B. SAFETY EVALUATION (Continued)

Yes	No	N/A	15. Personnel are trained in electrical work to be performed as well as safety procedures.
			16. Chlorine safety precautions are followed:
Yes	No	N/A	a. NIOSH-approved 30-minute air pack
Yes	No	N/A	b. All standing chlorine cylinders chained in place
Yes	No	N/A	c. All personnel trained in the use of chlorine
Yes	No	N/A	d. Chlorine repair kit available
Yes	No	N/A	e. Chlorine leak detector tied into plant alarm system
Yes	No	N/A	f. Chlorine cylinders stored in adequately ventilated areas?
Yes	No	N/A	g. Ventilation fan with an outside switch
Yes	No	N/A	h. Posted safety precautions
Yes	No	N/A	i. Existing emergency SOP and/or RMP or SPCC?
Yes	No	N/A	17. Facility has complied with the six employer responsibilities for the Worker Right-to-Know Law (P.A. 83-240)
Yes	No	N/A	18. Emergency Action Plan on file with local fire department and appropriate emergency agency.
Yes	No	N/A	19. Laboratory safety devices (eyewash and shower, fume hood, proper labeling and storage, pipette suction bulbs) available.
Yes	No	N/A	20. Facility post warning signs (no smoking, high voltage, non potable water, chlorine hazard, watch-your-step, and exit).

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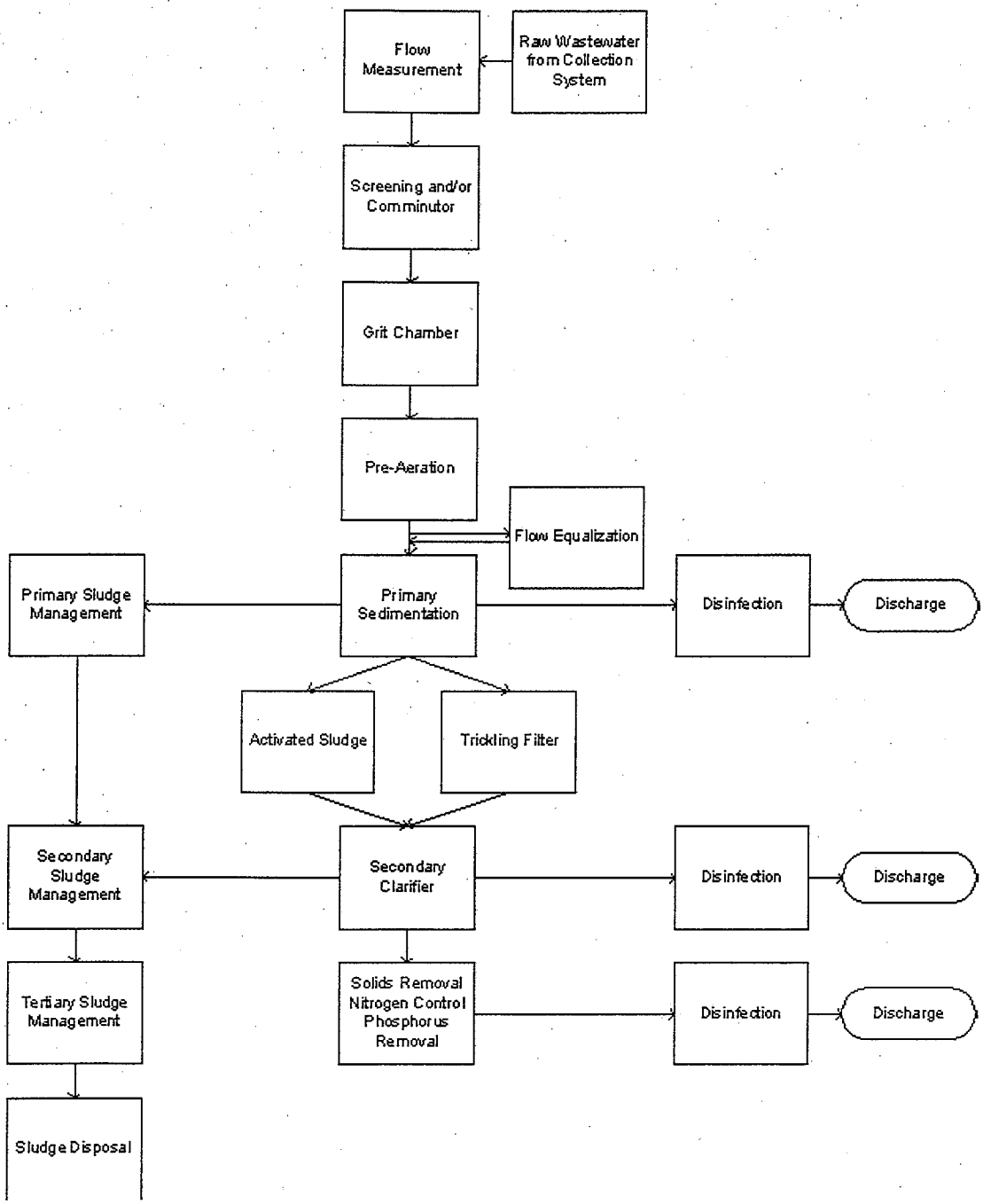
Figure 4-1

General Wastewater Treatment Flow Diagram



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5. SAMPLING

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Related Websites

Agency-wide Quality System Documents: http://www.epa.gov/quality/qa_docs.html

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5. A. Evaluation of Permittee Sampling Program and Compliance Sampling

Wastewater sampling/analysis is an integral part of the National Pollutant Discharge Elimination System (NPDES) Compliance Monitoring Program. NPDES permits contain specific and legally enforceable effluent limitations and monitoring requirements.

Objectives and Requirements

When evaluating the permittee sampling program, the inspector should:

- Verify that the permittee's sampling program complies with the permit
- Verify that the permittee's sampling program complies with:
  - 40 *Code of Federal Regulations (CFR)* 136.1 to 136.5 and Appendices A, B, and C (Guidelines for Establishing Test Procedures for the Analysis of Pollutants) for wastewater samples and
  - 40 *CFR* Part 503 which requires that for biosolids samples, metal analyses be done in accordance with SW-846 methods (in Test Methods for Evaluating Solid Waste Physical/Chemical Methods) and Standard Methods for the Examination of Water and Wastewater.
- Document violations to support enforcement action.

In addition, specific objectives of the sampling conducted by inspectors include the following:

- Verify compliance with effluent limitations
- Verify accuracy of reports and program self-monitoring
- Support enforcement action
- Support permit development reissuance and/or revision
- Determine the quantity and quality of effluent.

Sampling, analysis, preservation technique, sample holding time, and sample container requirements are provided under 40 *CFR* Part 136 as authorized by Section 304(h) of the Clean Water Act (CWA). Chapter Seven contains more information on required analytical procedures "Laboratory Analyses Techniques Evaluation." See the checklist for use in evaluating the permittee's sampling program at the end of this chapter.

For all NPDES permittees the inspector should include a review of sampling procedures and quality control measures the facility uses to ensure the integrity of sample data.

To evaluate sampling procedures, assess the following seven areas:

- Sample collection techniques

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- Field measurements
- Sample labeling (including location(s)) and documentation
- Sample preservation and holding time
- Transfer of custody and shipment of samples
- Quality control
- Data handling and reporting.

Significant Industrial User Monitoring Program

It is the responsibility of the permitted Publicly Owned Treatment Works (POTW) with a pretreatment program to oversee sampling procedures of industrial users and to conduct compliance monitoring of its own. Therefore, during a Pretreatment Compliance Inspection (PCI) or audit, the inspector may also need to evaluate POTW sampling procedures for significant industrial users who discharge to the POTW in addition to evaluating the sampling procedures of any permitted POTW. According to the General Pretreatment Regulations, 40 *CFR* 403.12(o), industrial users and POTWs subject to 40 *CFR* 403.12 reporting requirements must maintain the following monitoring records:

- Date, exact place, method and time of sampling, and name of sampler
- Date of analysis
- Name of analyst
- Analytical techniques/methods used
- Analytical results.

During a PCI or an audit, the inspector evaluates the POTW industrial user monitoring program with respect to the criteria specified in the POTW pretreatment program. Elements of the sampling scheme will include the seven areas addressed above and any other areas specifically addressed in the particular pretreatment program. Chapter Nine, "Pretreatment," discusses the focus of this evaluation in greater detail.

Biosolids Monitoring Program

Chapter Ten discusses evaluation of a permittee's biosolids monitoring program. In addition, Appendix L lists approved analytical methods, sample containers, preservation techniques, and holding times for biosolids samples.

Toxicity Testing Program

Chapter Eight discusses evaluation of a permittee's whole effluent toxicity testing program. In addition, for methods manuals for Whole Effluent Toxicity testing go to http://www.epa.gov/owm, as well as http://www.epa.gov/waterscience/WET.

Storm Water Program

Chapter Eleven provides considerations for performing storm water sampling.

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5. B. Sampling Procedures and Techniques

Whether an inspector is evaluating a permittee's sampling program or conducting compliance sampling on the permittee's effluent, that inspector must be familiar with the procedures and techniques necessary for accurate sampling of wastewaters. The following discussion details the procedures for sample collection, preservation, transfer, quality control, and data handling.

Wastewater Sample Collection Techniques

Sample collection is an important part of the compliance monitoring program. Without proper sample collection procedures, the results of such monitoring programs are neither useful nor valid, even with the most precise and accurate analytical measurements.

Selection of Representative Sampling Sites

Normally, samples should be collected at the location specified in the permit. In some instances, the sampling location specified in the permit or the location chosen by the permittee may not be adequate for the collection of a representative sample. In that case, the inspector should determine the most representative sampling point available and collect a sample at both locations. If the facility disagrees the reason for the conflict must be documented for later resolution by the permitting authority.

Influent Samples. Document and take these samples at points of high turbulence flow to ensure good mixing. In some instances, the most desirable location may not be accessible. Ensure sampling equipment sampling points are above plant return lines, and sampling equipment should be placed so that it does not interfere with flow measuring devices. The preferred sampling points for raw wastewater are:

- Waste flowing from last process in a manufacturing operation
- Pump wet well (if turbulent)
- Upstream collection lines, tank, or distribution box following pumping from the wet well or sump
- Flume throat
- Aerated grit chamber
- Upstream siphon following the comminutor (in absence of grit chamber).

If it is not possible to sample at a preferred point, choose an alternative location and document the basis for choosing that location.

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Effluent Samples. Collect these samples at the site the permit specifies or, if the permit does not specify a site then the inspector should select the most representative site after final treatment and downstream from all entering wastestreams before they enter the receiving waters. Occasionally, municipal plant permits may specify sampling prior to chlorination. For these plants, monitor all parameters at the upstream location except fecal coliforms, pH, and total residual chlorine. Collect wastewater for use in bioassays at the location specified in the facility's NPDES permit.

Collect samples either manually (grab or composite) or with automatic samplers (continuous or composite). The following general guidelines apply when taking samples:

- Take samples at a site specified in the NPDES permit and/or at a site selected to yield a representative sample.
- Use a sampling method (grab, composite, continuous) as required in the permit. Some parameters that are not to be collected by automatic samplers, but must be hand collected are dissolved oxygen, total residual chlorine, oil and grease, coliforms, purgeable organics, sulfides, cyanide, and total phenols.
- Avoid collecting large nonhomogeneous particles and objects.
- Collect the sample facing upstream to avoid contamination.
- Do not rinse sample container with sample when collecting oil and grease and microbiological samples, but fill it directly to within 2.5 to 5 cm from the top.
- Fill the container completely if the sample is to be analyzed for purgeable organics, oxygen, ammonia, hydrogen sulfide, free chlorine, pH, hardness, sulfite, ammonium, ferrous iron, acidity, or alkalinity.
- Collect sufficient volume to allow for quality assurance testing. (Table 5-1 provides a guide to numerous sample volumes, but additional volumes may be necessary for quality assurance testing.)

The following general guidelines apply when using automatic samplers:

- Collect samples where the wastewater is well mixed. Collect the sample near the center of the flow channel at 0.4 to 0.6 depth (mid-depth).
- Obtain a sufficient volume of sample to perform all required analyses plus any additional amount for quality control. Individual portions of a composite sample should be at least 100 milliliters in order to minimize sampler solids bias.
- For automatic samplers which use a peristaltic pump, obtain adequate flow rates in the sampler tubing to effectively transport the suspended solids. To avoid solids bias, the velocity of the wastewater in sample tubing should be at least 2 fps and the tubing diameter should be at least 0.25 inch.
- Time of sample collection begins when the last aliquot is dispensed into the composite sample container.

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Table 5-1

Volume of Sample Required for Determination of the Various Constituents of Industrial Wastewater (Associated Water and Air Resource Engineers, Inc. 1973 *Handbook for Monitoring Industrial Wastewater.* USEPA Technology Transfer.)

Tests	Volume of Sample, (1) ml
PHYSICAL	
Color and Odor(2)	100 to 500
Corrosivity(2)	Flowing sample
Electrical conductivity(2)	100
pH, electrometric(2)	100
Radioactivity	100 to 1,000
Specific gravity(2)	100
Temperature(2)	Flowing sample
Toxicity(2)	1,000 to 20,000
Turbidity(2)	100 to 1,000
CHEMICAL	
Dissolved Gases:	
Ammonia,(3) NH(3)	500
Carbon dioxide,(3) free $C0_2$	200
Chlorine,(3) free Cl_2	200
Hydrogen,(3) H_2	1,000
Hydrogen sulfide,(3) H_2S	500
Oxygen,(3) O_2	500 to 1,000
Sulfur dioxide,(3) free SO_2	100
Miscellaneous:	
Acidity and alkalinity	100
Bacteria, iron	500
Bacteria, sulfate-reducing	100
Biochemical oxygen demand (BOD)	100 to 500
Carbon dioxide, total $C0_2$ (including $C0_3^{--}$, $HC0_3^-$, and free)	200
Chemical oxygen demand (dichromate)	50 to 100
Chlorine requirement	2,000 to 4,000
Chlorine, total residual Cl_2 (including OCl^-, HOCl, NH_2Cl, $NHCl_2$, and free)	200
Chloroform-extractable matter	1,000
Detergents	100 to 200
Hardness	50 to 100
Hydrazine	50 to 100
Microorganisms	100 to 200
Volatile and filming amines	500 to 1,000
Oily matter	3,000 to 5,000
Organic nitrogen	500 to 1,000
Phenolic compounds	800 to 4,000
pH, colorimetric	10 to 20
Polyphosphates	100 to 200
Silica	50 to 1,000
Solids, dissolved	100 to 20,000
Solids, suspended	50 to 1,000
Tannin and lignin	100 to 200

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Table 5-1

Volume of Sample Required for Determination of the Various Constituents of Industrial Wastewater (Continued)

Tests	Volume of Sample, (1) ml
Cations:	
Aluminum, Al^{+++}	100 to 1,000
Ammonium,(3) $NH4^{+}$	500
Antimony, Sb^{+++} to Sb^{+++++}	100 to 1,000
Arsenic, As^{+++} to As^{+++++}	100 to 1,000
Barium, Ba^{++}	100 to 1,000
Cadmium, Cd^{++}	100 to 1,000
Calcium, Ca^{++}	100 to 1,000
Chromium, Cr^{+++} to Cr^{++++++}	100 to 1,000
Copper, Cu^{++}	200 to 4,000
Iron,(3) Fe^{++} and Fe^{+++}	100 to 1,000
Lead, Pb^{++}	100 to 4,000
Magnesium, Mg^{++}	100 to 1,000
Manganese, Mn^{++} to Mn^{+++++}	100 to 1,000
Mercury, Hg^{+} and Hg^{++}	100 to 1,000
Potassium, K^{+}	100 to 1,000
Nickel, Ni^{++}	100 to 1,000
Silver, Ag^{+}	100 to 1,000
Sodium, Na^{+}	100 to 1,000
Strontium, Sr^{++}	100 to 1,000
Tin, Sn^{++} and Sn^{++++}	100 to 1,000
Zinc, Zn^{++}	100 to 1,000
Anions:	
Bicarbonate, HCO_3^{-}	100 to 200
Bromide, Br^{-}	100
Carbonate, CO_3^{--}	100 to 200
Chloride, Cl^{--}	25 to 100
Cyanide, CN^{-}	25 to 100
Fluoride, Fl^{-}	200
Hydroxide, OH^{-}	50 to 100
Iodide, I^{-}	100
Nitrate, NO_3^{-}	10 to 100
Nitrite, NO_2^{--}	50 to 100
Phosphate, ortho, PO_4^{--}, HPO_4^{--}, $H_2PO_4^{-}$	50 to 100
Sulfate, SO_4^{--}, HSO_4	100 to 1,000
Sulfide, S^{--}, HS^{-}	100 to 500
Sulfite, SO_3^{--}, HSO_3^{-}	50 to 100

(1) Consider volumes specified in this table as guides for the approximate quantity of sample necessary for a particular analysis. The exact quantity used should be consistent with the volume prescribed in the standard method of analysis, whenever a volume is specified.
(2) Use aliquots for other determinations.
(3) Obtain samples for unstable constituents in separate containers, preserved as prescribed; containers must be completely filled and sealed against air exposure.

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Sample Types

Two types of sample techniques are used: grab and composite. For many monitoring procedures, 40 *CFR* Part 136 does not specify sampling type. For these procedures, the NPDES permit writer determines the appropriate sample type and specifies them in the NPDES permit.

Grab Samples. Grab samples are individual samples collected over a period of time not exceeding 15 minutes and are representative of conditions at the time the sample is collected. The sample volume depends on the type and number of analyses to be performed. The collection of a grab sample is appropriate when a sample is needed to:

- Sample an effluent that does not discharge on a continuous basis
- Provide information about instantaneous concentrations of pollutants at a specific time
- Allow collection of a variable sample volume
- Corroborate composite samples
- Monitor parameters not amenable to compositing (e.g., pH, temperature, dissolved oxygen, chlorine, purgeable organics, oil and grease, coliform bacteria, and others specified by the NPDES permit, which may include phenols, sulfites, and hexavalent chromium). Volatile organics, sulfides, phenols, and phosphorus samples can be composited. If you composite use special handling procedures.

Composite Samples. Collect these samples over time, either by continuous sampling or by mixing discrete samples, and represent the average characteristics of the wastestream during the compositing period use. Composite samples are used when stipulated in a permit and when:

- Average pollutant concentration during the compositing period is determined
- Mass per unit time loadings is calculated
- Wastewater characteristics are highly variable.

Various methods for compositing samples are available, select one based on either time or flow proportioning. Table 5-2 lists the advantages and disadvantages of various methods. The permit may specify which type of composite sample to use. Collect composite samples either manually or with automatic samplers. Inspectors should consider variability in wastestream flow rate and parameter concentrations carefully when choosing compositing methods, sampling equipment (tubing and containers), and quality assurance procedures. The compositing methods are as follows:

- Time Composite Sample—This method requires discrete sample aliquots collected in one container at constant time intervals. This method is appropriate when the flow of the sampled stream is constant (flow rate does not vary more than ±10 percent of the average flow rate) or when flow monitoring equipment is not available.

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Table 5-2

Compositing Methods

Method	Advantages	Disadvantages	Comments
Time Composite			
Constant sample volume, constant time interval between samples	Minimal instrumentation and manual effort; requires no flow measurement	May lack representativeness, especially for highly variable flows	Widely used in both automatic samplers and manual handling
Flow-Proportional Composite			
Constant sample volume, time interval between samples proportional to stream flow	Minimal manual effort	Requires accurate flow measurement reading equipment; manual compositing from flowchart	Widely used in automatic as well as manual sampling
Constant time interval between samples, sample volume proportional to total stream flow at time of sampling	Minimal instrumentation	Manual compositing from flowchart in absence of prior information on the ratio of minimum to maximum flow; chance of collecting too small or too large individual discrete samples for a given composite volume	Used in automatic samplers and widely used as manual method
Constant time interval between samples, sample volume proportional to total stream flow since last sample	Minimal instrumentation	Manual compositing from flow chart in absence of prior information on the ratio of minimum to maximum flow; chance of collecting either too small or too large individual discrete samples for a given composite volume	Not widely used in automatic samplers but may be done manually
Sequential Composite			
Series of short period composites, constant time intervals between samples	Useful if fluctuations occur and time history is desired	Requires manual compositing of aliquots based on flow	Commonly used; however, manual compositing is labor intensive
Series of short period composites, aliquots taken at constant discharge increments	Useful if fluctuations occur and the time history is desired	Requires flow totalizer; requires manual compositing of aliquots based on flow	Manual compositing is labor intensive
Continuous Composite			
Constant sample volume	Minimal manual effort, requires no flow measurement highly variable flows	Requires large sample capacity; may lack representativeness for highly variable flows	Practical but not widely used
Sample volume proportional to stream flow	Minimal manual effort, most representative especially for highly variable sample volume, variable pumping capacity and power	Requires accurate flow measurement equipment, large sample volume, variable pumping capacity, and power	Not widely used

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- Flow-Proportional Composite Sample—There are two methods used for this type of sample. One method collects a constant sample volume at varying time intervals proportional to stream flow (e.g., 200 milliliters sample collected for every 5,000 gallons of flow). In the other method, collect the sample by increasing the volume of each aliquot as the flow increases, while maintaining a constant time interval between the aliquots.

- Sequential Composite Sample—This method requires discrete samples collected in individual containers at constant time intervals or discharge increments—for example, samples collected every 15 minutes, composited into separate containers each hour. The discrete samples can then be manually flow-proportioned to form the composite sample. Alternatively, take a constant sample volume at constant discharge increments, as measured with a totalizer.

- Continuous Composite Sample— Collect this sample continuously from the wastestream. The sample may be constant volume, or the volume may vary in proportion to the flow rate of the wastestream.

Sample Volume

The volume of samples collected depends on the type and number of analyses needed, as reflected in the parameters to be measured. Obtain the volume of the sample sufficient for all the required analyses plus an additional amount to provide for any split samples or repeat analyses. Table 5-1 provides a guide to sample volumes required for determining the constituents in wastewater. Consult the laboratory receiving the sample for any specific volume required. EPA's *Methods for Chemical Analysis of Water and Wastes* (USEPA 1979b) and *Handbook for Sampling and Sample Preservation of Water and Wastewater* (USEPA 1982), and the current Environmental Protection Agency (EPA)-approved edition of *Standard Methods for the Examination of Water and Wastewater* [American Public Health Association (APHA), American Water Works Association (AWWA), and Water Environment Federation (WEF)] contain specific recommended minimum sample volumes for different pollutant parameters.

Sample Containers

The 40 *CFR* Part 136 describes required sample containers, sample preservation, and sample holding time. Table 5-3 includes this material. It is essential that the sample containers be made of chemically resistant material unaffected by the concentrations of the pollutants measured. In addition, sample containers must have a closure that will protect the sample from contamination. Collect wastewater samples for chemical analysis in plastic (polyethylene) containers. Exceptions to this general rule are oil and grease samples, pesticides, phenols, polychlorinated biphenyls (PCBs), and other organic pollutant samples. Collect these in properly cleaned glass jars or bottles and sealed. Collect bacteriological samples in properly sterilized plastic or glass containers. Collect samples that contain constituents that will oxidize when exposed to sunlight (such as iron cyanide complexes) in dark containers.

Ensure sample containers are clean and uncontaminated. Check analytical procedures to determine if they specify container cleaning procedures. Use precleaned and sterilized disposable containers (e.g., polyethylene cubitainers). If these are not used or if the analytical method does not specify procedures, use the following procedures for cleaning sample containers:

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- Wash with hot water and detergent.
- Rinse with acid (e.g., nitric for metals).
- Rinse with tap water, then rinse three or more times with organic-free water.
- Rinse glass containers with an interference-free, redistilled solvent (such as acetone or methylene chloride for extractable organics).
- Dry in contaminant-free area.

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Table 5-3

Required Containers, Preservation Techniques, and Holding Times (Excerpt from 40 *CFR* Part 136, Table II)

Parameter	Container[1]	Preservative[2,3]	Maximum Holding Time[4]
BACTERIAL TESTS			
Coliform, fecal and total	P,G	Cool, 4°C 0.008% $Na_2S_2O_3$[5]	6 hours
Fecal streptococci	P,G	Cool, 4°C 0.008% $Na_2S_2O_3$[5]	6 hours
INORGANIC TESTS			
Acidity	P,G	Cool, 4°C	14 days
Alkalinity	P,G	Cool, 4°C	14 days
Ammonia	P,G	Cool, 4°C H_2SO_4 to pH<2	28 days
Biochemical oxygen demand	P,G	Cool, 4°C	48 hours
Biochemical oxygen demand, carbonaceous	P,G	Cool, 4°C	48 hours
Bromide	P,G	None required	28 days
Chemical oxygen demand	P,G	Cool, 4°C H_2SO_4 to pH<2	28 days
Chloride	P,G	None required	28 days
Chlorine, total residual	P,G	None required	Analyze immediately
Color	P,G	Cool, 4°C	48 hours
Cyanide, total and amenable to chlorination	P,G	Cool, 4°C NaOH to pH≥12 0.6 g ascorbic acid[5]	14 days[6]
Fluoride	P	None required	28 days
Hardness	P,G	HNO_3 to pH<2, H_2SO_4 to pH<2	6 months
Hydrogen ion (pH)	P,G	None required	Analyze immediately
Kjeldahl and organic nitrogen	P,G	Cool, 4°C H_2SO_4 to pH<2	28 days
METALS[7]			
Chromium VI	P,G	Cool, 4°C	24 hours
Mercury	P,G	HNO_3 to pH<2	28 days
Metals except above	P,G	HNO_3 to pH<2	6 months

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Table 5-3

Required Containers, Preservation Techniques, and Holding Times (Excerpt from 40 *CFR* Part 136, Table II) (Continued)

Parameter	Container[1]	Preservative[2,3]	Maximum Holding Time[4]
INORGANIC TESTS (Continued)			
Nitrate	P,G	Cool, 4°C	48 hours
Nitrate-nitrite	P,G	Cool, 4°C H_2SO_4 to pH<2	28 days
Nitrite	P,G	Cool, 4°C	48 hours
Oil and grease	G	Cool, 4°C HCl, H_2SO_4 to pH<2	28 days
Organic carbon	P,G	Cool, 4°C HCl, H_2SO_4 to pH<2	28 days
Orthophosphate phosphorus	P,G	Filter immediately Cool, 4°C	48 hours
Dissolved oxygen Probe Winkler	G bottle & top G bottle & top	None required Fix onsite and store in the dark	Analyze immediately 8 hours
Phenols	G	Cool, 4°C H_2SO_4 to pH<2	28 days
Phosphorus (elemental)	G	Cool, 4°C	48 hours
Phosphorus, total	P,G	Cool, 4°C H_2SO_4 to pH<2	28 days
Residue, total	P,G	Cool, 4°C	7 days
Residue, filterable	P,G	Cool, 4°C	7 days
Residue, nonfilterable (TSS)	P,G	Cool, 4°C	7 days
Residue, settleable	P,G	Cool, 4°C	48 hours
Residue, volatile	P,G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific conductance	P,G	Cool, 4°C	28 days

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Table 5-3

Required Containers, Preservation Techniques, and Holding Times (Excerpt from 40 *CFR* Part 136, Table II) (Continued)

Parameter	Container[1]	Preservative[2,3]	Maximum Holding Time[4]
INORGANIC TESTS (Continued)			
Sulfate	P,G	Cool, 4°C	28 days
Sulfide	P,G	Cool, 4°C, add zinc acetate plus sodium hydroxide to pH >9	7 days
Sulfite	P,G	None required	Analyze immediately
Surfactants	P,G	Cool, 4°C	48 hours
Temperature	P,G	None required	Analyze immediately
Turbidity	P,G	Cool, 4°C	48 hours
ORGANIC TESTS[8]			
Purgeable halocarbons	G, teflon-lined septum	Cool, 4°C 0.008% $Na_2S_2O_3$[5]	14 days
Purgeable aromatic hydrocarbons	G, teflon-lined septum	Cool, 4°C 0.008% $Na_2S_2O_3$[5] HCl to pH 2[9]	14 days
Acrolein and acrylonitrile	G, teflon-lined septum	Cool, 4°C 0.008% $Na_2S_2O_3$[5] Adjust pH to 4-5[10]	14 days
Phenols[11]	G, teflon-lined cap	Cool, 4°C 0.008% $Na_2S_2O_3$[5]	7 days until extraction 40 days after extraction
Benzidenes[11]	G, teflon-lined cap	Cool, 4°C 0.008% $Na_2S_2O_3$[5]	7 days until extraction[13]
Phthalate esters[11]	G, teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
Nitrosamines[11,14]	G, teflon-lined cap	Cool, 4°C 0.008% $Na_2S_2O_3$[5] Store in the dark	7 days until extraction; 40 days after extraction
Polychlorinated biphenyls (PCBs)[11]	G, teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
Nitroaromatics and isophorone[11]	G, teflon-lined cap	Cool, 4°C 0.008% $Na_2S_2O_3$[5] Store in the dark	7 days until extraction; 40 days after extraction

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Table 5-3

Required Containers, Preservation Techniques, and Holding Times (Excerpt from 40 *CFR* Part 136, Table II) (Continued)

Parameter	Container[1]	Preservative[2,3]	Maximum Holding Time[4]
ORGANIC TESTS[8] (Continued)			
Polynuclear aromatic hydrocarbons[11]	G, teflon-lined cap	Cool, 4°C 0.008% $Na_2S_2O_3$[5] Store in the dark	7 days until extraction; 40 days after extraction
Haloethers[11]	G, teflon-lined cap	Cool, 4°C 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction
Chlorinated hydrocarbons[11]	G, teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
2,3,7,8-tetrachlorodibenzo-p-dioxin[11]	G, teflon-lined cap	Cool, 4°C 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction
PESTICIDES TEST			
Organochlorine pesticides[11]	G, teflon-lined cap	Cool, 4°C pH 5-9[15]	7 days until extraction; 40 days after extraction
RADIOLOGICAL TEST			
Alpha, beta, and radium	P,G	HNO_3 to pH<2	6 months
WHOLE EFFLUENT TOXICITY TESTS			
Acute and Chronic, for NPDES Compliance	P,G	Cool, 0-6°C NO ADDITIONS	36 Hours to test initiation

[1] Polyethylene (P) or glass (G).

[2] Perform sample preservation steps immediately upon sample collection. For composite chemical samples, preserve each aliquot at the time of collection. When use of an automatic sampler makes it impossible to preserve each aliquot, then preserve chemical samples by maintaining at 4°C until compositing and sample splitting are completed.

[3] When shipping any sample by common carrier or sent through the United States mail, comply with the Department of Transportation Hazardous Materials Regulations (49 *CFR* Part 172). See fact sheet in Appendix N. The person offering such material for transportation is responsible for ensuring such compliance. For the preservation requirements of this Table, the Office of Hazardous Materials, Materials Transportation Bureau, Department of Transportation has determined that the Hazardous Materials Regulations do not apply to the following materials: hydrochloric acid (HCl) in water solutions at concentrations of 0.04% by weight or less (pH about 1.96 or greater); nitric acid (HNO_3) in water solutions at concentrations of 0.15% by weight or less (pH about 1.62 or greater); sulfuric acid (H_2SO_4) in water solutions at concentrations of 0.35% by weight or less (pH about 1.15 or greater); and sodium hydroxide (NaOH) in water solutions at concentrations of 0.08% by weight or less (pH about 12.3 or less).

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Table 5-3

Required Containers, Preservation Techniques, and Holding Times (Excerpt from 40 *CFR* Part 136, Table II) (Continued)

[4] Analyze samples as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for the longer time and has received a variance from the Regional Administrator under § 136.3(e). Some samples may not be stable for the maximum time period given in the table. A permittee, or monitoring laboratory, is obligated to hold the sample for a shorter time if knowledge exists to show that this is necessary to maintain sample stability.

[5] Used only in the presence of residual chlorine.

[6] Maximum holding time is 24 hours when sulfide is present. Optionally, test all samples with lead acetate paper before pH adjustments to determine whether sulfide is present. If sulfide is present, remove by the addition of cadmium nitrate powder until a negative spot test is obtained. Filter the sample then NaOH is added to pH 12.

[7] Filter samples should be filtered immediately onsite before adding preservative for dissolved metals.

[8] Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific organic compounds.

[9] Analyze samples receiving no pH adjustment within 7 days of sampling.

[10] pH adjustment is if not needed if not measuring acrolein. Analyze samples for acrolein receiving no pH adjustment within 3 days of sampling.

[11] When the extractable analytes of concern fall within a single chemical category, observe the specified preservation and maximum holding times for optimum safeguarding of sample integrity. When the analytes of concern fall within two or more chemical categories, preserve the sample by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to between 6 and 9; hold samples preserved in this manner for 7 days before extraction and for 40 days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re: the requirement for thiosulfate reduction of residual chlorine) and footnotes 12 and 13 (re: the analysis of benzidine).

[12] If 1,2-diphenylhydrazine is likely to be present, adjust the pH of the sample to 4.0 ± 0.2 to prevent rearrangement to benzidine.

[13] Store extracts up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.

[14] For the analysis of diphenylnitrosamine, add 0.008% $Na_2S_2O_3$ and adjust pH to between 7 and 10 with NaOH within 24 hours of sampling.

[15] Perform the pH adjustment upon receipt at the laboratory and omit if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% $Na_2S_2O_3$.

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EPA Sample Identification Methods

Identify each sample accurately and completely. Use labels or tags to identify the samples that are moisture-resistant and able to withstand field conditions. Use a waterproof pen to complete the labels or tags. A numbered label or tag associated with a field sample data sheet containing detailed information on the sample is preferable to using only a label or tag for information[1]. The information for each sample should include the following:

- Facility name/location
- Sample site location
- Sample number
- Name of sample collector
- Date and time of collection
- Indication of grab or composite sample with appropriate time and volume information
- Identification of parameter to be analyzed
- Preservative used.

Wastewater Sample Preservation and Holding Time

In most cases, wastewater samples contain one or more unstable pollutants that require immediate (e.g., within 15 minutes) preservation and/or analysis. Provide appropriate chemical preservation before transferring samples to the laboratory. Procedures used to preserve samples include cooling, pH adjustment, and chemical treatment. For some parameters such as cyanide and phenols, add preservatives to sample bottles prior to or immediately following sample collection. For many samples, if preservatives are not appropriately used, bacteria can quickly degrade certain constituents (such as phenols and phosphorus). Other constituents may volatilize (such as volatile organics and sulfides) or may react to form different chemical species (hexavalent chromium, for example). Proper preservation and holding times are essential to ensure sample integrity. (See Table 5-3 and refer to 40 *CFR* Part 136.)

Analysis of samples within one day ensures against error from sample deterioration. However, such prompt analysis is not feasible for composite samples in which portions may be stored for as long as 24 hours. Where possible, provide sample preservation during compositing, usually by refrigeration to 4°C (or icing). If using an automatic sampler with ice, replace the ice as necessary to maintain low temperatures. This is a particular limitation of automatic samplers used during the summer when ice must be frequently replaced.

The 40 *CFR* Part 136 indicates maximum sample holding times. Times listed are the maximum holding times between sample collection and analysis that are allowed for the sample to be considered valid. Typically, the holding time limitations begin upon combination of the last aliquot in a sample. When use of an automatic sampler makes it impossible to preserve each aliquot, the preservation (chemical) should be done immediately following the composite (40 *CFR* 136.3).

[1]Note: Preprinted labels, data sheets, chain-of-custody forms, etc., can be done in the field using software developed by the Superfund Program.

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Transfer of Custody and Shipment of Samples

To ensure the validity of the permit compliance sampling data in court, written records must accurately trace the custody of each sample through all phases of the monitoring program. The primary objective of this chain-of-custody is to create an accurate written record (see an example chain-of-custody form in Appendix M) that can be used to trace the possession and handling of the sample from the moment of its collection through its analysis and introduction as evidence.

- Use sample seals to protect the sample's integrity from the time of collection to the time it is opened in the laboratory. The seal should indicate the collector's name, the date and time of sample collection, and sample identification number.

- Pack samples properly to prevent breakage. Seal or lock the shipping container to readily detect any evidence of tampering can be readily detected. Use of tamper proof evidence tape is recommended.

- Place samples on ice or synthetic ice substitute that will maintain sample temperature at 4°C throughout shipment.

- Accompany every sample with a sample tag and a chain-of-custody record that has been completed, signed, and dated. The chain-of-custody record should include the names of sample collectors, sample identification numbers, date and time of sample collection, location of sample collection, and names and signatures of all persons handling the sample in the field and in the laboratory.

- The responsibility for proper packaging, labeling, and transferring of possession of the sample lies with the inspector.

- Accompany all sample shipments with the chain-of-custody record and other pertinent forms. The originator retains a copy of these forms. Also, the originator must retain all receipts associated with the shipment.

- EPA Inspectors with the responsibility of working with hazardous materials that are placed in commerce (transporting/shipping) must have hazardous materials training as required by the Department of Transportation (See Appendix N).

- When transferring possession of samples, the transferee must sign and record the date and time on the chain-of-custody record (use the currently approved record). In general, make custody transfers for each sample, although samples may be transferred as a group, if desired. Each person who takes custody must fill in the appropriate section of the chain-of-custody record.

- Pack and ship samples in accordance with applicable International Air Transportation Association (IATA) and/or DOT regulations. See Table 5-3, footnote 3.

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Quality Control

Conduct control checks during the actual sample collection to determine the performance of sample collection techniques. In general, the most common monitoring errors usually are improper sampling methodology, improper preservation, inadequate mixing during compositing and splitting, and excessive sample holding time. In addition, collect and analyze the following samples to check sample collection techniques:

Blanks

- **Trip Blank**. This is a sample vial(s) filled at the laboratory with deionized water. The blank(s) follows the same handling and transport procedures as the samples collected during the event. The blank(s) functions as a check on sample contamination originating from sample transport, shipping and from site conditions.

  Note: Expose the trip blank vial(s), to the same environmental conditions (i.e., light, temperature, etc.) of the sample vial(s) but do not open until it is time for analysis.

- **Field Blank/Field Reagent Blank**. These are similar to the trip blanks except they are prepared in the field with deionized water exactly as the sample(s) that are collected. Field blanks are used to check for analytical artifacts and/or background introduced by sampling and analytical procedures.

- **Equipment/Rinsate Blank**. Collect a blank when using an automatic sampler or other non-dedicated equipment during the sampling process. The blank is a check of the equipment cleanliness. For automatic samplers, prepare blanks prior to collecting samples, by pumping deionized organic free water through the sampler and collecting the discharge purge water in a sample container for analysis for the constituents of concern.

Field Duplicate. Collect this sample simultaneously from the same source at selected stations on a random time frame by grab samples or from two sets of field equipment installed at the site. Duplicate samples check analytical precision as well as evaluate the "representativeness" of the sample aliquot.

Split Samples. These are samples that have been divided into two containers for analysis by separate laboratories. These samples provide an excellent means of identifying discrepancies in the permittee's analytical techniques and procedures. When filling split samples from a single composite jug, shake the composited sample well and half fill the EPA sample container, then shake the composite again and fill half of the permittee's container. Repeat the procedure for each parameter collected.

The laboratories performing the sample analyses should also use the following control measures:

Prep/Reagent Blank. A sample consisting of reagent(s), without the target analyte or sample matrix, introduced into the analytical procedure at the appropriate point and carried through all subsequent steps to determine the contribution of the reagents and of the involved analytical steps to error in the observed value.

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Quality Control Sample. This is an uncontaminated sample matrix spiked with known amounts of analytes from a source independent from the calibration standards. Use this sample to establish intra laboratory or analyst specific precision and bias or to assess the performance of all or a portion of the measurements' system.

Matrix Spike/Matrix Spike Duplicate (MS/MSD). This sample is three times the normal volume required for a specific chemical analysis to which a known quantity of analyte has been added prior to all sample preparation. The laboratory utilizes the MS/MSD samples as part of their Quality Assurance/Quality Control Program.

- Use a matrix spike to verify accuracy of the analytical procedures.
- A matrix spike duplicate is a duplicate of a matrix spike sample. It measures the precision of the analysis in terms of relative percent difference.

Table 5-4 indicates quality control procedures for field analyses and equipment. Quality control is discussed in greater detail in Chapter Seven of this manual and EPA's *NPDES Compliance Inspector Training Laboratory Analyses Manual*, April 1990.

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Table 5-4

Quality Control Procedures for Field Analysis and Equipment

Parameter	General	Daily	Frequency
Dissolved Oxygen			
Membrane Electrode	• Enter the make, model, and serial and/or ID number for each meter in a logbook. • Report data to nearest 0.1 mg/l.	• Calibrate meter using manufacturer's instructions or Winkler-Azide method. • Check membrane for air bubbles and holes. Change membrane and KCl if necessary. • Check leads, switch contacts, etc., for corrosion and shorts if meter pointer remains off-scale.	• Quarterly, check instrument calibration and linearity using a series of at least three dissolved oxygen standards. • Quarterly, take all meters to the laboratory for maintenance, calibration, and quality control checks.
Winkler-Azide method	• Record data to nearest 0.1 mg/l.	• Duplicate analysis should be run as a precision check. Duplicate values should agree within ±0.2 mg/l.	
pH			
Electrode Method	• Enter the make, model, and serial and/or ID number for each meter in a logbook.	• Calibrate the system against traceable standard buffer solutions of known pH value which closely bracket the actual sample pH (e.g., 4, 7, and 10 at the start of a sampling run). • Periodically check the buffers during the sample run and record the data in the logbook. • Be on the alert for erratic meter response arising from weak batteries, cracked electrodes, fouling, etc. • Check response and linearity following highly acidic or alkaline samples. Allow additional time for equilibration. • Check against the closest reference solution each time a violation is found. • Rinse electrodes thoroughly between samples and after calibration. Blot dry.	

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Table 5-4

Quality Control Procedures for Field Analysis and Equipment (Continued)

Parameter	General	Daily	Frequency
Conductivity			
	• Enter the make, model, and serial and/or ID number for each meter in a logbook.	• Standardize with KCl standards having similar specific conductance values to those anticipated in the samples. Calculate the cell constant using two different standards. • Rinse cell after each sample to prevent carryover.	• Quarterly, take all meters to lab for maintenance, calibration, and quality control checks. • Quarterly, check temperature compensation. • Quarterly, check date of last platinizing, if necessary. • Quarterly, analyze NIST or EPA reference standard, and record actual vs. observed readings in the logbook.
Residual Chlorine			
Amperometric Titration	• Enter the make, model, and ID and/or serial number of each titration apparatus in a logbook. Report results to nearest 0.01 mg/l.	• Refer to instrument manufacturer's instructions for proper operation and calibration procedures.	• Biweekly, return instrument to lab for maintenance and addition of fresh, standardized reagents.

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Table 5-4

Quality Control Procedures for Field Analysis and Equipment (Continued)

Parameter	General	Daily	Frequency
Manual Thermometer	• Enter the make, model, and serial and/or ID number and temperature range. • All standardization should be against a traceable NIST or NIST calibrated thermometer. Reading should agree within ±1°C. If enforcement action is anticipated, calibrate the thermometer before and after analysis. All data should be read to the nearest 1°C. Report data between 10° and 99°C to two significant figures.	• Check for air spaces of bubbles in the column, cracks, etc. Compare with a known source if available.	• Biweekly, check at two temperatures against a NIST or equivalent thermometer. Enter data in logbook. • Temperature readings should agree within ±1°C or the thermometer should be replaced or recalibrated. • Initially and biannually, determine accuracy throughout the expected working range of 0°C to 50°C. A minimum of three temperatures within the range should be used to verify accuracy. Preferable ranges are 5-10°C, 15-25°C, and 35-45°C.
Thermistors, Thermographs	• Enter the make, model, and serial and/or ID number of the instrument in a logbook. All standardization shall be against a NIST or NIST calibrated thermometer. Reading should agree within ±1°C. If enforcement action is anticipated, refer to the procedure listed above.	• Check thermistor and sensing device for response and operation according to the manufacturer's instruction. Record actual vs. standard temperature in logbook.	• Initially and biannually, determine accuracy throughout the expected working range of 0°C to 50°C. A minimum of three temperatures within the range should be used to verify accuracy. Preferable ranges are 5-10°C, 15-25°C, and 35-45°C.
Flow Measurement			
	• Enter the make, model, and serial and/or ID number of each flow measurement instrument in a logbook.	• Install the device in accordance with the manufacturer's instructions and with the procedures given in owner's manual.	• Annually affix record of calibration (NIST, manufacturer) to the instrument log.

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Table 5-4

Quality Control Procedures for Field Analysis and Equipment (Continued)

Parameter	General	Daily	Frequency
Automatic Samplers			
	• Enter the make, model, and serial and/or ID number of each sampler in a logbook.		• Check intake velocity vs. head (minimum of three samples), and clock time setting vs. actual time interval.

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Quality Assurance Project Plan

The EPA has developed the Quality Assurance Project Plan (QAPP) as a tool for project managers and planners to document the type and quality of data needed for the agency to make environmental decisions and to describe the methods for collecting and assessing those data. The QAPP is required for all EPA projects resulting in the generation, collection, and use of environmental data. The development, review, approval and implementation of the QAPP is an integral part of an Agency-wide Quality System, which is required per the authority of EPA Order 5360.1 A2.

If the EPA is to have confidence in the quality of data used to support environmental decisions, there must be a systematic planning process in place. A product of the systematic planning process is the QAPP. An example of the systematic planning process endorsed by the EPA is the Data Quality Objectives (DQO) Process. The QAPP ensures that the needed management and technical practices are in place so that environmental data used to support agency decisions are of adequate quality and usability for their intended purpose.

Prior to the start of data collection, a QAPP defining the goals and scope of the project, the need for sample collection, a description of the data quality objectives and QA/QC activities to ensure data validity and usability must be developed by the project officer. Thereafter, a review by all parties to the sampling effort, such as a Quality Assurance (QA) Officer, must be conducted. Also, EPA laboratories will require a copy of an approved QAPP prior to conducting any sample analysis. This QAPP requirement applies to both EPA staff and outside contractors. The process for approval of the QAPP and other documents related to the data collection activity should be outlined in the lead organization's Quality Management Plan (QMP).

For further information on the QAPP's please visit the Office of Environmental Information (OEI) web page at: www.epa.gov/quality. Then click on the radio button for "documents" which contains valuable information. There is also a section on Guidance on the same web-site.

Data Handling and Reporting

Verified analytical results are normally entered into a laboratory data management system of some type. The system should contain the sampling data, including time and exact location, analysis dates and times, names of analysts, analytical methods/techniques used, and analytical results. Data are then reported to the project officer (inspector) for inclusion into the compliance report. The quality assurance manual by EPA (*Handbook for Analytical Quality Control in Water and Wastewater Laboratories*, USEPA 1979) and the article by J.J. Delfino ("Quality Assurance In Water and Wastewater Analysis Laboratories," Delfino 1977) provide useful information to the inspector on a number of data management techniques.

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5. C. References and Permittee Sampling Inspection Checklist

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PERMITTEE SAMPLING INSPECTION CHECKLIST

A. PERMITTEE SAMPLING EVALUATION

Yes	No	N/A	1.	Take samples at sites specified in permit.
Yes	No	N/A	2.	Locations adequate for representative samples.
Yes	No	N/A	3.	Flow proportioned samples obtained when required by permit.
Yes	No	N/A	4.	Complete sampling and analysis on parameters specified by permit.
Yes	No	N/A	5.	Conduct sampling and analysis in frequency specified by permit.
Yes	No	N/A	6.	Permittee uses method of sample collection required by permit. Required method:_____ If not, method being used is: ( ) Grab ( ) Manual composite ( ) Automatic Composite
			7.	Sample collection procedures adequate:
Yes	No	N/A		a. Samples refrigerated during compositing.
Yes	No	N/A		b. Proper preservation techniques used.
Yes	No	N/A		c. Containers and sample holding times before analyses conform to 40 *CFR* 136.3.
Yes	No	N/A		d. Samples analyzed in time frame needed.
Yes	No	N/A	8.	Facility performs monitoring and analyses more often than required by permit; if so, results reported in permittee's self-monitoring report.
Yes	No	N/A	9.	Samples contain chlorine.
Y es	No	N/A	10.	Use contract laboratory for sample analysis.
Yes	No	N/A	11.	POTW collects samples from industrial users in pretreatment program.

B. SAMPLING INSPECTION PROCEDURES AND OBSERVATIONS

Yes	No	N/A	1.	Obtain grab samples.
Yes	No	N/A	2.	Obtain composite sample. Compositing Frequency:___ Preservation:_____
Yes	No	N/A	3.	Refrigerate sample during compositing.
Yes	No	N/A	4.	Obtain flow proportioned sample.
Yes	No	N/A	5.	Obtain sample from facility sampling device.
Yes	No	N/A	6.	Sample representative of volume and nature of discharge.
Yes	No	N/A	7.	Sample split with permittee.
Yes	No	N/A	8.	Employ chain-of-custody procedures.
Yes	No	N/A	9.	Samples collected in accordance with permit.
Yes	No	N/A	10.	Observe excessive foam, grease, floating solids at the outfall.

C. AUTOMATIC SAMPLER PROCEDURES AND OBSERVATIONS

Yes	No	N/A	1.	Sample intake tubing place in a well mixed, representative location (0.4 to 0.6 depth).
Yes	No	N/A	2.	Individual aliquot volume checked and at least 100ml.

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PERMITTEE SAMPLING INSPECTION CHECKLIST (Continued)

C. AUTOMATIC SAMPLER PROCEDURES AND OBSERVATIONS (Continued)

Yes	No	N/A	3.	Proper sample tubing (teflon for organics, otherwise tygon) and tubing at ID at least 0.25 inch.
Yes	No	N/A	4.	Proper composite sample container (glass for organics, otherwise plastic.
Yes	No	N/A	5.	Proper refrigeration (4°C or ice), with required documentation.
Yes	No	N/A	6.	Proper wastewater velocity in the sample tubing (at least 2 fps).

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6. FLOW MEASUREMENT

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O. Supplemental Flow Measurement Information

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6. A. Evaluation of Permittee's Flow Measurement

Objectives and Requirements

To comply with the permit requirements established under the National Pollutant Discharge Elimination System (NPDES), the permittee must accurately determine the quantity of wastewater being discharged. Discharge flow an measurement is an integral part of the NPDES program, it is important that the inspector evaluate the accuracy of the measurement.

In addition to providing usable information for enforcement purposes, flow measurement serves to:

- Provide data for pollutant mass loading calculations
- Provide operating and performance data on the wastewater treatment plant
- Compute treatment costs, based on wastewater volume
- Obtain data for long-term planning of plant capacity, versus capacity used
- Provide information on Infiltration and Inflow (I/I) conditions, and the need for cost-effective I/I correction

A Flow Measurement Inspection Checklist for the inspector's use appears at the end of this chapter.

Evaluation of Facility-Installed Flow Devices and Data

There are two types of wastewater flow: closed channel flow and open channel flow. Closed channel flow occurs under pressure in a liquid-full conduit (usually a pipe). The facility will usually have a metering device inserted into the conduit which measure flow. Examples of closed channel flow measuring devices are the Venturi meter, the Pitot tube, the paddle wheel, the electromagnetic flowmeter, Doppler, and the transit-time flowmeter. In practice, closed channel flow is normally encountered between treatment units in a wastewater treatment plant, where liquids and/or sludges are pumped under pressure.

Open channel flow occurs in conduits that are not liquid-full. Open channel flow are partially full pipes not under pressure. Open channel flow is the most prevalent type of flow at NPDES-regulated discharge points.

Measure open channel flow using primary and secondary devices. Primary devices are standard hydraulic structures, such as flumes and weirs, that are inserted in the open channel. Inspectors can obtain accurate flow measurements merely by measuring the depth of liquid (head) at the specific point in the primary device. In a weir application, for example, the flow rate is a function of the head of liquid above the weir crest.

Facilities use secondary devices in conjunction with primary devices to automate the flow

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measuring process. Typically, secondary devices measure the liquid depth in the primary device and convert the depth measurement to a corresponding flow, using established mathematical relationships. Examples of secondary devices are floats, ultrasonic transducers, bubblers, and transit-time flowmeters. A recorder generally measures the output of the secondary device transmitted to a recorder and/or totalizer to provide instantaneous and historical flow data to the operator. Outputs may also be transmitted to sampling systems to facilitate flow proportioning. Appendix O contains further information on flow measurement devices.

The inspector must assure the permittee obtains accurate wastewater flow data to calculate mass loading (quantity) from measured concentrations of pollutants discharged as required by many NPDES permits. The permittee must produce data that meet requirements in terms of precision and accuracy. Precision refers to data reproducibility or the ability to obtain consistent data from repeated measurements of the same quantity. Accuracy refers to the agreement between the amount of a component measured by the test and the amount actually present.

The accuracy of flow measurement (including both primary and secondary devices) varies widely with the device, its location, environmental conditions, and other factors such as maintenance and calibration. Faulty fabrication, construction, and installation of primary devices are common sources of errors. Improper calibration, misreading, and variation in the speed of totalizer drive motors are major errors related to secondary devices. See Appendix O - "Supplement Flow Measurement Information." When evaluating facility installed devices, the inspector should do the following:

- Verify that the facility has installed primary and secondary devices according to manufacturer's manual instructions.
- Inspect the primary device for evidence of corrosion, scale formation, or solids accumulation that may bias the flow measurement.
- Verify that weirs are level, plumb, and perpendicular to the flow direction.
- Verify that flumes are level, the throat walls (narrowed section of flume) are plumb, and the throat width is the standard size intended.
- Inspect historical records (i.e., strip charts and logs) for evidence of continuous flow measurements. Compare periods of missing data with maintenance logs for explanations of measuring system problems.
- Observe the flow patterns near the primary device for excessive turbulence or velocity. The flow lines should be straight.
- Ensure that the flow measurement system or technique being used measures the entire wastewater discharge as required by the NPDES permit. Inspect carefully the piping to determine whether there are any wastewater diversions, return lines, or bypasses around the system. Make sure the system meets the permit requirement, such as instantaneous or continuous, daily, or other time interval measures. Noted anomalies in the inspection report.
- Verify that the site chosen for flow measurement by the facility is appropriate and is in

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accordance with permit requirements.

- Verify that the site chosen by the facility for flow measurement is suitable for type of discharge, flow range, suspended solids concentration, and other relevant factors.
- Verify that the facility has closed channel flow measuring devices where the pipe is always full. If these devices are used, then there must be also a means for the permittee and regulatory agencies/inspector to verify the accuracy of these meters. Primary flow measuring devices such as weirs and flumes are ideal for this purpose.
- Verify that the facility uses appropriate tables, curves, and formulas to calculate flow rates.
- Review and evaluate calibration and maintenance programs for the discharger's flow measurement system. The permit normally requires the facility to check the calibration regularly by the permittee. The facility must ensure that their flow measurement systems are calibrated by a qualified source at least once a year to ensure their accuracy. Lack of such a program is considered unacceptable for NPDES compliance purposes.
- Verify that the facility calibrates flowmeters across the full range of expected flow.
- Verify that primary and secondary devices are adequate for normal flow as well as maximum expected flow. Note whether the flow measurement system can measure the expected range of flow.
- Collect accurate flow data during inspection to validate self monitoring data collected by the permittee.
- The facility must install a flow measuring system that has the capability of routine flow verification by the permittee or appropriate regulatory personnel.

Evaluation of Permittee Data Handling and Reporting

The permittee or facility must keep flow measurement records for a minimum period of three years as the permit requires. Many flow measuring devices produce a continuous flowchart for plant records. Flow records should contain date, flow, time of reading, and operator's name, if applicable the facility must also record. The facility should record maintenance, inspection dates, and calibration data.

The inspector should review the permittee's records and note the presence or absence of data such as:

- Frequency of routine operational inspections
- Frequency of maintenance inspections

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- Frequency of flowmeter calibration (should be as specified in permit, generally at least once per year)
- Irregularity or uniformity of flow.

Evaluation of Permittee Quality Control

The inspection should evaluate following quality control issues during a compliance inspection to ensure:

- Proper operation and maintenance of equipment
- Accurate records
- Sufficient inventory of spare parts
- Valid flow measurement techniques
- Precise flow data
- Adequate frequency of calibration checks.

Evaluate precision of float driven flow meters when flows are stable. Push the float gently downward, hold for 30 seconds, then allowed to return normally. The recorded flow rate should be the same before and after the float was moved. Evaluate accuracy by measuring the instantaneous flow rate at the primary device used at the facility and comparing the value against the value on the meter, graph, integrator, or company record. The difference between two stable totalizer readings (flow is steady for 10 minutes or more) should not exceed ±10 percent of the instantaneous flow measured at the primary device. Note that most flow measurement systems have both an instantaneous meter readout as well as a totalizer. Both of these devices should be in agreement but that is not always the case due to electrical and other various malfunctions in the flow measuring system. In most cases, the totalizer reading will be what is reported by the permittee. If this is the case, then that device should be checked for accuracy and the permittee's flow measuring system rated accordingly.

In addition, the inspector can evaluate accuracy by installing a second flow measurement system, sometimes referred to as a reference system. Agreement in measured flow rates between the two systems should be within ±10 percent of the reference rate if all conditions are as recommended for the systems.

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6. B. Flow Measurement Compliance

Objectives

The current NPDES program depends heavily on the permittee's submittal of self-monitoring data. The flow discharge measured during the NPDES compliance inspection should verify the flow measurement data collected by the permittee, support any enforcement action that may be necessary, and provide a basis for reissuing or revising the NPDES permit.

Flow Measurement System Evaluation

The responsibility of the inspector includes collecting accurate flow data during the inspection and validating data collected during the permittee's self-monitoring.

The NPDES inspector must check both the permittee's flow data and the flow measurement system to verify the permittee's compliance with NPDES permit requirements. When evaluating a flow measurement system, the inspector should consider and record findings on the following:

- Whether the system measures the entire discharge flow.
- The system's accuracy and good working order. This will include a thorough physical inspection of the system and comparison of system readings to actual flow or those obtained with calibrated portable instruments.
- The need for new system equipment.
- The existence or absence of a routine calibration and maintenance program for flow measurement equipment.

If the permittee's flow measurement system is accurate within ±10 percent, the inspector should use the installed system. If the flow sensor or recorder is found to be inaccurate, the inspector should determine whether the equipment can be corrected in time for use during the inspection. If the equipment cannot be repaired in a timely manner, use the portable flow sensor and recorder used to assess the accuracy of the permittee's system for the duration of the inspection. If nonstandard primary flow devices are being used, request the permittee to supply data on the accuracy and precision of the method being employed.

For flow measurement in pipelines, the inspector may use a portable flowmeter. The inspector should select a flowmeter with an operating range wide enough to cover the anticipated flow to be measured. The inspector should test and calibrate the selected flowmeter before use. The inspector should select the site for flow measurement according to permit requirements and install the selected flowmeter according to the manufacturer's specifications. The inspector should use the proper tables, charts, and formulas as specified by the manufacturer to calculate flow rates.

Four basic steps are involved in evaluating the permittee's flow measurement system:

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- Physical inspection of the primary device
- Physical inspection of the secondary device and ancillary equipment
- Flow measurement using the primary/secondary device combination of the permittee
- Certification of the system using a calibrated, portable instrument.

The following sections present, procedures for inspecting the more common types of primary and secondary devices, for measuring flow using common permanent and portable systems, and for evaluating flow data. Please note that the number of primary/secondary device permutations is limitless; therefore, it is not feasible to provide procedures for all systems. When encountering systems other than those discussed here the inspector should consult the manufacturers manual/personnel for advice before preparing a written inspection procedure.

Primary Device Inspection Procedures

The two most common open channel primary devices are sharp-crested weirs and Parshall flumes. Common sources of error when using them include the following:

- Faulty fabrication—weirs may be too narrow or not "sharp" enough. Flume surfaces may be rough, critical dimensions may exceed tolerances, or throat walls may not be vertical.

- Improper installation—the facility may install weirs and flumes too near pipe elbows, valves, or other sources of turbulence. The devices may be out of level or plumb.

- Sizing errors—the primary device's recommended applications may not include the actual flow range.

- Poor maintenance—primary devices corrode and deteriorate. Debris and solids may accumulate in them.

Specific inspection procedures for the sharp-crested weir, the Parshall flume, and the Palmer-Bowlus flume devices follow.

Sharp-Crested Weir Inspection Procedures

- Inspect the upstream approach to the weir.

  - Verify that the weir is perpendicular to the flow direction.

  - Verify that the approach is a straight section of conduit with a length at least 20 times the maximum expected head of liquid above the weir crest.

  - Observe the flow pattern in the approach channel. The flow should occur in smooth stream lines without velocity gradients and turbulence.

  - Check the approach, particularly in the vicinity of the weir, for accumulated solids,

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debris, or oil and grease. The approach must have no accumulated matter.

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- Inspect the sharp-crested weir.
  - Verify that the crest of the weir is level across the entire conduit traverse.
  - Measure the width of the weir crest. The edge of the weir crest should be no more than 1/8-inch thick.
  - Make certain the weir crest corresponds to zero gauge elevation (zero output on the secondary device).
  - Measure the angle formed by the top of the crest and the upstream face of the weir. This angle must be 90 degrees.
  - Measure the chamfer (beveled edge) on the downstream side of the crest. The chamfer should be approximately 45 degrees.
  - Visually survey the weir-bulkhead connection for evidence of leaks or cracks which permit bypass.
  - Measure the height of the weir crests above the channel floor. The height should be at least twice the maximum expected head (2H) of liquid above the crest.
  - Measure the width of the end contraction. The width should be at least twice the maximum expected head (2H) of the liquid above the crest.
  - Inspect the weir for evidence of corrosion, scale formation, or clinging matter. The weir must be clean and smooth.
  - Observe flow patterns on the downstream side of the weir. Check for the existence of an air gap (ventilation) immediately adjacent to the downstream face of the weir. Ventilation is necessary to prevent a vacuum that can induce errors in head measurements. Also ensure that the crest is higher than the maximum downstream level of water in the conduit.
  - Verify that the nappe is not submerged and that it springs free of the weir plate.
  - If the weir contains a V-notch, measure the apex angle. The apex should range from 22.5 degrees to 90 degrees. Verify that the head is between 0.2 and 2.0 feet. The weir should not be operated with a head of less than 0.2 feet since the nappe may not spring clear of the crest.

King's *Handbook of Hydraulics*, 1963, frequently referenced throughout this chapter, provides a detailed discussion on weirs.

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Parshall Flume Inspection Procedures

- Inspect the flume approach.
  - The flow pattern should be smooth with straight stream lines, be free of turbulence, and have a uniform velocity across the channel.
  - The upstream channel should be free of accumulated matter.
- Inspect the flume.
  - The flume should be located in a straight section of the conduit.
  - Flow at the entrance should be free of "white" water.
  - The flume should be level in the transverse and translational directions.
  - Measure the dimensions of the flume. Dimensions are strictly prescribed as a function of throat width (see Figure I-5 in Appendix O for critical dimensions).
  - Measure the head of liquid in the flume and compare with the acceptable ranges in Table I-4 in Appendix O.
- Inspect the flume discharge.
  - Verify that the head of water in the discharge is not restricting flow through the flume. The existence of a "standard wave" is good evidence of free flow and verifies that there is no submergence present.
  - Verify whether submergence occurs at near maximum flow (e.g., look for water marks on the wall).

Palmer-Bowlus Flume Inspection Procedures

- Inspect the flume approach as outlined above (these flumes are seldom used for effluent flow measurement).
- Inspect the flume.
  - The flume should be located in a straight section of the conduit.
  - Flow at the entrance should be free of "white" water.
  - Observe the flow in the flume. The profile should approximate that depicted in Figure I-8 in Appendix O.
  - The flume should be level in the transverse direction and should not exceed the translational slope in Table I-6 in Appendix O.

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  - Measure the head of water in the flume. Head should be within the ranges specified in Table I-6 in Appendix O.

- Inspect the flume discharge.

  - Verify that free flow exists. Look for the characteristic "standing wave" in the divergent section of the flume.

Venturi Meter Inspection Procedures

- Verify that the facility installed the Venturi meter according to manufacturer's instructions.

- Verify that the facility installed the Venturi meter downstream from a straight and uniform section of pipe, at least 5 to 20 diameters, depending on the ratio of pipe to throat diameter and whether straightening vanes are installed upstream. (Installation of straightening vanes upstream will reduce the upstream piping requirements.)

- Verify that the pressure measuring taps are free of debris and are not plugged.

- Calibrate the Venturi meter in place by either the volumetric method or the comparative dye dilution method to check the manufacturer's calibration curve or to develop a new calibration curve.

Secondary Device Inspection Procedures

The following are common sources of error in the use of secondary devices:

- Improper location—gauge is located in the wrong position relative to the primary device.
- Inadequate maintenance—gauge is not serviced regularly.
- Incorrect zero setting—zero setting of gauge is not the zero point of the primary device.
- Operator error—human error exists in the reading.

Specific inspection procedures follow.

Flow Measurement in Weir Applications

- Determine that the head measurement device is positioned 3 to 4 head lengths upstream of a weir.

- Verify that the zero or other point of the gauge is equal to that of the primary device.

The inspector should use an independent method of measuring head, such as with a yardstick or carpenter's rule (be sure to take your measurement at least four times the maximum head upstream and from the weir and convert to nearest hundredth of a foot). To determine flow

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rate, use the appropriate head discharge relationship formula (see Table I-1 in Appendix O).

Flow Measurement in Parshall Flume Applications

Flow Measurement—Free-Flow Conditions.

- Determine upstream head (H_a) using staff gauge.
  - Verify that staff gauge is set to zero head. Use either a yardstick or carpenter's rule.
  - Verify that staff gauge is at proper location (two-thirds the length of the converging section back from the beginning of the throat).
  - Read to nearest division the gauge division at which liquid surface intersects gauge.
  - Read H_a in feet from staff gauge.
- To determine flow rate, use Figure I-6 in Appendix O in the unit desired, use tables published in flow measurement standard references, or calculate using the coefficients in Table I-5 in Appendix O.

Flow Measurement—Submerged-Flow Condition.

Generally it is difficult to make field measurements with submerged-flow conditions. In cases when measurements can be obtained (using a staff or float gauge), the procedures listed below should be followed:

- Determine upstream head using staff or float gauge.
  - Read to nearest division and, at the same time as for H_b, the gauge division at which liquid surface intersects gauge.
  - Calculate H_a from gauge reading.
- Determine downstream head (H_b) using staff or float gauge.
  - H_b refers to a measurement at the crest.
  - Read to nearest division, and at the same time as for H_a, the gauge division at which liquid surface intersects gauge.
  - Calculate H_b from staff reading.

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- Determine flow rate.
  - Calculate percent submergence:

$$\left[\frac{H_b}{H_a}\right] \times 100.$$

  - Consult Table I-6 in Appendix O.
  - When a correction factor is obtained, use H_a and find free-flow from Figure I-6.
  - Multiply this free-flow value by the correction factor to obtain the submerged flow.

The inspector may use an independent method of measuring head, such as a yardstick or carpenter's rule at the proper head measurement point. Because of the sloping water surface in the converging section of a flume, it is essential that the proper head measurement point be used.

Flow Measurement in Palmer-Bowlus Flume Applications

- Obtain head measurements as in the Parshall Flume application, using the secondary device. The head is the height of water above the step. The total depth upstream of the step is not the head.
- Refer to manufacturer-supplied discharge tables to convert head measurements to flow data. Palmer-Bowlus flumes, unlike Parshall flumes, are not constructed to standard dimensional standards. The inspector must not use discharge tables supplied by other manufacturers.

Verification

Most flow measurement errors result from inadequate calibration of the flow totalizer, and recorder. If the inspector has determined that the primary device has been installed properly, verification of the permittee's system is relatively simple. Compare the flow determined from the inspector's independent measurement to the flow of the permittee's totalizer or recorder. The inspector's flow measurements should be within 10 percent of the permittee's measurements to certify accurate flow measurement. Optimally, flow comparisons should be made at various flow rates to check system accuracy.

When the permit requires that the daily average flow be measured by a totalizing meter, the inspector should verify that the totalizer is accurate, i.e., properly calibrated. This can be done during a period of steady flow by reading the totalizer and at the same time starting a stopwatch. Start the stopwatch just as a new digit starts to appear on the totalizer. After 10 to 30 minutes, the totalizer should be read again; just as a new digit begins to appear, the stop watch is read. Subtract the two totalizer readings to determine, the total flow over the measured time period. Calculate the flow rate in gallons per minute by using the time from the stop watch. Compare this flow rate to the flow determined by actual measurement of the head

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made at the primary device at the time interval. Consider the calibration of the totalizer satisfactory if the two flows are within 10 percent of each other, when the actual measured flow is used as the known value, or divisor, in the percent calculation.

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6. C. References and Flow Measurement Inspection Checklist

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FLOW MEASUREMENT INSPECTION CHECKLIST

A. GENERAL

Yes	No	N/A	1. a.	Primary flow measuring device properly installed and maintained.
Yes	No	N/A	b.	Flow measured at each outfall? _____ Number of outfalls? _____
Yes	No	N/A	c.	Is there a straight length of pipe or channel before and after the flowmeter of at least 5 to 20 diameters?
Yes	No	N/A	d.	If a magnetic flowmeter is used, are there sources of electric noise in the near vicinity?
Yes	No	N/A	e.	Is the magnetic flowmeter properly grounded?
Yes	No	N/A	f.	Is the full pipe requirement met?
Yes	No	N/A	2. a.	Flow records properly kept.
Yes	No	N/A	b.	All charts maintained in a file.
Yes	No	N/A	c.	All calibration data entered into a log book.
Yes	No	N/A	3.	Actual discharged flow measured.
Yes	No	N/A	4.	Effluent flow measured after all return lines.
Yes	No	N/A	5.	Secondary instruments (totalizers, recorders, etc.) properly operated and maintained.
Yes	No	N/A	6.	Spare parts stocked.
Yes	No	N/A	7.	Effluent loadings calculated using effluent flow.

B. FLUMES

Yes	No	N/A	1.	Flow entering flume reasonably well-distributed across the channel and free of turbulence, boils, or other disturbances.
Yes	No	N/A	2.	Cross-sectional velocities at entrance relatively uniform.
Yes	No	N/A	3.	Flume clean and free of debris and deposits.
Yes	No	N/A	4.	All dimensions of flume accurate and level.
Yes	No	N/A	5.	Side walls of flume vertical and smooth.
Yes	No	N/A	6.	Sides of flume throat vertical and parallel.
Yes	No	N/A	7.	Flume head being measured at proper location.
Yes	No	N/A	8.	Measurement of flume head zeroed to flume crest.
Yes	No	N/A	9.	Flume properly sized to measure range of existing flow.
Yes	No	N/A	10.	Flume operating under free-flow conditions over existing range of flows.
Yes	No	N/A	11.	Flume submerged under certain flow conditions.
Yes	No	N/A	12.	Flume operation invariably free-flow.

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FLOW MEASUREMENT INSPECTION CHECKLIST (Continued)

C. WEIRS

Yes	No	N/A	1.	What type of weir does the facility use?
Yes	No	N/A	2.	Weir exactly level.
Yes	No	N/A	3.	Weir plate plumb and its top and edges sharp and clean.
Yes	No	N/A	4.	Downstream edge of weir is chamfered at 45°.
Yes	No	N/A	5.	Free access for air below the nappe of the weir.
Yes	No	N/A	6.	Upstream channel of weir straight for at least four times the depth of water level and free from disturbances.
Yes	No	N/A	7.	Distance from sides of weir to side of channel at least 2H.
Yes	No	N/A	8.	Area of approach channel at least (8 × nappe area) for upstream distance of 15H.
Yes	No	N/A	9.	If not, is velocity of approach too high?
Yes	No	N/A	10.	Head measurements properly made by facility personnel.
Yes	No	N/A	11.	Leakage does not occur around weir.
Yes	No	N/A	12.	Use of proper flow tables by facility personnel.

D. OTHER FLOW DEVICES

	1.	Type of flowmeter used:
	2.	What are the most common problems that the operator has had with the flowmeter?
	3.	Measured wastewater flow: _____ mgd; Recorded flow: _____; Error _____%

E. CALIBRATION AND MAINTENANCE

Yes	No	N/A	1.	Flow totalizer properly calibrated.
			2.	Frequency of routine inspection by proper operator: _____/day.
			3.	Frequency of maintenance inspections by plant personnel: _____/year.
Yes	No	N/A	4.	Flowmeter calibration records kept. Frequency of flowmeter calibration: _____/month.
Yes	No	N/A	5.	Flow measurement equipment adequate to handle expected ranges of flow rates.
Yes	No	N/A	6.	Calibration frequency adequate.

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7. LABORATORY PROCEDURES AND QUALITY ASSURANCE

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7. A. Objectives and Requirements

The analytical laboratory provides both qualitative and quantitative information for determining the extent of permittee compliance with permit discharge requirements. To be valuable or useful, the data must be representative and accurately describe the characteristics and concentrations of constituents in the samples submitted to the laboratory. The objectives of laboratory Quality Assurance (QA) are to monitor and document the accuracy and precision of the results reported and to meet reliability requirements.

QA refers to a total program for ensuring the reliability of data by utilizing administrative and technical procedures and policies regarding personnel, resources, and facilities. QA is required for all functions bearing on environmental measurements and includes activities such as project/study definition; sample collection and tracking; laboratory analysis; data validation, analysis, reduction, and reporting; documentation; and data storage systems. Thus, the QA program is designed to evaluate and maintain the desired quality of data. Quality Control (QC), a function of QA, is the routine application of procedures for controlling the accuracy and precision of the measurement process and includes the proper calibration of instruments and the use of the appropriate analytical procedures.

The 40 *Code of Federal Regulations* (*CFR*) Section 122.41(e) (conditions applicable to all permits), requires adequate laboratory and process controls, including appropriate QA procedures. Each permittee's laboratory must have a QA/QC program. The laboratory must document the QA program in a written QA/QC manual and the lab should make it available to all personnel responsible for sample analyses. The manual must clearly identify the individuals involved in the QA program and document their responsibilities. The laboratory's standard operating procedures must meet user requirements in terms of specificity, completeness, precision, accuracy, representativeness, and comparability of the required testing procedures . The laboratory should devote approximately 10 to 20 percent of their resources to their QA/QC program.

Guidance in this chapter is broad based and may not be applicable to every laboratory. This chapter includes a Laboratory Quality Assurance Checklist for the inspector's use at the end of the chapter. For detailed information concerning laboratory QA, refer to Environmental Protection Agency's (EPA's) *Handbook for Analytical Quality Control in Water and Wastewater Laboratories* (USEPA 1979a). Further information is also available in the U.S. Environmental Protection Agency's (EPA's) *NPDES Compliance Monitoring Inspector Training Laboratory Analysis Module* (April 1990). If a more detailed assessment of a laboratory is required, personnel with more extensive knowledge of the methodologies should perform the inspection.

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7. B. Sample Handling Procedures

Evaluation of Permittee Sample Handling Procedures

Proper sample handling procedures are necessary in the laboratory from the sample's receipt to its discard. Sample handling procedures for small permittees may differ from procedures for larger permittees because staff organizational structures and treatment facility designs vary from one facility to the next. However, proper sample handling procedures should be standardized, utilized and documented by all permittees. In evaluating laboratory sample handling procedures, the inspector should verify the following:

- The laboratory has a sample custodian.
- The laboratory area is secure and restricts entry to authorized personnel only.
- The laboratory has a sample security area that is dry, clean, and isolated, has sufficient refrigerated space, and can be locked securely.
- A minimum number of people handle the samples.
- The custodian receives all incoming samples, signs the chain-of-custody record sheet accompanying the samples and retains the sheet as a permanent record.
- The custodian performs or analyzes checks of proper preservation, container type, and holding times and documents results.
- The custodian ensures that samples are properly stored.
- Only the custodian distributes samples to personnel who are to perform analyses.
- Transfer of samples is usually document by the sample custodian.
- Care and custody records for handling samples are accurate and up-to-date.

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7. C. Laboratory Analyses Techniques Evaluation

Evaluation of Permittee Laboratory Analytical Procedures

The permittee's laboratories or its contract laboratories must use uniform methods, thus, eliminating methodology as a variable when data are compared or shared among laboratories. The permittee's laboratory must select by consulting 40 *CFR* Part 136 or EPA for approval of alternative methods. A permittee may only use alternative test procedures if the procedures have EPA approval, as specified by 40 *CFR* 136.4 and 136.5, and promulgated under Public Law (PL) 92-500.

Many standardized test procedures promulgated under 40 *CFR* Part 136 are covered in *Methods for Chemical Analysis of Water and Wastes* (USEPA 1979b). Revisions and new additions to this publication are made whenever new analytical techniques or instruments are developed. These are considered accepted after final publication in the *Federal Register*. The latest accepted edition of *Standard Methods for the Examination of Water and Wastewater* [American Public Health Association (APHA), American Water Works Association (AWWA), and Water Environment Federation (WEF)]. (The most current 40 *CFR* Part 136 may supersede any method or technique cited in this manual.) Other approved methods from United States Geological Survey (USGS), American Society for Testing and Materials (ASTM), and several commercial vendor methods are also reference in 40 CFR 136.

In evaluating laboratory analytical procedures, the inspector should verify the following:

- The lab follows analytical methods specified in the most current 40 *CFR* Part 136 and properly performs any deviations allowed by 40 *CFR* Part 136.
- The lab uses a QC system that conforms to the system specified in the permit or to that detailed in published *Standard Methods* (APHA, AWWA, and WEF) (e.g., initial demonstration of capability for organic analyses).
- The lab maintains a QC record on reagent preparation, instrument calibration and maintenance, incubator temperature, and purchase of supplies.
- The lab conducts QC checks are made on materials, supplies, equipment, instrument calibration and maintenance, facilities, analyses, and standard solutions.
- The lab maintains documentation of any EPA-approved deviation from specified test procedures.

Evaluation of Permittee Laboratory Facilities and Equipment

To verify that the proper analytical procedures are being followed, the inspector should have the responsible analyst describe each of the procedures. The inspector should be alert to any

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deviation from the specified analytical method. Any questions regarding the proper procedures can be resolved by referring to the cited methodology. Even simple analyses can yield invalid results if the methodology cited in 40 *CFR* Part 136 is not exactly followed. Certain required deviations from the approved method are cited in 40 CFR 136, notes.

Laboratory Services

The availability of laboratory services affects data reliability. The inspector should verify that the laboratory provides the following items:

- An adequate supply of laboratory pure water, free from chemical interferences and other undesirable contaminants. The lab should check water quality routinely and document it.
- Adequate bench, instrumentation, storage, and recordkeeping space.
- Clean and orderly work area to help avoid contamination.
- Adequate humidity and temperature control.
- Adequate lighting and ventilation.
- Dry, uncontaminated, compressed air when required.
- Efficient fume hood systems.
- Necessary equipment such as hot plate, incubator, water bath, refrigerator for samples, pH meter, thermometer, and balance.
- Electrical power for routine laboratory use and, if appropriate, voltage-regulated sources for delicate electronic instruments.
- Emergency equipment, fire extinguisher, eye wash station, shower, first aid kit, gloves, and goggles.
- Vibration-free area for accurate weighings.

The inspector should also check that the lab uses proper safety equipment (lab coats, gloves, safety glasses, goggles, and fume hoods) where necessary. The laboratory should have a fire extinguisher, eye wash station, shower, and first aid kit. The inspector should document any problems and refer to the proper authority [e.g., Occupational Safety and Health Administration (OSHA)].

Instruments and Equipment

Instrumentation is extremely important in the analytical laboratory. To a certain extent, analytical instrumentation is always developmental; manufacturers are continually redesigning and upgrading their products, striving for miniaturization, enhanced durability and sensitivity,

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and improved automation. In evaluating laboratory instruments and equipment, the inspector should verify the following:

- The lab follows standard and specific procedures for cleaning glassware and containers are followed. Chapter Two of EPA's *NPDES Compliance Monitoring Inspector Training Laboratory Analysis Module* (April 1990) contains detailed information on glassware cleaning.
- The lab has written requirements (e.g., standard operating procedures) for daily operation of instruments and equipment which are easily accessible and the staff follow them.
- Standards and appropriate blanks are available from suppliers to perform standard calibration procedures. The lab should use standard concentrations that closely bracket actual sample concentrations. Sources of standards are documented and where possible, traceable to a national standard [e.g., National Institute of Standards and Technology (NIST)].
- Records of each set of analysis performed including the order in which calibration, QA and samples were analyzed (i.e., analysis run logs or instrument run logs).
- Lab has written troubleshooting procedures are available to identify common equipment malfunctions.
- Lab follows written schedules for replacement, cleaning, checking, and/or adjustment by service personnel.
- Lab maintains documentation on equipment maintenance and service checks.

Commonly used analytical instruments include analytical balances, pH meters, dissolved oxygen meters, conductivity meters, turbidimeters, spectrophotometers, atomic absorption spectrophotometers, organic carbon analyzers, selective ion analyzers, gas-liquid chromatographs, titrimetric analyses, and temperature controls. Chapter Two of EPA's *NPDES Compliance Monitoring Inspector Training Laboratory Analysis Module*. (April 1990) includes a detailed discussions on these instruments.

Maintenance of laboratory facilities and equipment is an important factor in laboratory QA. Qualified service checks should be performed and documented.

Supplies

Chemical reagents, solvents, and gases are available in many grades of purity, ranging from technical grade to various ultrapure grades. The purity of the materials required in analytical chemistry varies with the type of analysis. The parameter being measured, the analytical method, and the sensitivity and specificity of the detection system determine the purity of the reagents required. Do not use reagents of lesser purity than that specified by the method. In evaluating laboratory supplies, the inspector should verify that the laboratory:

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- Uses the required reagent purity for the specific analytical method.
- Stores standard reagents and solvents according to the manufacturer's directions.
- Checks working standards frequently to determine changes in concentration or composition.
- Verifies concentrations of stock solutions before being used to prepare new working standards.
- Date supplies with limited shelf life upon receipt and observe shelf-life recommendations, including the discard date on the container and the storage requirements.
- Prepare and standardize reagents against reliable primary standards.
- Label standards and reagents properly including the date of preparation, concentration and the analyst's identification.
- Store standards and reagents in appropriate containers and under required method conditions. If conditions are not specified, standards and reagents are stored according to 40 *CFR* Part 136, Table II. See Chapter Five, Sampling, Table 5-3.
- Check the accuracy of purchased solutions as per method requirements.
- Use clean containers of suitable composition with tight-fitting stoppers or caps for storage.
- Discard reagents when signs of discoloration, formation of precipitates, or significant changes in concentrations are observed.
- Prepare stock solutions and standards using volumetric glassware.

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7. D. Quality Assurance and Quality Control

Evaluation of the Precision and Accuracy of the Permittee Laboratory

The purpose of laboratory control procedures is to ensure high-quality analyses by the use of control samples, control charts, reference materials, and instrument calibration. The laboratory must initiate and maintain controls throughout the analysis of samples. Specifically, each testing batch must contain at least one blank, standard, duplicate, and spiked (as applicable) sample analysis. When a batch contains more than 10 samples, every tenth sample should be followed by a duplicate and a spike (as applicable).

The precision of laboratory findings refers to the reproducibility or degree of agreement among replicate measurements of the same quantity. The closer the numerical values of the measurements come to each other, the more precise are the measurements. In a laboratory QC program, precision is determined by the analysis of actual samples in duplicate. These may represent a range of concentrations and a variety of interfering materials usually encountered during the analysis. Accuracy refers to the degree of difference between observed values and known or actual values. The closer the value of the measurement comes to the actual value, the more accurate the measurement is. The accuracy of a method can be determined by analyses of samples to which known amounts of reference standards have been added (spiked samples).

In evaluating the precision of the measurement process, the inspector should verify that:

- The lab introduces control samples into the train of actual samples to monitor the performance of the analytical system. Control samples include any digestions, extractions, distillations and other sample preparations as for sample analyses.
- Perform duplicate analyses with each batch of samples to determine precision. In general, 10 percent of the samples should be duplicated.
- Prepare and use precision control charts or other statistical techniques for each analytical procedure. Develop precision control charts by collecting data from a minimum of 15 to 20 duplicate samples (run in controlled conditions) over an extended period (e.g., 10 to 20 days). Statistical methods include calculation of mean, standard deviation, and variance to define the range and variability of the data.
- Take corrective actions when data fall outside the warning and control limits.
- Document out-of-control data, the situation, and the corrective action taken.

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In evaluating accuracy, the inspector should verify that the laboratory:

- The lab introduces spiked samples into the train of actual samples at least 10 percent of the time to monitor the performance of the analytical system.
- The lab uses spiked samples to monitor accuracy in each sample batch.
  - The amount of additive is appropriate to the detection limit and sample concentration.
- Prepare and use accuracy control charts for each analytical procedure. The lab should develop accuracy control charts by collecting data for a minimum of 15 to 20 samples over an extended period of time.
  - Establish accuracy limits (as % recovery) based on standard deviations whose upper and lower control limits are established at three times the standard deviation above and below the central line.
  - Establish the upper and lower warning limits at twice the standard deviation above and below the central line. Note: Some parameters have a defined warning limit required by 40 *CFR* Part 136.
  - Take corrective actions when data fall outside the warning and control limits.
  - Document out-of-control data or situation and the corrective action taken.

Evaluation of Permittee Data Handling and Reporting

An analytical laboratory must have a system for uniformly recording, correcting, processing, and reporting data. The inspector should verify that the laboratory:

- Uses correct formulas to calculate the final results.
- Applies round-off rules are uniformly.
- Establishes significant figures for each analysis.
- Cross-checking calculations provisions are available.
- Determine control chart approaches and statistical calculations for the purposes of QC and reporting.
- The laboratory report forms provide complete data documentation and permanent recording, and they facilitate data processing.
- The program for data handling provides data in the form/units required for reporting.
- Maintain laboratory records for a minimum of 3 years (or longer and made available if requested by EPA or the State).

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- Keeps laboratory notebooks or pre-printed data forms that are bound permanently to provide good documentation, including the procedures performed and the details of the analysis, such as the original value recorded, correction factors applied, blanks used, and the reported data values. The dated notes indicate who performed the tests and include any abnormalities that occurred during the testing procedure. Laboratory maintains the notes as a permanent laboratory record.

- Procedures for correction of data entry errors are defined. Original data entries can be read and the individual(s) making the corrections are clearly identified.

- Back up computer data with duplicate copies (i.e., electronic and hardcopy).

- Proper data handling and reporting procedures are implemented by all contract laboratories performing sample analyses.

- Maintain data records that allow the recalculation of all results reported by the laboratory(ies) from the original unprocessed results (i.e., raw data) to the final results sent to EPA and the regulatory authority for a minimum of three (3) years.

Evaluation of Permittee Laboratory Personnel

Analytical operations in the laboratory vary in complexity. Consequently, laboratory should clearly define work assignments in the laboratory. All analysts should be thoroughly instructed in basic laboratory operations. Those persons performing complex analytical tasks should be qualified and properly trained. All analysts must follow specified laboratory procedures and be skilled in using the laboratory equipment and techniques required for the analyses assigned to them. In evaluating laboratory personnel, the inspector should consider the following factors:

- Adequacy of training

- Skill and diligence in following procedures

- Skill and knowledge of staff in using equipment and analytical methods (particularly for complex equipment such as gas chromatography)

- Precision and accuracy in performing analytical tasks

- Assignment of clearly defined tasks and responsibilities.

Evaluation of Contract Laboratories

When the permittee contracts with the laboratory to analyze samples, the inspector may need to evaluate the laboratory practices at the contracted laboratory. The practices can also be evaluated by other designated EPA inspectors. If a deficiency is identified at a contract laboratory, the permittee is responsible for the deficiency and will be notified.

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Overview of the Discharge Monitoring Report Quality Assurance Program and How It Relates to the Inspection Program

The validity of the National Pollutant Discharge Elimination System (NPDES) program depends on the quality of the self-monitoring program. The Discharge Monitoring Report Quality Assurance (DMR QA) program is an important tool used to ensure the quality of NPDES self-monitoring data. The program is designed to evaluate and improve the ability of laboratories serving NPDES permittees to analyze and report accurate self-monitoring data.

Majors must purchase under NPDES performance evaluation samples containing constituents normally found in industrial and municipal wastewaters from accredited providers . They must analyze these samples using the analytical methods and laboratory normally employed for their reporting of NPDES self-monitoring data. The supplier of the performance evaluation sample will evaluate the results and respond to the permittee.

Highlights

- The DMR QA Program has been an excellent means of focusing on and improving the quality of laboratory results used in developing DMR data. Improvements in the DMR QA data have been significant.
- This program has helped major permittees identify and correct both analytical and data handling problems in their laboratories.
- In general, permittees are receptive to the program and recognize its value, including some who challenged EPA's authority to require participation.
- Regions and States are generally supportive and have made good use of the results of this program for targeting inspections and directing other follow-up activities. This ability to concentrate corrective actions on problem permittees results in an increased efficiency in improving the self-monitoring data of all NPDES permittees.
- The program is one of the least resource-intensive methods for maintaining direct and regular technical contact with NPDES permittees. It has been recognized as a cost-effective effort.
- Utilizing computer technology, the following ways of managing and analyzing DMR QA data were started in FY 1985: compiling tracking summaries, comparing performance of the major industries, tracking multiple permittees, and regenerating past performance evaluation reports.

The DMR QA Program and the NPDES inspection programs are interdependent in several areas. First, to target the inspections, the regulatory agency can use DMR QA evaluations of permittee performance can be used, since the evaluations identify potential problems in laboratory analysis or data handling and reporting. This targeting helps to direct limited resources to permittees who need them most. Non-reporting of DMR QA results is an important trigger for on-site inspections.

The results are provide to and tracked by EPA and the State DMR QA coordinator.

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Finally, EPA uses the Performance Audit Inspection (PAI), to follow up the DMR QA. The DMR QA results should be cross-checked with the permit prior to the onsite visit, and parameters that were failed should be checked by the inspector during a laboratory inspection.

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LABORATORY QUALITY ASSURANCE CHECKLIST

A. GENERAL

Yes	No	N/A	1. Written laboratory QA manual available.

B. SAMPLE HANDLING PROCEDURES

Yes	No	N/A	1. Laboratory has sample custodian and a back-up custodian.
Yes	No	N/A	2. Access to laboratory area restricted to authorized personnel only.
Yes	No	N/A	3. Sample security area available within laboratory that is dry, clean, and isolated; has sufficient refrigerated space; and can be locked securely.
Yes	No	N/A	4. Custodian receives and logs in all incoming samples.
Yes	No	N/A	5. Follows established chain-of-custody procedures.
Yes	No	N/A	6. Checks of proper preservation, container type, and holding times performed by the custodian or the analysts with the results fully documented.
Yes	No	N/A	7. Samples properly stored by custodian.
Yes	No	N/A	8. Samples distributed to analysts by custodian only.
Yes	No	N/A	9. Transfer of samples fully documented.
Yes	No	N/A	10. Accurate and up-to-date care and custody records for handling samples maintained.
Yes	No	N/A	11. Documentation and procedures for disposal of test samples and test standards.

C. LABORATORY PROCEDURES

Yes	No	N/A	1. EPA-approved written analytical testing procedures used and protocols are easily accessible by laboratory personnel.
Yes	No	N/A	2. If alternate analytical procedures used, proper written approval obtained.
Yes	No	N/A	3. Calibration and maintenance of instruments and equipment satisfactory.
Yes	No	N/A	4. QA procedures used.
Yes	No	N/A	5. QC procedures adequate.
			6. Duplicate samples are analyzed % of time.
			7. Spiked samples are used % of time.
Yes	No	N/A	8. Whole Effluent Toxicity (WET) testing is required by the permit and conducted by the laboratory. Culturing procedures are adequately documented for each organism tested.
Yes	No	N/A	9. WET testing protocols are clearly described.
Yes	No	N/A	10. Commercial laboratory used. Name _____ Address _____ Contact _____ Phone _____

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		Certification #

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LABORATORY QUALITY ASSURANCE CHECKLIST (Continued)

D. LABORATORY FACILITIES AND EQUIPMENT

Yes	No	N/A	1. Proper grade laboratory pure water available for specific analysis.
Yes	No	N/A	2. Adequate bench, instrumentation, storage, and recordkeeping space available.
Yes	No	N/A	3. Clean and orderly work area available to help avoid contamination.
Yes	No	N/A	4. Dry, uncontaminated compressed air available.
Yes	No	N/A	5. Sufficiently ventilate fume hood.
Yes	No	N/A	6. Laboratory sufficiently lighted and ventilated.
Yes	No	N/A	7. Adequate electrical sources available.
Yes	No	N/A	8. Instruments/equipment in good condition.
Yes	No	N/A	9. Use proper safety equipment (lab coats, gloves, safety glasses, goggles, and fume hoods) when necessary.
Yes	No	N/A	10. Written requirements for daily operation of instruments available.
Yes	No	N/A	11. Standards and appropriate blanks available to perform daily check procedures.
Yes	No	N/A	12. Sources of standards documented and where possible traceable to a national standard (e.g., NIST).
Yes	No	N/A	13. Records of each set of analysis including order in which calibration, QC and samples were analyzed (i.e., analysis run logs or instrument run logs) available.
Yes	No	N/A	14. Written troubleshooting procedures for instruments available.
Yes	No	N/A	15. Schedule for required maintenance exists.
Yes	No	N/A	16. Proper volumetric glassware used.
Yes	No	N/A	17. Glassware properly cleaned.
Yes	No	N/A	18. Properly store standard reagents and solvents with the expiration dates clearly displayed on the containers.
Yes	No	N/A	19. Frequently checked working standards.
Yes	No	N/A	20. Discard standards after recommended shelf-life has expired.
Yes	No	N/A	21. Background reagents and solvents run with every series of samples.
Yes	No	N/A	22. Written procedures exists for cleanup, hazard response methods, and applications of correction methods for reagents and solvents.
Yes	No	N/A	23. Replace gas cylinders at 100-200 psi.

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LABORATORY QUALITY ASSURANCE CHECKLIST (Continued)

E. LABORATORY'S PRECISION, ACCURACY, AND CONTROL PROCEDURES

Yes	No	N/A	1. Analyzed multiple replicates (blanks, duplicates, spikes, and splits) for each type of control check and information recorded.
Yes	No	N/A	2. Plotted precision and accuracy control methods used to determine whether valid, questionable, or invalid data are being generated from day to day.
Yes	No	N/A	3. Generate control samples introduced into the train of actual samples to ensure that valid data.
Yes	No	N/A	4. Precision and accuracy of the analyses are sufficient.

F. DATA HANDLING AND REPORTING

Yes	No	N/A	1. Uniformly apply round-off rules.
Yes	No	N/A	2. Establish significant figures for each analysis.
Yes	No	N/A	3. Use provision for cross-checking calculation.
Yes	No	N/A	4. Use correct formulas to calculate final results.
Yes	No	N/A	5. Control chart approach and statistical calculations for QC and report available and followed.
Yes	No	N/A	6. Report forms developed to provide complete data documentation and permanent records and to facilitate data processing.
Yes	No	N/A	7. Data reported in proper form and units.
Yes	No	N/A	8. Laboratory records readily available to regulatory agency for required time of 3 years.
Yes	No	N/A	9. Laboratory notebook or pre-printed data forms bound permanently to provide good documentation.
Yes	No	N/A	10. Computer data backed up with duplicate copies (i.e., electronic and hardcopy).
Yes	No	N/A	11. Efficient filing system exists, enabling prompt retrieval of information and channeling of report copies.
Yes	No	N/A	12. Data records allow recalculation of all results reported by the laboratory(ies) from the original unprocessed results (raw data) to the final results sent to EPA and the regulatory authority.

G. LABORATORY PERSONNEL

Yes	No	N/A	1. Enough analysts present to perform the analyses necessary.
Yes	No	N/A	2. Analysts have on hand the necessary references for EPA procedures being used.
Yes	No	N/A	3. Analysts trained in procedures performed through formal or informal training or certification programs.

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8. TOXICITY

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Related Websites

Whole Effluent Toxicity (WET) Methods: http://www.epa.gov/waterscience/WET
Office of Wastewater Management (OWM) Homepage: http://www.epa.gov/owm

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8. A. Objectives

By definition, toxicity is a characteristic of a substance (or group of substances) that causes adverse effects in organisms. Adverse effects include an increased rate of morbidity (the rate of occurrence of disease) and mortality (the rate of occurrence of death), as well as those effects that limit an organism's ability to survive in nature, such as impaired reproductive ability or growth. Toxicity of a substance is measured by observing the responses of organisms to increasing concentrations of that substance. One substance is more toxic than another when it causes the same adverse effects at a lower concentration.

Whole Effluent Toxicity (WET) is a National Pollutant Discharge Elimination System (NPDES) permit parameter designed to evaluate the toxicity of the entire wastestream as opposed to just individual pollutants. The WET testing may be either performed or evaluated as part of one of five NPDES inspections:

- Compliance Evaluation Inspection (CEI)
- Compliance Sampling Inspection (CSI)
- Performance Audit Inspection (PAI)
- Toxics Sampling Inspection (XSI)
- Compliance Biomonitoring Inspection (CBI).

In addition, the toxicity of a municipal treatment plant effluent should be considered as part of the Pretreatment Compliance Inspection (PCI), especially if unacceptable levels of toxicity have been demonstrated and the cause of the toxicity has been investigated and found to be from industrial or commercial dischargers contributing to the system.

Methods manuals for Whole Effluent Toxicity testing can be accessed at:

http://www.epa.gov/waterscience/WET.

The inspector should understand the permittee's WET testing requirements so that the appropriate objectives can be met:

- Assess compliance with NPDES permit conditions
- Determine compliance with State water quality standards
- Consider overall Lab WET test performance (reference toxicants and other WET QA/QC requirements)
- Evaluate quality of self-monitoring data
- Assess adequacy of self-monitoring procedures
- Document presence or absence of toxic conditions
- Identify need to perform Toxicity Reduction Evaluation (TRE) and/or a Toxicity Identification Evaluation (TIE)
- Develop permit limits for WET, if appropriate

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WET test reviews performed as part of a routine facility inspection are cursory. The intent is to quickly ascertain if the facility is following their permit requirements and, secondarily, to see if there are any obvious problems with reporting or lab performance. The following checklist provides some of the more obvious and quickly determined issues that can be addressed during a facility inspection.

- Does the facility have a copy of its NPDES permit readily available? (Although the inspector should bring a copy in the event the permittee cannot find his).
- Check the permit for the WET testing frequency and any special conditions related to WET testing, including whether a testing frequency decrease is authorized.
- Are *all* test reports for WET tests performed over the last three years available for review?
- Are the test reports complete (e.g., bench data sheets for chemicals and test organisms, chain of custody tags, statistical analyses, etc.)?
- Was the correct type test performed?
- Did effluent samples contain any measurable chlorine, or > 10 mg/l ammonia?
- Was the test initiated within 36 hours of the first test sample being grabbed or removed from the compositor? This can be verified by checking dates and times on chain-of-custody tags and bench sheets.
- Did the lab or permittee make any judgement decisions beyond their authority?
- Were there any aberrations in the test?
- Were the test results reported correctly to the permittee and on the DMR?
- Was the test invalid due to poor control performance?
- If the test was declared invalid, was a retest performed and reported?

In the case of a PAI, the laboratory performing the WET tests is evaluated, as well as the NPDES permittee. This type of inspection requires more extensive information than is presented in this section. The inspector is therefore referred to the Environmental Protection Agency's (EPA) *Manual for the Evaluation of Laboratories Performing Aquatic Toxicity Tests* (EPA-600/4-90/031) for the protocol to perform a PAI.

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8. B. Requirements of WET Testing

Types of WET Testing

WET tests are techniques to determine the toxicity of a permittee's discharge or effluent by measuring the responses of organisms to a set of multi-concentration solutions of the effluent and dilution water. The WET test methods, as revised November, 2002, are specified in 40 *CFR* Part 136 and described in the WET methods manuals that can be accessed at http://www.epa.gov/waterscience/WET. Test designs may vary in number of organisms used, duration (acute or chronic) or in the way in which the effluent contacts the organism (flow-through, static, static renewal), depending on suspected toxicants present and how the results are to be used. Range finding (screening) tests normally use few organisms and a single effluent concentration. However, WET testing is usually performed as a definitive testing.

In a definitive test, several groups (replicates) of organisms are exposed for a predetermined length of time to a set of multi-concentration solutions of effluent and dilution water. The tests consist of a control and a minimum of five effluent concentrations, with four replicates of each dilution. See the WET methods manuals for more details. The response of each organism in each test concentration is observed and recorded, and the number of responses is analyzed in relation to the concentrations of effluent to which the organisms were exposed.

WET testing may be performed as either acute or chronic tests. The terms acute and chronic refer to the length of time that the organisms are exposed to the toxicant. The duration of the tests should be specified in the NPDES permit. Generally, acute tests measure short-term effects with impacts usually resulting in death or extreme physiological disorder. A response observed in 96 hours or less typically is considered acute. Chronic tests involve a stimulus that lingers or continues for a relatively long period, often one-tenth of a lifespan or more. Chronic should be considered a relative term depending on the lifespan of an organism. Typically most WET chronic tests run for seven days. Acute effects result in death. A chronic effect may result in death, stunted growth, or reduced reproductive rates.

Common test responses indicating the presence of toxic conditions include:

- Death — Increase in number of organisms killed by a test solution when compared to the control
- Growth — Measurement of reduction in growth compared to the control (including mean weight of an organism)
- Reproduction — Measurement of reduction in reproductive rates compared to the control
- Terata — Increase in number of gross abnormalities shown in early life stages compared to the control.

WET tests are also described according to the way in which organisms are physically exposed to test solutions. The terms flow-through, static renewal, and static are most commonly used to describe the test design type. In a flow-through test, effluent and dilution water are

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mechanically renewed continuously. This test setup requires specialized equipment (a serial or proportional dilutor or syringe pumps) and is more costly to operate than a static test. In a static renewal test, the test solutions are replaced periodically (usually daily) with fresh effluent and dilution water. In a static test, the solutions used at the start of the test are not replaced for the test's duration. Both static renewal and static tests require less sophisticated equipment. The method of test design type should be specified in the NPDES permit for the acute test methods. The selection of test design type for the chronic test methods is pre-described in the test methods.

WET Test Components

The following discussions pertain primarily to issues in a lab audit.

WET tests consist of a number of components, as shown below:

- Effluent
- Dilution water
- Test apparatus
- Test organisms
- Reference toxicants
- Test results.

In simple terms, effluent and dilution water are combined in the test system with test organisms to produce test results. Each component including food items must be of a specific quality for successful toxicity testing. It is the inspector's job to determine (insofar as possible) from the information available, that the test components adhere to the standards specified in the NPDES permit or accepted reference method (e.g., EPA's WET methods at 40 *CFR* Part 136). Review of the permittee's sampling logbook, chain-of-custody forms, and contract lab reports should provide most of the information necessary to assess the quality of the test components.

Each component has specific requirements (e.g., sample location for the effluent, sample holding time, dilution water constituents, choice of test apparatus materials). Accurate and reproducible test results can only be expected when the critical test components are handled properly. It is, therefore, very important to understand the relationships between these test components and the critical factors that determine the acceptability of each from a quality assurance standpoint. Critical factors that would likely be encountered during a NPDES inspection are described in the following sections.

Effluent

Effluent sampling strategy will usually be specified in the NPDES permit. Effluent samples must be representative of the entire discharge and free of contamination from other sources. Samples collected for off-site toxicity testing are to be chilled to 0°-6°C during or immediately after collection, and shipped iced to the performing laboratory.

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The type and frequency of samples taken (e.g., grab, composite) must be consistent with those required in the permit. For flow-through tests that are not done by pumping effluent directly into dilutors, daily sample sizes must be sufficient to supply the dilutor for periods ranging from 24 to 36 hours. This volume will depend on the type of test being conducted and the number of dilutions being run. For static renewal tests, daily sample volumes should be sufficient to replenish all dilutions in the test series and to provide separate vials of the dilutions to allow for dissolved oxygen (DO), pH, salinity, and other chemical analyses without contamination of the test dilutions. This volume will depend on the type of test being conducted and dilutions being run. Table 8-1 provides guidance as to representative sampling strategies for various situations. For some volatile toxicants that are acutely toxic (e.g., chlorine) standard composite sampling does not yield an effluent sample that is representative of the actual discharge due to volatilization of chlorine during sampling, shipping and holding. On-site flow-through testing would yield more appropriate test results where, considering available dilution, the effluent contains measurable amounts of chlorine.

Samples for onsite tests should be used immediately when practical, but must be used within 36 hours of collection. It is usually not possible to refrigerate the large-volume samples (200 liters or more) that are required for flow-through fish tests, but all other samples should be either iced or refrigerated if they are not to be used immediately. Note: hand-delivered samples used on the same day of collection do not need to be cooled at 0°-6°C prior to test initiation.

Samples to be used for offsite tests should be iced for shipment and refrigerated (0°-6°C) upon receipt by the testing laboratory. As a minimum requirement in all cases, tests should be initiated within 36 hours of collection. In the case of short-term chronic tests, samples taken on days one, three, and five may be held for a longer period of time to complete the test. In no case should any preservative be added to samples or chemical disinfection performed prior to being tested for toxicity, nor should samples be dechlorinated unless the permit specifically allows for sample dechlorination.

Dilution Water

The choice of dilution water is generally specified in the NPDES permit and depends on the purpose of the toxicity test. Synthetic dilution water is used to evaluate the inherent toxicity of the effluent. Dilution water from the receiving stream or a nontoxic equivalent is used to test for interactions after discharge. Receiving waters, synthetic waters, or synthetic waters adjusted to approximate receiving water characteristics may be used for dilution water, provided that the water meets the qualifications for an acceptable dilution water. Under no circumstances should the dilution water cause any toxic responses in test organisms. A lack of toxic responses in control organisms is evidence of the suitability of the dilution water. Control organisms should have less than or equal to 10 percent mortality in acute tests and less than or equal to 20 percent mortality for chronic tests. EPA manuals describe various techniques for the preparation of synthetic dilution water which may be necessary to use if the natural receiving water exhibits unacceptable levels of toxicity.

Dilution water obtained from receiving waters should be immediately used for testing. If it will not be used within 24 hours, it should be refrigerated (0°-6°C) as soon as it is collected. In any case, the receiving water should be used within 36 hours of collection. So that no appreciable change in toxic characteristics occurs before testing, the lapsed time (holding time) from sample collection to first use of the sample in test initiation must not exceed 36 hours unless a

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variance has been granted. If holding is necessary, the samples must be stored under strict conditions (temperatures for WET samples as 0°-6°C). The location from which the dilution water was obtained should be noted in the permittee's sampling log. It should be upstream and out of the influence of the outfall. The location should be free of other sources of contamination (e.g., other outfalls).

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Table 8-1

Recommended Sampling Strategies for Continuous and Intermittent Discharges for Flow-Through, Static Renewal, and Static Toxicity Tests*

CONTINUOUS DISCHARGE

TEST TYPE	CHRONIC	ACUTE Retention Time < 14 Days	ACUTE Retention Time >14 Days
Flow-through**	-	Two Grab samples daily (early a.m. and late p.m.)	One grab sample daily
Static renewal	3x 24-Hour composite samples, every other day	Four separate grab samples each day for four concurrent tests	One grad sample daily
Static	Single 24-Hour composite sample on first day	Four separate grab samples on first day for four concurrent tests	One grab sample on first day

* Sampling requirements should be clearly specified in the permit

* For flow-through tests, it is always preferable to pump directly to the dilutor

INTERMITTENT DISCHARGE

TEST TYPE	CHRONIC	ACUTE Continuous Discharge During 1 or 2 Adjacent 8-Hour Shifts	ACUTE Discharge From Batch Treatment	ACUTE Discharge to Estuary on Outgoing Tide
Flow-through	-	One grab sample midway through shifts daily	One grab sample of discharge daily	One grab sample of discharge daily
Static renewal	3x 24-Hour composite samples collected for duration of discharge unless discharge ceases	One grab sample midway through shifts on first day	One grab sample of discharge daily	One grab sample of discharge daily
Static	Composite sample collected for duration of discharge, first day	One grab sample midway through shifts on first day	One grab sample of discharge on first day	One grab sample of discharge on first day

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Test System

WET tests may be performed in a fixed or mobile laboratory. Depending on the scope of the program, facilities may include equipment for rearing, holding, and acclimating test organisms. Temperature control is achieved using circulating water baths, heat exchangers, or environmental chambers. Appropriate dilution water may be groundwater, surface water, reconstituted water, or dechlorinated tap water. Holding, acclimation, and dilution water should be temperature controlled and aerated whenever possible. Air used for aeration must be free of oil and fumes; filters to remove oil in air are desirable. Test facilities must be well-ventilated and free of fumes. During holding, acclimating, and testing, test organisms should be shielded from external disturbances. Reference toxicants should be properly stored in a closed area separate from the WET testing areas.

Any materials that come into contact with either effluent or dilution water must not release, absorb, or adsorb toxicants. A number of different choices for test equipment are available. Glass and No. 304 or 306 stainless steel are generally acceptable for freshwater holding, mixing, and test chambers. Stainless steel, however, is not acceptable for saltwater systems. Square-sided glass aquaria should be held together with small beads of silicone adhesive, with any unnecessary adhesive removed from inside the aquaria. If stainless steel containers are used, they must be welded, not soldered. Other specialized containers of nitex or teflon are also acceptable. Tanks for storing effluents and dilution water may also be made of fiberglass. All containers or tubes made of these materials are reusable with appropriate cleaning (see below).

Polyethylene, polypropylene, polyvinyl chloride, polystyrene, and tygon may also be used for containers or tubing, but should be checked for toxicity before being used. Because these materials may absorb toxicants during a test, their reuse is discouraged to prevent absorbed toxicants from leaching into new effluent or dilution water.

Copper, galvanized metal, brass, lead, and rubber must not contact the testing solutions at any time.

New plasticware (from a known nontoxic source) can be used after rinsing with dilution water. New glassware should be soaked overnight in dilute (20 percent) nitric or hydrochloric acid, rinsed in tap water, and then rinsed with dilution water before use.

Glassware and stainless steel components that must be reused should be soaked in detergent and scrubbed (or washed in a laboratory dishwasher), rinsed twice with tap water, rinsed with dilute acid, rinsed twice with tap water, rinsed with full strength acetone, rinsed twice with tap water, and then rinsed with dilution water before use. Glassware for algae tests should be neutralized in sodium bicarbonate before use.

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Test Organisms

Organisms used for toxicity testing are limited to certain species for which there are established testing protocols (EPA 40 *CFR* Part 136). Species commonly used in biomonitoring include daphnids, mysids, fathead minnows, silversides, and algae. The life stage, source, acclimation and feeding procedures, presence of disease, and the number of organisms placed in test chambers all affect the degree to which organisms respond to toxicants. Therefore, it is important that these factors comply with accepted test method procedures. Test conditions for various types of tests and organisms can be accessed at: http://www.epa.gov/waterscience/WET.

The inspector should ascertain, as closely as possible, that the following procedures are being observed:

- The correct organisms must be utilized in the test (most often as specified in the NPDES permit). "Wild" organisms are rarely appropriate in WET testing. Test organisms used in toxicity testing must be of known history, free of disease, and acclimated to test conditions. Culture information should be recorded. Test organisms must also be of the appropriate age. The appropriate number of organisms must be used in each test vessel.

- Test organisms should be fed according to the requirements for the particular type of test. When feeding is necessary for mysid or fish tests, excess food should be removed daily by aspirating with a pipette, to avoid problems such as food buildup leading to excessive oxygen demand.

- A daily log (that is a daily bench sheet for each test being performed) should be kept by the lab of feeding, reproduction, growth, mortality, and any abnormal behavioral observations.

- The following procedures must be adhered to (by the contract laboratory) for holding test organisms:

  - Test organisms purchased may be used to start mass cultures. However, if the organisms are to be used for testing then they must be no more than 48 hours old (if fish, purchased and shipped) and must be <24 hours old (fish, if not shipped, and freshwater invertebrates) at the start of the test. Freshwater invertebrates used in a test must also have all been released within an 8 hour period, to ensure reproductive performance is not impacted.

  - Maintain DO levels above 4 mg/L for warm water species and above 6 mg/L for cold water species.

- The laboratory should record the source of test organisms (hatchery, in-house, or elsewhere), as well as holding conditions (temperature, dissolved oxygen).

- Test organisms should be handled as little as possible to minimize stress:

  - Dip nets should be used for large organisms

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- Pipettes should be used for transferring small organisms such as daphnids and midge larvae.

Reference Toxicants

Reference toxicants are used to evaluate the health and sensitivity of test organisms over time and for documenting initial and ongoing laboratory performance. A laboratory performs a definitive toxicity test with a reference toxicant at least once per month using each toxicity test method conducted in that month. The monthly results are plotted on a control chart to track trends in organism health or sensitivity.

EPA does not require the use of specific reference toxicants and does not set required acceptance ranges for reference toxicant testing. Testing laboratories must perform at least one acceptable reference toxicant test per month for each type of toxicity test method conducted in that month regardless of the source of test organisms. If a test method is conducted only monthly, or less frequently, a reference toxicant test must be performed concurrently with each effluent toxicity test to document ongoing laboratory performance and assess organism sensitivity and consistency when organisms are cultured in-house. When organisms are obtained from external suppliers, concurrent reference toxicant tests must be performed with each effluent sample, unless the test organism supplier provides control chart data from at least the past five months of reference toxicant testing, which will assess organism sensitivity and health. The method manuals require a laboratory to obtain consistent, precise results with reference toxicant toxicity tests with effluents under the NPDES permits.

An attempt should be made to match the type of reference toxicant used (e.g., metal or chlorinated organic) to the major pollutant in the wastewater tested. Reference toxicant data must be included with the contract lab report.

Reference toxicant test results should not be used as *de facto* criteria for rejection of individual effluent or receiving water tests. The methods manuals provide guidance for what to do when more than 1 reference test in 20 reference toxicant tests falls outside of control chart limits, or when a reference toxicant test result falls "well" outside of control limits. The laboratory should investigate sources of variability, take corrective actions to reduce identified sources of variability, and perform an additional reference toxicant test during the same month.

Conduct of the Test(s)

Test methods should be used by analysts experienced in the use or conduct of aquatic tests and the interpretation of data from aquatic toxicity testing. Test conditions should be those as specified in the summary of test condition tables provided for each method. Physical and chemical measurements taken during the test (e.g., temperature, pH, and DO) must be conducted at a minimum as specified in the method manuals. The test methods should follow the procedures as described in each test method section of the manual following the table of recommended test conditions. Test organisms should be obtained and added according to the guidance in any specific method.

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Recordkeeping and Data Reporting

Proper recordkeeping is essential to an effective program. Chain-of-custody (COC) procedures should consistently be used to document sample transfer. Hand-written entries on bench sheets and COC tags must generally be clear and legible. The permittee should maintain a sample log containing information as to the date, time, and type of sample taken as well as the sampler's name. Unusual conditions should be noted. When evaluating the contract lab's data reporting, the inspector should verify that the following are included:

- Summary of test results, description of test conditions, material tested, and other data for quality assurance.
- Methods used for all analyses. The method title, method number and method source should be provided in the laboratory standard operating procedure (SOP) and test report. Tests must be conducted as stated in SOP and laboratory should verify test was conducted according to SOP.
- Date and time test started; date and time test terminated, type and volume of test chambers, volume of solution used per chamber, number of organisms per test chamber, number of replicate test chambers per treatment.
- The test temperature (mean and range), details of whether test was aerated or not, feeding frequency, and amount and type of food, any pH control measures taken.
- Any deviation from standard test methods. The test endpoint(s), and any deviation(s) from method must be clearly noted.
- The reference toxicity results for tests conducted for the test period with specific test details to verify species, temperature, and dilution water used in reference toxicant test.
- Any acclimation of test organisms (temperature mean and range) and the reason(s) for acclimation.
- Any other relevant information.

It is important that the contract lab to have a copy of the permittee's NPDES permit, including any modifications. By having a copy of the permit, the lab can better ensure that proper test procedures are being followed.

Any deviations from specifications should be documented and described in the data report by the testing laboratory. For WET test data submitted under NPDES permits, all required test conditions must be met or the test is considered invalid and must be repeated with a newly collected sample. Deviations from recommended test conditions must be evaluated on a case-by-case basis to determine the validity of test results. Deviations from recommended test conditions may or may not invalidate a test result depending on the degree of the departure and the objective of the test. Consideration of the degree of the deviation and the potential or observed impact of the deviation on the test result before rejecting or accepting a test result is valid. For example, if dissolved oxygen is measured below 4.0 mg/L in one test chamber, the reviewer should consider whether any observed mortality in that test chamber corresponded with the drop in dissolved oxygen. Whereas slight deviations in test conditions may not

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invalidate an individual test result, test condition deviations that continue to occur frequently in a given laboratory may indicated the need for improved quality control in that laboratory.

Data for each test should be provided as the raw toxicity data in tabular form, including daily records of affected organisms in each concentration (including controls) and replicate, and in graphical form (plots of toxicity data) and include a table of LC_{50}s, NOECs, IC_{25}, IC_{50}, etc. (as required in the applicable NPDES permit). Records should indicate statistical methods used to calculate endpoints, and have a summary table of physical and chemical data. Testing laboratories should maintain quality assurance/quality control (QA/QC) control charts for percent minimum significant difference (PSMD) along with the statistical endpoints such as NOEC, LC50, EC25. Testing laboratories should regularly plot the individual raw test data and the average treatment responses to examine possible causes of excessive variability. For more information on possible contributing factors to WET variability and recommendation for reducing it, see sec 7.3 *of Understanding and Accounting for Method variability in Whole Effluent Toxicity Applications Under the National Pollutant Discharge Elimination System Program*, U.S. EPA, 2000. EPA/833/R-00/003.

The concentration-response relationship generated for each multi-concentration test must be reviewed to ensure that calculated test results are interpreted appropriately. All WET test results (from multi-concentration tests) reported under the NPDES program should be reviewed and reported according to USEPA guidance on the evaluation of concentration-response relationships (USEPA, 2000a). This guidance provides review steps for 10 different concentration-response patterns that may be encountered in WET test data. Based on the review, the guidance provides one of three determinations: that calculated effect concentrations are reliable and should be reported, that calculated effect concentrations are anomalous and should be explained, or that the test was inconclusive and the test should be repeated with a newly collected sample. It should be noted that the determination of a valid concentration-response relationship is not always clear cut. Data from some tests may suggest consultation with professional toxicologists and/or regulatory officials. Tests that exhibit unexpected concentration-response relationships also may indicate a need for further investigation and possible retesting. Each test must be reviewed to ensure that the test acceptability requirements have been met and that the data from the calculated test results are interpreted appropriately (USEPA, 2002a). Test review should include reviewing reference toxicant testing and the within-test variability should be reviewed. EPA's preferred method of data analysis is point estimation, but when NPDES permit require sublethal hypothesis testing endpoints, the within-in test variability must be reviewed and variability criteria applied. When tests are used for non-regulatory purposes, the variability is not required.

In addition to reviewing the concentration-response relationship, the within-test variability of individual tests should be reviewed. When NPDES permits require sublethal hypothesis testing endpoints (e.g., reproduction for the *Ceriodaphnia dubia* test), within-test variability must be reviewed and variability criteria must be applied as described in the chapter on "Report Preparation and Test Review" of each manual. Compare the PMSD measured in the test with the PMSD bounds listed in the report chapter. When the methods are used for non-regulatory purposes, the variability criteria are recommended but are not required, and their use (or the use of alternative variability criteria) may depend upon the intended uses of the test results and the requirements of any applicable data quality objectives and quality assurance plan.

Within-test variability is measured as the percent minimum significant difference (PMSD) and must be calculated and compared to the upper bounds that are established for test PMSDs. Tests conducted under NPDES permits that fail to meet this variability criteria and that show "no toxicity" at the permitted receiving water concentration (i.e., no significant difference from the

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control at the receiving water concentration or above) are considered invalid and must be repeated on a newly collected sample. Lower bounds on the PMSD are also applied, such that test concentrations are not considered toxic (i.e., significantly different from the control) if the relative difference from the control is less than the lower PMSD bound.

To avoid penalizing laboratories that achieve unusually high precision, lower PMSD bounds are applied when a hypothesis test result (e.g., no observed effect concentration (NOEC) or lowest observed effect concentration (LOEC)) is reported. Lower PMSD bounds are based on the 10th percentiles of national PMSD data. The 10th percentile PMSD represents a practical limit to the sensitivity of the test method because few laboratories are able to achieve such precision on a regular basis and most do not achieve it even occasionally. In determining hypothesis test results, a test concentration is not considered toxic if the relative difference from the control is less than the lower PMSD bounds. See *Understanding and Accounting for Method variability in Whole Effluent Toxicity Applications Under the National Pollutant Discharge Elimination System Program*, U.S. EPA, 2000. EPA/833/R-00/003 for specific examples of implementing lower PMSD bounds. To reduce within-test variability and to increase statistical sensitivity when test endpoints are expressed using hypothesis testing rather than the preferred point estimation techniques, variability criteria must be applied during test review when NPDES permits require sublethal hypothesis testing endpoints NOEC or LOEC and the effluent is determined to have no toxicity at the permitted receiving water concentration.

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8. C. Analysis of Results

Each test manual has specified test acceptability criteria (e.g., minimum control survival) that must be achieved in order to have an acceptable test result. See the summary of test conditions and TAC for the specific test method section of the manual. In general, the valid interpretation of test results requires that control organisms meet minimum criteria for survival, growth, and/or reproduction.

Mortality in controls must not exceed 10 percent for acute toxicity tests and 20 percent for chronic tests (or other values as required by States through their regulations). If control survival does not meet 90 or 80 percent for an acute or chronic test, respectively, then results should not be used for calculating summary statistics, and a determination of compliance using the test results cannot be made. For chronic tests, control organisms also must meet minimum requirements for growth and reproduction contained in the methods. Tests not meeting the test control acceptability criteria (TAC) to achieve survival, growth, or reproduction are not valid. When using dual controls, the dilution water control should be used for determining the acceptability of the test and for comparisons with the tested effluent.

Each test manual has specified acceptable ranges of test conditions that are to be met, such as temperature, dissolved oxygen concentration, salinity, pH, light intensity and duration of photoperiod, organism loading (numbers or weight per volume), feeding, and cleaning procedures. Tests not meeting the other test conditions in the Summary of Test Conditions and TAC for the specific test method should be reviewed with caution and referred to the regional biologist. For each parameter discussed in these tables, the parameter is either recommended (i.e., must do) or required (i.e., should do). For example, the chronic *Ceriodaphnia dubia* test type is static renewal and specified as required. Meaning the test type for this test method must be static renewal. For WET test data submitted under NPDES permits, all required test conditions must be met or the test is considered invalid and must be repeated with a newly collected sample. The inspector should review the EPA methods manual for a more extensive discussion of each of these factors. The EPA methods manuals for Whole Effluent Toxicity testing can be accessed at: http://www.epa.gov/waterscience/WET.

After a test has met the required TAC and test conditions, the next step is data review (see chapter on "Report Preparation and Test Review" of each manual). Test review should be conducted on each test by both the testing laboratory and the regulatory authority.

The concentration-response relationship generated for each multi-concentration test must be reviewed to ensure that calculated test results are interpreted appropriately. EPA provides guidance on reviewing concentration-response relationships (USEPA, 2000). Test results that do not meet the expected pattern may be determined to be reliable, anomalous, or inconclusive.

Questionable results in an acute test include:

- Higher mortalities in lower concentrations than in higher concentrations of effluent
- 100 percent mortality in all effluent dilutions
- Greater percent mortality in the control than in the lower dilutions of effluent.

Questionable results in a chronic test include:

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- Greater growth or reproduction or fewer terata at higher concentrations of effluent than at lower concentrations
- No growth or reproduction or 100 percent terata at all effluent concentrations
- Less growth or reproduction or more terata in controls than in lower effluent concentrations.

When any of these abnormalities occur (outside of experimental error), the results and test conditions should be reviewed by the regional biologist or NPDES toxicologist. It should be recognized, however, that often there will be minor variations in test results. For example, *Ceriodaphnia dubia* reproduction may be higher at intermediate concentrations that are not toxic but provide a greater food resource than lower concentrations. Thus, variations should not always be used to eliminate otherwise valid results. However, if the normally expected pattern is not found, summary statistics calculated on the results should be assessed with caution - see *Understanding and Accounting for Method variability in Whole Effluent Toxicity Applications Under the National Pollutant Discharge Elimination System Program*, U.S. EPA, 2000. EPA/833/R-00/003 for specific examples.

The test results need to be expressed such that compliance with the permittee's WET limits can be determined. For the NPDES Permit Program, the point estimation techniques are the preferred statistical methods in calculating end points for effluent toxicity tests.

The following definitions may help the inspector to interpret the results:

- The LC_{50} (for lethal concentration) is the calculated percentage of effluent (point estimate) at which 50 percent of the organisms die in the test period. Usually, the LC_{50} is calculated statistically by computer programs that fit the response curve to a mathematical function. Computer-based calculation procedures usually print an estimate of the error associated with the LC_{50} estimate.

- The EC_{50} (for effect concentration) is the calculated concentration (point estimate) at which 50 percent of the organisms show a particular effect (not necessarily death). For some species (e.g., *Ceriodaphnia dubia*) where the point of death is not certain, immobility is often used as a surrogate for death. Results for responses like the immobility responses in *Daphnia* may be reported as an EC_{50} (calculated in the same manner as the LC_{50}). Often, however, no distinction is made between the EC_{50} and the LC_{50} when the response is a surrogate for death.

- The No Observed Effect Concentration (NOEC) is the highest tested concentration at which the organisms' responses are not statistically different from the control organisms' responses. The NOEC [like the Lowest Observed Effect Concentration (LOEC) and Chronic Value (ChV) defined in the following paragraph] is normally determined only for chronic tests.

- The LOEC is the lowest tested concentration at which organisms' responses are statistically different from controls.

- The ChV is the calculated geometric mean of the NOEC and LOEC (the square root of the product of the NOEC and LOEC).

- The Inhibition Concentration (IC_{25}) is the calculated percentage of effluent (point estimate) at which the organisms exhibit a 25-percent reduction in a non-quantal biological measurement such as fecundity or growth.

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- The percent response at a criterion concentration is reported. For example, the permit or standard may prohibit toxicity at 100 percent effluent or less. In this case, the observed percent response at 100 percent effluent would be reported.

- The response may be reported in Toxic Units (TU), either as Acute TUa or Chronic TUc.

There is an inverse relationship between toxicity and the effluent concentration percentage causing a toxic response. In other words, the same toxicity test response (e.g., LC_{50}), at lower percentages of effluent indicates higher toxicity than test results at higher percentages of effluent. TUs are defined as $100/LC_{50}$ for acute or 100/NOEC for chronic, with the LC_{50} or NOEC expressed as percent effluent. An effluent with an LC_{50} of 50% has an acute toxicity of 2.0 acute toxic units (100/50 = 2). Similarly, an effluent with a NOEC of 25% effluent has a chronic toxicity of 4 chronic toxic units (100/25). The major advantage of using toxic units to express toxicity test results is that toxic units increase linearly as the toxicity of the effluent increases. So the magnitude of a TU indicates the degree of toxicity. Therefore, an effluent with a TUa of 4 is twice as toxic as an effluent with a TUa of 2. EPA's Technical Support Document for Water Quality-based Toxics Control (EPA/505-2-90-01, 1991) provides a more extensice discussion of the application of toxic units and the relevance to NPDES permits. EPA's Technical Support Document (TSD, 1991) provides a more extensive discussion of the application of TU's and their relevance in an NPDES permit.

In addition to reviewing the concentration-response relationship, the within-test variability of individual tests should be reviewed. When NPDES permits require sublethal hypothesis testing endpoints (e.g., reproduction for the *Ceriodaphnia dubia* test), within-test variability must be reviewed and variability criteria must be applied as described in the chapter on "Report Preparation and Test Review" of each manual. Compare the PMSD mesaured in the test with the PMSD bounds listed in the report chapter. When the methods are used for non-regulatory purposes, the variability criteria are recommended but are not required, and their use (or the use of alternative variability criteria) may depend upon the intended uses of the test results and the requirements of any applicable data quality objectives and quality assurance plan.

See *Understanding and Accounting for Method variability in Whole Effluent Toxicity Applications Under the National Pollutant Discharge Elimination System Program*, U.S. EPA, 2000. EPA/833/R-00/003 for specific examples.

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8. D. References

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U.S. Environmental Protection Agency. March 1991. *Technical Support Document for Water Quality-based Toxics Control.* EPA/505-2-90-01

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9. PRETREATMENT

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Related Websites

Office of Wastewater Management (OWM) Homepage: http://www.epa.gov/owm

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9. A. Review of the General Pretreatment Regulations

Development of 40 *CFR* Part 403

In addition to materials in this chapter, inspectors must be familiar with Chapter 1 - "Introduction" & Chapter 2 - "Inspection Procedures".

The Clean Water Act (CWA) requires the Environmental Protection Agency (EPA) to promulgate regulations to control the discharge of pollutants to the Nation's waters to preserve their physical, chemical, and biological integrity. The National Pollutant Discharge Elimination System (NPDES) program is the primary regulatory mechanism developed to control point-source discharges to the surface waters of the United States. The National Pretreatment Program is the mechanism developed to regulate nondomestic users who discharge pollutants to Publicly Owned Treatment Works (POTWs) that could pass through or interfere with the treatment plant, threaten worker health and safety, or contaminate sludges.

The General Pretreatment Regulations [40 *Code of Federal Regulations (CFR)* Part 403] were promulgated on June 26, 1978. The regulations were revised and repromulgated on January 28, 1981. Since publication of the rule in 1981, the regulations have continued to be revised. Amendments have been made to the regulations to clarify some aspects and to respond to the findings of the Pretreatment Implementation Review Task Force (PIRT) study conducted in 1984. Additional regulatory changes were promulgated on July 24, 1990 (*55 Federal Register* 30082) in response to recommendations made in the Domestic Sewage Study (DSS) and on July 17, 1997, (62 *FR* 38405-38415) to change procedures. A summary of the General Pretreatment Regulations is provided in Table 9-1. Major technical changes resulting from final regulatory amendments or court decisions are noted in this table.

Summary and Background

The three specific objectives cited in 40 *CFR* 403.2 of the General Pretreatment Regulations are to:

- Prevent the introduction of pollutants that would cause interference with the POTW or limit the use and disposal of its sludge
- Prevent the introduction of pollutants that would pass through the treatment works or be otherwise incompatible
- Improve the opportunities to recycle or reclaim municipal and industrial wastewaters and sludges.

In addition, improved POTW worker health and safety and reduction of influent loadings to sewage treatment plants are further objectives of pretreatment. Briefly stated, the definitions for interference and pass through are the following (see 40 *CFR* 403.3 for the exact definitions):

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- Interference is a discharge that alone or in conjunction with other discharges, disrupts the POTW or sludge processes, uses, and disposal, and therefore in turn causes violation of any requirement of the POTW's NPDES permit or prevents the POTW from using its chosen sludge use or disposal practice.

- Pass through is a discharge that exits the POTWs to waters of the United States in quantities or concentrations which, alone or in conjunction with other discharges, causes a POTW NPDES permit violation.

The General Pretreatment Regulations detail the procedures, responsibilities, and requirements of EPA, States, POTWs, and industries. To achieve the objectives of the regulations, implementation of the program by all regulated entities must be accomplished. The specific responsibilities of each are explained below.

The term Publicly Owned Treatment Works or POTW means a treatment works as defined by section 212 of the Act, which is owned by a State or municipality (as defined by section 502(4) of the Act). This definition includes any devices and systems used in the storage, treatment, recycling and reclamation of municipal sewage or industrial wastes of a liquid nature. It also includes sewers, pipes and other conveyances only if they convey wastewater to a POTW Treatment Plant. The term also means the municipality as defined in section 502(4) of the Act, which has jurisdiction over the Indirect Discharges to and the discharges from such a treatment works.

Many of the specific prohibitions provide municipalities with the basis for instituting a proactive capacity, management, operation, and maintenance (CMOM) program, protecting the collection system from degradation due to explosion, corrosion, and obstruction. Particularly if locations of overflows (Sanitary Sewer Overflows {SSOs} and Combined Sewer Overflows {CSOs}) are predictable (based on facility history) and persistent, implementation of these pretreatment requirements should be evaluated.

Guidance manuals developed to assist EPA Regional Offices, States, POTWs, and industries with implementation of the General Pretreatment Program are listed in Section C, "References," of this chapter. In addition, policy memorandums from the EPA Office of Water Enforcement and Permits on pretreatment issues are listed.

Program Development and NPDES Requirements

Two terms are important in understanding the General Pretreatment Regulations: "Control Authority" and "Approval Authority." Control Authority directly regulates the significant industrial users (SIUs) (see glossary for definition) discharging to a POTW. The Control Authority is the POTW if the POTW has an approved pretreatment program. In the absence of an approved pretreatment program, the NPDES State is the Control Authority, if authorized by EPA. In the event neither the POTW nor the NPDES State has an approved pretreatment program, then EPA is the Control Authority. The Approval Authority oversees the development and implementation of POTW pretreatment programs and, for POTWs without an approved pretreatment program, is also the Control Authority that regulates industrial discharges to the POTW. The EPA Regional Office is the Approval Authority until a State is approved to administer the pretreatment program. Once a State is approved, the EPA Regional Office

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maintains oversight responsibilities. See Figure 9-1 for a visual representation of Control Authority and Approval Authority.

The NPDES permit must include development and implementation requirements for POTWs required to develop a program. Those requirements will thereby become an enforceable component of the permit. Part 403.8 of the General Pretreatment Regulations details the responsibilities of a POTW during the development of a pretreatment program. Additional information on the responsibilities of Control Authorities is provided in the EPA *Guidance Manual for POTW Pretreatment Program Development* (1993) and subsequent EPA guidance manuals.

The Control Authority Pretreatment program is submitted to the Approval Authority, either the EPA Regional Office or the approved State. Once approval has been received the state or EPA amends the NPDES permit to require the Control Authority to implement the program.

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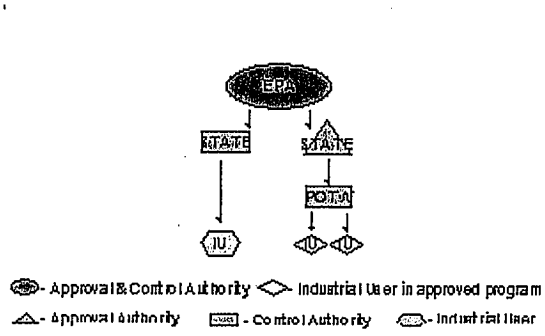
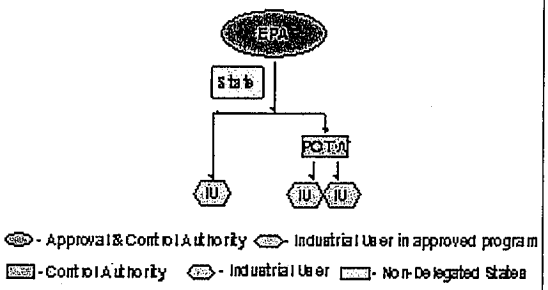
Figure 9-1

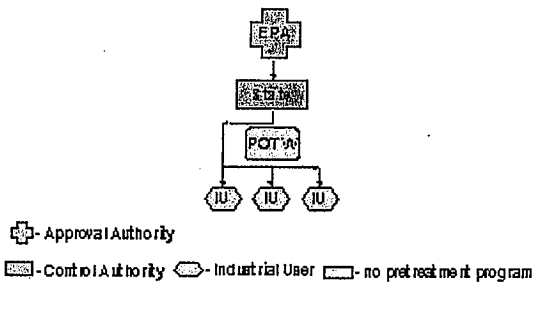
Approval Authority vs. Control Authority



Delegated States



Non-Delegated States



States Assuming Direct Responsibility

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Approval Authority Responsibilities

The EPA Regional Office or an approved State administer a pretreatment program. The principal tasks for which an Approval Authority (EPA Regional Office or delegated State) is responsible are the following:

- Reviewing and approving POTW pretreatment programs and major modifications (see "Control Authority Responsibilities" for what Control Authority program development entails)
- Overseeing POTW program implementation, i.e., conducting Pretreatment Compliance Inspections (PCIs), audits, and annual report reviews
- Providing POTWs with technical assistance on the requirements of the General Pretreatment Regulations, categorical pretreatment standards, and POTW pretreatment program requirements
- Notifying POTWs of new and existing program requirements
- Determining SIU and POTW compliance with all applicable Federal requirements
- Applying and enforcing pretreatment standards and requirements at industries discharging to POTWs that do not have an approved local pretreatment program
- Initiating enforcement action against noncompliant POTWs or industries.

Part 403.10 of the General Pretreatment Regulations identifies the requirements a State must meet to receive approval of the pretreatment program as part of its NPDES authority, that is, to become an Approval Authority. For States preferring to assume the responsibility of directly regulating industries discharging to POTWs and, hence, being considered the Control Authority in lieu of POTWs within the State, 40 *CFR* 403.10(e) provides that option.

Control Authority Responsibilities

Before a Control Authority pretreatment program is approved, the Approval Authority (EPA or state) is the Control Authority for industries discharging to the POTW. After program approval, the Control Authority becomes responsible for implementing the requirements specified in the General Pretreatment Regulations [40 *CFR* 403.8(f)], the POTW pretreatment program, and the requirements of the NPDES permit. Note the permittee must comply with the permit regardless of program approval. To fully implement the pretreatment program throughout the entire service area, the Control Authority has responsibilities related to several specific areas:

- Legal authority
  - Deny or place a new or increased discharge condition

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- Require industrial users (IUs) to comply with applicable pretreatment standards and requirements
- Require development of compliance schedules
- Carry out all inspection, surveillance, and monitoring procedures to determine industrial user compliance
- Enter premises of industrial users
- Apply Federal pretreatment standards to IUs
- Seek injunctive relief for noncompliance
- Seek or assess civil or criminal penalties of at least $1,000 a day per violation
- Immediately halt a discharge that presents or appears to present an imminent endangerment to the health or welfare of persons or to the environment or that threatens to interfere with the POTW's operation
- Comply with confidentiality requirements
- Develop and enforce an adequate sewer use ordinance
- Control through permit order, or similar means, the contribution to the POTW by each industrial user. Individual control mechanisms that contain minimum required elements must be issued to significant industrial users.

• Pretreatment standards

- Identify and locate all possible industrial users that may be subject to the pretreatment program
- Identify the character and volume of pollutants contributed to the POTW
- Establish and periodically reevaluate local limits to ensure protection of the POTW from interference or pass through and to ensure the use or disposal of POTW sludge
- Notify all industrial users of appropriate pretreatment standards, any changes to the regulations, and requirements of the Resource Conservation and Recovery Act (RCRA)
- Update the industrial survey to identify new industries that should be regulated by the POTW pretreatment program, and identify changes in manufacturing processes and wastewater discharge characteristics at existing facilities
- Comply with public participation requirements.

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- Industrial user compliance and enforcement
  - Establish reporting, inspection, and monitoring requirements and procedures to enable evaluation of compliance, including proper QA/QC and chain-of-custody procedures for sampling and analysis
  - Inspect and sample industrial users. At a minimum, significant industrial users must be sampled and inspected at least once a year
  - Evaluate each significant industrial user at least once every 2 years for the need for a slug discharge control program
  - Perform sampling and analysis in a manner to produce evidence admissible in enforcement proceedings or in judicial actions.
  - Develop and implement an enforcement response plan to guide compliance evaluation and enforcement activities
  - Evaluate industry compliance by reviewing and analyzing industrial user self-monitoring reports and Control Authority monitoring data
  - Investigate instances of noncompliance
  - Initiate appropriate enforcement action to bring users into compliance
  - Establish other procedures as required and/or determined to be needed to regulate the significant industries discharging to the POTW.
- Public participation
  - Publish at least annually, in the local newspaper with the greatest circulation, a list of the industrial users that were in significant noncompliance within the past 12 months as defined in 40 *CFR* 403.8(f)(2)(vii)
  - Notify the public of any changes to the sewer use ordinance or local limits after approval by the Approval Authority
  - Submit pretreatment program modifications to Approval Authority.
- Data management
  - Maintain records of pertinent industrial user activities and compliance status
  - Maintain a current understanding of the categorical pretreatment standards and General Pretreatment Regulations, and notify industries of any changes
  - Provide the Approval Authorities with any reports required.

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- Resources
  - Provide adequate resources and qualified personnel for program implementation

As pretreatment needs change, the Control Authority may need to revise the approved program. When this occurs, the Control Authority should submit the modifications to the Approval Authority for review and approval.

Industry Responsibilities

Industrial dischargers to POTWs must comply with the following:

- Prohibited discharge standards—The general and specific prohibited discharge standards (40 *CFR* 403.5) noted in Table 9-1.
- Appropriate pretreatment standards—Categorical pretreatment standards (40 *CFR* Parts 405-471), State requirements, or locally developed discharge limitations as per 40 *CFR* 403.5.
- Reporting requirements—As specified in 40 *CFR* 403.12 and/or by the POTW. The requirements provided in 40 *CFR* 403.12 are summarized in Table 9-1.

The types of industrial facilities that are categorical industries are listed in Table 9-2. EPA has developed categorical pretreatment standards for these industries based on the type of wastes produced by the manufacturing processes at each type of industry, the wastewater control technologies available to the industry, and economic considerations. The categorical pretreatment standards developed apply to the wastewaters from specific manufacturing processes. The standards apply at the point of discharge from the pretreatment unit for the regulated process, or if there is no pretreatment unit, they apply at the end of the regulated process.

Where the Control Authority has determined that specific limitations for certain pollutants of concern are needed to protect the POTW from interference, pass through, and sludge contamination, the Control Authority must develop and enforce such limitations. These local limitations generally are applied at the point where the industrial facility discharges to the POTW.

An industry must meet the more stringent pretreatment standard for each pollutant. For a categorical industry, this will be the categorical pretreatment standard or a local limit for each pollutant regulated. If the point at which the Control Authority's limitation applies is not the same as the point at which the categorical pretreatment standard applies, the control authority will have to either compare a calculation to adjust the categorical pretreatment standard to the discharge limitations or sample at both points so that they can determine compliance with categorical standards and local limits.

When evaluating the pretreatment standards to determine the appropriate limitation, the inspector should note that different categorical pretreatment standards were developed for each type of industry. If the industry combines the flows from more than one regulated process or

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combines a regulated process flow with other flows before these wastes are treated, the Control Authority and the industry must adjust the categorical pretreatment standard using the Combined Wastestream Formula (CWF). The equation is provided in 40 *CFR* 403.6(e) of the

General Pretreatment Regulations. If the wastewaters are mixed after treatment, the categorical pretreatment standards must still be adjusted, in this case by flow weighted averaging of all flows introduced prior to the sample point. In either case, the resulting alternative limit cannot be set below the level of detection for that pollutant. Additional information on the combined wastestream formula and the flow weighted averaging formula is provided in EPA's *Guidance Manual for Implementing Production-Based Pretreatment Standards and the Combined Wastestream Formula* (1985).

Categorical industries have specific reporting requirements as per 40 *CFR* 403.12. A summary of the reports that categorical industries are required to submit is provided in Table 9-2. A Control Authority may require additional reports from all industries discharging to the system, including categorical industries.

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Table 9-1

Summary of the General Pretreatment Regulations

403.1	Purpose and Applicability
403.2	Objectives of General Pretreatment Regulations
403.3	Definitions
403.4	State or Local Law
	The Federal General Pretreatment Regulations are not meant to affect any State or local regulatory requirements as long as these requirements are at least as stringent as the Federal regulations.
403.5	National Pretreatment Standards: Prohibited Discharges
	This section specifies general and specific prohibited discharge standards that Control Authorities must incorporate into their pretreatment programs. The general prohibitions specify that pollutants introduced into POTWs by a nondomestic source shall not pass through the POTW or interfere with the operation or performance of the works. The section provides that Control Authorities required to develop local pretreatment programs and POTWs where interference and pass through are likely to recur develop and enforce specific limitations (local limits) to implement the general prohibitions against interference, pass through, and sludge contamination.
	The specific prohibitions specify prevention of discharge of pollutants that cause any of the following at the POTW:
	• Fire or explosion hazard, including no discharge with a closed-cup flashpoint of less than 60°C (140°F) using test methods in 40 *CFR* 261.21
	• Corrosive structural damage (no pH<5.0)
	• Obstruction to the flow in the POTW
	• Interference
	• Heat causing inhibition of biological activity and temperatures at the POTW treatment plant to exceed 40°C (104°F)
	• Petroleum oils, nonbiodegradable cutting oils, or products of mineral oils in amounts that will cause interference or pass through
	• Fume toxicity or reactivity
	• Trucked or hauled pollutants except at designated discharge points.
	Additionally, industrial users are provided with an affirmative defense (if specified conditions are met) for actions brought against them for alleged violations of the general or specific prohibitions contained in this section.

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Table 9-1

Summary of the General Pretreatment Regulations (Continued)

403.6	National Pretreatment Standards: Categorical Standards This section discusses development and implementation of categorical pretreatment standards including, but not limited to, compliance deadlines, concentrations and mass limits, prohibition of dilution as a substitute treatment, and the Combined Wastestream Formula (CWF) to determine discharge limitations.
403.7	Revision of Categorical Pretreatment Standards to Reflect POTW Removal of Pollutants This section (referred to as the removal credits provision) provides the criteria and procedures to be used by a POTW in revising the pollutant discharge limits specified in categorical pretreatment standards to reflect removal of pollutants by the POTW.
403.8	Pretreatment Program Requirements: Development & Implementation by POTW This section covers the requirements for pretreatment program development by a Control Authority. Included in this section are criteria for determining which POTWs must develop pretreatment programs, incorporation of approved programs and compliance schedules into NPDES permits, deadlines for program approvals, and program and funding requirements. 403.8(f) sets out the requirements of a POTW program. Specifically, it requires the Control Authority to have sufficient legal authority to enforce the approved pretreatment program. The section also discusses that all Control Authorities with approved programs, or programs under development, must develop and implement procedures to ensure compliance with the requirements of a pretreatment program.
403.9	Control Authority Pretreatment Programs and/or Authorization to Revise Pretreatment Standards: Submission for Approval This section discusses requirements and procedures for submission and review of Control Authority pretreatment programs. Included in this section are discussions of conditional program approval, approval authority action, and notification where submissions are defective.
403.10	Development and Submission of NPDES State Pretreatment Programs This section discusses requirements and procedures for submission and review of NPDES State pretreatment programs. Included in this section are discussions of approvals and deadlines for State programs, legal authority, program and funding requirements, and contents of program submissions.
403.11	Approval Procedures for Control Authority Pretreatment Programs and Revision of Categorical Pretreatment Standards This section provides the administrative procedures for the review and approval or denial of Control Authority pretreatment program submissions and requests for removal credit authority.

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Table 9-1

Summary of the General Pretreatment Regulations (Continued)

403.12	Reporting Requirements for POTWs and Industrial Users This section presents reporting requirements for Control Authorities and industrial users. Reports required by industrial users include the following: • Baseline Monitoring Report (BMR). Due to the Control Authority within 180 days of the effective date of the categorical pretreatment standards (40 *CFR* 403.6). In addition, new source BMR reporting requirements are discussed in this section. • Compliance schedule progress reports. Due to the Control Authority within 14 days of completion of compliance schedule milestones or due dates. • 90-day compliance report. Due to the Control Authority within 90 days of the compliance date of the categorical standards. • Periodic reports on continued compliance. Due to the Control Authority at least semiannually, usually in June and December after the compliance date. • Notices of potential problems including slug loadings. Due to the Control Authority immediately upon identification of discharges, including slug loadings that could cause problems to the POTW for both noncategorical and categorical industries. • Notice of changed discharge. Due to the Control Authority from categorical and noncategorical users in advance of any significant change in volume or character of pollutants discharged. • Notice of violation and resampling. Notification due to the Control Authority within 24 hours of noting a violation; results of resampling due within 30 days. • Notification of hazardous waste discharge. Notification to the POTW, EPA, and State Hazardous Waste authorities of the hazardous wastes discharges to the POTW. Reports required from Control Authorities include the following: • Compliance schedule (for development of pretreatment programs) progress reports • Annual POTW reports. Also discussed in detail in this section are monitoring requirements for industrial users and signatory and recordkeeping requirements for Control Authorities and industrial users.

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Table 9-1

Summary of the General Pretreatment Regulations (Continued)

403.13	Variances from Categorical Pretreatment Standards for Fundamentally Different Factors This provision allows an industrial user, or any interested person, to request a variance for the establishment of limits either more or less stringent than that required by a categorical pretreatment standard. The primary criterion required for approval of this variance is that the factors relating to the industrial user's discharges be fundamentally different from factors considered by EPA in establishing categorical pretreatment standards for these discharges.
403.14	Confidentiality This section covers confidentiality requirements and prohibitions for EPA, States, and Control Authorities. Effluent data are available to the public without restriction.
403.15	Net/Gross Calculation This provision provides for adjustment of categorical pretreatment standards to reflect the presence of pollutants in the industrial user's intake water.
403.16	Upset Provision This provision is consistent with the NPDES regulations and allows an upset of an industry's pretreatment system (which meets the conditions of an upset as specified in this provision) to be an affirmative defense to an action brought for noncompliance with categorical pretreatment standards. The industrial user shall have the burden of proof for such a defense.
403.17	Bypass This provision requires industrial users to operate their treatment systems at all times and includes criteria for allowing a bypass to occur and notification procedures for both an anticipated and unanticipated bypass.
403.18	Modification of Control Authority Pretreatment Programs This provision specifies procedures and criteria for "minor" and "substantial" modifications to approved Control Authority pretreatment programs and incorporation of substantial modifications into the Control Authority.
403.19	Provisions of specific applicability to the Owatonna Waste Water Treatment Facility This section provides specific regulatory requirements for the Owatonna Waste Water Treatment Facility and its participating Industrial Users to implement a project under the Project XLC program in Steele County, Minnesota. This project requires includes legal authorities and requirements that are different than the administrative requirements otherwise specified in 40 *CFR* Part 403.
403.20	Pretreatment Program Reinvention Pilot Projects Under Projects XL This section provides administrative procedures to allow any POTW with a final "Project XL" agreement to implement a Pretreatment Program that includes legal authorities and requirements that are different than the administrative requirements otherwise specified in 40 *CFR* Part 403.

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Table 9-1

Summary of the General Pretreatment Regulations (Continued)

Appendix A	Program Guidance Memorandum This memorandum summarizes the Agency's policy on the use of construction grants for treatment and control of combined sewer overflows and storm water discharges.
Appendix B	[Reserved]
Appendix C	[Reserved]
Appendix D	Selected Industrial Subcategories Considered Dilute for Purposes of the Combined Wastestream Formula (previously titled "Selected Industrial Subcategories Exempted from Regulation Pursuant to Paragraph 8 of the NRDC v. Costle Consent Decree" The Appendix D published on January 21, 1981, provided a list of industrial subcategories that had been exempted (pursuant to paragraph 8 of the NRDC vs. EPA Consent Decree) from regulation by categorical pretreatment standards. Appendix D was revised on October 9, 1986, to update the list of exempted industrial categories and to correct previous errors by either adding or removing various subcategories or by changing the names of some categories or subcategories. Each of the subcategories, as indicated by the revised Appendix D title, contains wastestreams that are classified as dilute for purposes of applying categorical pretreatment standards to other wastestreams and for using the combined wastestream formula to adjust these standards.
Appendix E	Sampling Procedures This appendix provides a general description of composite and grab sampling procedures.
Appendix F	[Reserved]
Appendix G	Pollutant Eligible for a Pollutant Credit

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Table 9-2

Categorical Pretreatment Standards

Industrial Categories With Categorical Pretreatment Standards in Effect			Effluent Guidelines Currently Under Development*
	N	Aluminum Forming (Part 467)	
E	N	Battery Manufacturing (Part 461)	• Metal Products and Machinery
E	N	Builder's Paper and Board Mills (Part 431)	• Pulp, Paper, and Paperboard, Phases 2 and 3
E	N	Carbon Black Manufacturing (Part 458)	
E	N	Centralized Waste Treatment (Part 437)	• Meat Products
	N	Coil Coating (Part 465)	• Aquatic Animal Production
E	N	Copper Forming (Part 468)	
E	N	Electrical and Electronic Components (Part 469)	
E		Electroplating (Part 413)	
E	N	Fertilizer Manufacturing (Part 418)	
	N	Glass Manufacturing (Part 426)	
	N	Grain Mills Manufacturing (Part 406)	
	N	Ink Formulating (Part 447)	
	N	Inorganic Chemicals (Part 415)	
E	N	Iron and Steel Manufacturing (Part 420)	
E	N	Leather Tanning and Finishing (Part 425)	
E	N	Metal Finishing (Part 433)	
E	N	Metal Molding and Casting (Part 464)	
E	N	Nonferrous Metals Forming and Metal Powders (Part 471)	
E	N	Nonferrous Metals Manufacturing (Part 421)	
E	N	Organic Chemicals, Plastics, and Synthetic Fibers (Part 414)	
E	N	Paint Formulating (Part 446)	
N	N	Paving and Roofing Materials (Part 443)	
E	N	Pesticide Chemicals (Part 455)	
E	N	Petroleum Refining (Part 419)	
E	N	Pharmaceutical Manufacturing (Part 439)	
E	N	Porcelain Enameling (Part 466)	
E	N	Pulp, Paper, and Paperboard (Part 430)	
	N	Rubber Manufacturing (Part 428)	
	N	Soap and Detergent Manufacturing (Part 417)	
E	N	Steam Electric Power Generating (Part 423)	
E	N	Timber Products Processing (Part 429)	
E	N	Transportation Equipment Cleaning (Part 442)	
		Waste Combustors (Part 444)	
E	N		

E = Standards in effect for existing sources.
N = Standards in effect for new sources.

*From August 2000, Effluent Guideline Plan [304(m)].

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9. B. Pretreatment Compliance Inspections (PCIs) and Audits

Scope of PCIs and Audits

The Pretreatment Compliance Inspection (PCI), the pretreatment program audit, and the program performance report (submitted at least annually by the POTW) provide an opportunity for EPA and State officials to assess the program and determine compliance of the Control Authority's pretreatment program.

EPA uses the PCI is to evaluate Control Authority compliance monitoring and enforcement activities. The inspector also determines whether any changes have been made to the Control Authority program since the last PCI, audit, performance report (i.e., annual report), or Control Authority modification request for approval. The NPDES inspector collects information on Control Authority program implementation for further evaluation by compliance personnel.

The inspector may conduct the PCI in conjunction with other NPDES inspections to conserve travel resources and allow integration of information on a POTW's operations. PCIs are compatible with Compliance Evaluation Inspections (CEIs), Compliance Sampling Inspections (CSIs), Performance Audit Inspections (PAIs), Diagnostic Inspections (DIs), and other nonroutine inspections, such as Toxics Sampling Inspections, and Compliance Biomonitoring Inspections. The inspector may combine a PCI with a site visit regarding sludge compliance as discussed in Chapter Ten.

Note that the POTW personnel involved in a CSI may be different from the ones involved in a PCI. Also, PCIs and audits rely heavily on file and record reviews to evaluate the Control Authority's pretreatment program. These records may have little bearing on the sampling inspection of the treatment facility. This distinction of a PCI to a CSI should be addressed during planning for the inspection.

Audits provide as a comprehensive review of the Control Authority pretreatment program. The audit addresses all of the items covered in a PCI but in greater detail. Consequently, the audit is more resource intensive than the PCI.

Procedures for conducting PCIs and audits are similar. In general, there are three major components:

- Pre-visit preparation for the PCI or audit
  - Coordination with the EPA Regional or State Pretreatment Coordinator
  - Review of background information: approved program, Control Authority annual reports (if available), NPDES permit compliance status, Control Authority fact sheet, previous inspection reports, and program modification requests from the Control Authority

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  - Notification of Control Authority (if appropriate).

- Onsite

  - Entry (presenting credentials)
  - Opening conference with Control Authority officials
  - Review of pretreatment files
  - Industrial inspections (optional)
  - Interview of officials using PCI or audit checklist
  - Tour of POTW (optional)
  - Closing conference.

- Follow-up

  - Preparation of report
  - Water Enforcement National Data Base (WENDB) data entry into PCS
  - Reportable Noncompliance/Significant Noncompliance (RNC/SNC) determination
  - Follow-up letter to the Control Authority
  - Enforcement action (when necessary)
  - NPDES permit or program modifications (when necessary).

If a PCI is conducted with an unannounced NPDES inspection, it also may be unannounced, but the Control Authority officials should be notified of the PCI upon arrival of the inspection team. At many POTWs, personnel responsible for implementing the program may not be the same as those operating the treatment plant.

The protocol involved in the onsite portion of the inspection is comparable to that of other NPDES inspections. The Pretreatment Program PCI or audit includes a tour of industrial facilities discharging to the POTW. This aspect is unique to the Pretreatment Program. The tour is optional for PCI, but mandatory for audits and may be included to evaluate the Control Authority's procedures for properly categorizing, monitoring and inspecting industries. For more detailed information on conducting PCIs and audits, refer to EPA's *Guidance for Conducting a Pretreatment Compliance Inspection* (September 1991), and *Control Authority Pretreatment Audit Checklist and Instructions* (May 1992).

See the PCI and audit guidance manuals, respectively for detailed checklists.

PCI Checklist Components

EPA developed the PCI checklist to assist NPDES inspectors in conducting and documenting the PCI. The checklist consists of the following sections:

- Cover page—Provides space for Control Authority name, address, and representatives present, as well as the date(s) of the inspection and inspectors' names, titles, and telephone numbers.

- Section I: Industrial User File Evaluation—This section documents problems or deficiencies noted during review of industrial user files. Generally, the inspector reviews the files to determine whether the Control Authority has notified the industrial user of applicable categorization and requirements, issued an adequate control mechanism,

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properly applied pretreatment standards, conducted sufficient compliance monitoring activities, and taken appropriate enforcement actions for violations.

- Section II: Supplemental Data Review/Interview—The inspector completes this section by interviewing the appropriate Control Authority personnel and enables the inspector to determine compliance with program requirements not easily determined by the file review or to acquire additional information. This section contains questions on the following six pretreatment program areas:

  - Control Authority Pretreatment Program Modifications
  - Industrial User Characterization
  - Control Mechanism Evaluation
  - Application of Pretreatment Standards and Requirements
  - Compliance Monitoring
  - Enforcement.

- Section III: Evaluation and Summary—This section consists of the same six pretreatment program areas listed above and allows the inspector to summarize deficiencies noted and any corresponding required and/or recommended corrective actions.

- Attachment A: Pretreatment Program Status Update—This section provides an update of the pretreatment program's status. It should be updated prior to the PCI, based on information from the most recent PCI or audit and latest pretreatment program performance report and should be revised during the inspection based on information obtained during the PCI, if necessary.

- Attachment B: Pretreatment Program Profile—This section provides information on the Control Authority's approved pretreatment program, NPDES permit conditions, and applicable pretreatment regulations.

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- Attachment C: Worksheets
  - WENDB Data Entry Worksheet—The WENDB data elements provide information to be entered in the Pretreatment Permits and Enforcement Tracking System (PPETS). This management information system tracks the permit compliance and enforcement status of approved pretreatment programs.
  - Reportable Noncompliance (RNC) Worksheet—This worksheet evaluates whether the Control Authority is in RNC for failure to implement its approved pretreatment program.
  - IU Site Visit Report—This report documents any industrial user site visits that were conducted as part of the PCI.
  - IU File Evaluation Worksheets—These optional worksheets assist the inspector in documenting and quantifying the Control Authority's performance in applying standards, compliance monitoring, and enforcement activities.

In addition to the completed checklist, the inspector will include other materials collected during the PCI in the final report as appendices, e.g.,:

- Example of Control Authority control mechanism or enforcement actions
- Names of industries that were not sampled or inspected in the past year
- Control Authority's Enforcement Response Plan (ERP)
- Annual list of industrial users in significant noncompliance.

See the EPA's *Guidance for Conducting a Pretreatment Compliance Inspection* (September 1991) the PCI checklist . The manual goes through each checklist section individually and explains the intent of the questions. As noted earlier, the manual provides more detailed information concerning the procedures for conducting the PCI.

Summary of Audit Checklist Components

The audit checklist has been developed to assist with a detailed review of a POTW pretreatment program, including pretreatment program modification, legal authority, industrial user characterization, control mechanism evaluation, application of pretreatment standards and requirements, compliance monitoring, enforcement, data management/ public participation, resources, and environmental effectiveness/pollution prevention. The audit checklist is divided into the following sections:

- Cover page
- Section I: Industrial User File Evaluation
- Section II: Data Review/Interview/Industrial User Site Visits
- Section III: Findings
- Attachment A: Pretreatment Program Status Update
- Attachment B: Pretreatment Program Profile
- Attachment C: Worksheets
  - Industrial User Site Visit Data Sheet
  - WENDB Data Entry Worksheet

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- RNC Worksheet.

The audit checklist collects more detailed information than the PCI checklist and, as with the completed PCI checklist, also may be augmented by additional audit data:

- NPDES pretreatment permit conditions
- Control Authority enforcement documents with pretreatment requirements (i.e., administrative order, consent decree)
- Locally developed discharge limitations as included in the approved program (or any limits that have been changed by the Control Authority)
- Copy of sewer use ordinance if different from that in the approved program
- Control Authority sampling and inspection schedule for regulated industries
- List of industries not sampled or inspected in the past year
- Control Authority chain-of-custody form
- List of noncompliant industries and history of enforcement actions taken
- Annual list of industrial users in significant noncompliance.

The audit checklist is part of the *Control Authority Pretreatment Audit Checklist and Instructions* (May 1992). The manual provides specific guidance on conducting an audit and using the checklist.

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9. C. References

EPA's *Guidance for Conducting a Pretreatment Compliance Inspection* (September 1991) contains a comprehensive list of reference materials (publications and memorandums) available from U.S. EPA or the Pretreatment Coordinator in your Region. **References published since the publication of the Pretreatment Guidance are listed below.**

Checklists for conducting pretreatment compliance inspections and audits are provided in EPA's *Guidance for Conducting a Pretreatment Compliance Inspection* (September 1991) and *Control Authority Pretreatment Audit Checklist and Instructions* (May 1992). The checklist provides a list of questions that should be considered during an audit or PCI. The inspector should contact the Regional or State Pretreatment Coordinator before a PCI or an audit is done.

References

Memoranda

Applicability of pH Waivers to Pretreatment Standards (May, 13, 1993).

Determining Industrial User Significant Noncompliance (January 17, 1992).

Determining Industrial User Compliance Using Split Samples (January 21, 1992).

Statistical Assessment of National Significant Industrial User Noncompliance (July 23, 1992).

Use of Grab Samples to Detect Violations of Pretreatment Standards (October 1, 1992).

Using Split Samples to Determine Industrial User Noncompliance (April 12, 1993).

EPA Guidance

U.S. Environmental Protection Agency. 1985. *Guidance Manual for Implementing Production-Based Pretreatment Standards and the Combined Wastestream Formula.*

U.S. Environmental Protection Agency. February 1991. *Control of Slug Loadings to POTWs: Guidance Manual.* 21 W-4001.

U.S. Environmental Protection Agency. May 1991. *Supplemental Manual on the Development and Implementation of Local Discharge Limitations Under the Pretreatment Program.*

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U.S. Environmental Protection Agency. 1993. *Guidance Manual for POTW Pretreatment Program Development.* EPA 833/B-83-100.

U.S. Environmental Protection Agency. April 1994. *Industrial User Inspection and Sampling Manual for POTWs.* EPA 831-B-94-001.

U.S. Environmental Protection Agency. June 1994. *Multijurisdictional Pretreatment Programs Guidance Manual.* EPA 833-94-005.

U.S. Environmental Protection Agency. October 1998. *Procuring Analytical Services: Guidance for Industrial Pretreatment Programs.* EPA 833-B-98-004.

U.S. Environmental Protection Agency. February 1999. *Introduction to the National Pretreatment Program.* EPA 833-B-98-002.

U.S. Environmental Protection Agency. September 1999. *Guidance Manual for Control of Wastes Hauled to Publicly Owned Treatment Works.* EPA 833-B-98-003.

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10. SEWAGE SLUDGE (BIOSOLIDS)

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L. Approved Methods for the Analysis of Sewage Sludge (40 *CFR* Part 503)

Related Websites

Office of Wastewater Management (OWM) Homepage: http://www.epa.gov/owm
Office of Science and Technology (OST) Homepage: http://www.epa.gov/ost

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10. A. Review of the Sewage Sludge Regulations (Biosolids)

In addition to materials in this chapter, inspectors must be familiar with Chapter 1 - "Introduction" & Chapter 2 - "Inspection Procedures".

Section 405 of the Clean Water Act (CWA) mandated the development of a Federal sludge management program. On February 19, 1993, Environmental Protection Agency (EPA) promulgated technical standards for the use or disposal of sewage sludge [see 40 *Code of Federal Regulations (CFR)* Part 503, 58 *Federal Regulation (FR)* 9248]. These regulations contain technical standards for three sewage sludge use or disposal practices: land application, surface disposal, and incineration. The National Pollutant Discharge Elimination System (NPDES) regulations had previously been revised in preparation for the issuance of the final technical standards. As NPDES permits are reissued, they include sludge use or disposal requirements. However, the Federal 503 sludge regulations are the minimum requirements that apply to and are enforceable against a facility engaged in a regulated sludge use or disposal practice, regardless of whether that facility's NPDES permit contains sludge use or disposal conditions. Thus, the NPDES permit is not a shield in the case of noncompliance with sludge requirements. This means that as of February 19, 1994, inspectors are expected to identify at a minimum violations of Part 503 requirements. Then if appropriate the enforcement authority can issue a notice of violation or take other appropriate enforcement actions.

The Federal and State sludge management programs currently regulates the use and disposal of sewage sludge, which is the residual generated from the treatment of domestic sewage in a treatment works. Facilities, such as Publicly Owned Treatment Works (POTWs), which are subject to NPDES permit conditions for aqueous discharges to surface waters are now, as generators and preparers of sewage sludge, subject to the 503 regulations. In addition, the sludge program includes other facilities that have not been a part of the NPDES program because they were not point sources of discharge to waters of the United States. Examples of facilities that are now regulated and that may eventually receive permits for the use and disposal of sewage sludge include sewage sludge incinerators, composting facilities, and sewage sludge surface disposal sites. Note, the Part 503 regulation also includes simplified requirements for the land application of domestic septage.

Although the regulations refer to the residual generated from the treatment of domestic sewage as sludge, the term "biosolids" is the current term in general use for those sewage sludges which have been treated and conditioned through biological, chemical, and/or physical processes for the purpose of beneficial reuse as a soil amendment for growing plants and trees.

While EPA was in the process of finalizing more comprehensive regulations to address the use or disposal of sewage sludge, there were existing Federal regulations that applied to the land application and landfilling of sludge. These regulations, issued as interim final criteria in 40 *CFR* Part 257, were promulgated jointly under the authority of the CWA and the Resource Conservation and Recovery Act (RCRA) in 1979. Regulations relating to sewage sludge land disposal practices are promulgated in 40 *CFR* Part 258 for disposal of sewage sludge in Municipal Solid Waste Landfills (MSWLFs) and 40 *CFR* Part 503 for sewage sludge use or

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disposal by land application, surface disposal, or incineration replaced them. The application of industrial sludge to the land continues to be regulated by 40 *CFR* Part 257. In addition, the Clean Air Act (CAA) regulations under 40 *CFR* Parts 60 and 61 continue to apply to the operations and air emissions of sewage sludge incinerators. The relevant requirements in 40 *CFR* Part 258 and 40 CFR Parts 60 and 61 are described below.

40 *CFR* Part 258—On October 9, 1991, EPA promulgated regulations under Part 258 that established criteria for MSWLFs and standards for the co-disposal of sewage sludge with municipal solid waste. Part 503 requires that sewage sludge be sent to a MSWLF to comply with the appropriate Part 258 requirements. Because the material that is disposed of in MSWLFs is very diverse (e.g., household garbage, commercial solid waste and sewage sludge), the approach to regulating solid waste is different. Instead of regulating pollutants in the solid waste, Part 258 imposes design, operation, and maintenance requirements on the final disposal site. Although pollutant limits are not imposed, sludge to be disposed of must be nonhazardous, as demonstrated by using the Toxicity Characteristic Leaching Procedure (TCLP) and pass a paint filter test to demonstrate the sludge has no free liquids.

40 *CFR* Part 60, Subpart O —Emission standards for particulates and opacity and operational standards are specified for new source sewage sludge incinerators. New source incinerators are those constructed after June 11, 1973. If mixed municipal waste is being incinerated, then Subpart Ea—Standards of Performance for Municipal Waste Combustors—apply.

40 *CFR* Part 61, Subparts C & E —Standards were promulgated under authority of the CAA that limit the emission of beryllium and mercury from sewage sludge incinerators. The Part 503 sludge regulations require compliance with the Part 61 beryllium and mercury emission standards.

In general, the Part 503 regulations apply the following types of requirements to the three sewage sludge use or disposal practices:

- Pollutant limits [9 pollutants under land application (40 *CFR* 503.13), 3 pollutants under surface disposal (40 *CFR* 503.23), and 7 pollutants under incineration (40 *CFR* 503.43)]
- Pathogen and vector attraction reduction requirements
- Management practices for siting and operation of sludge use or disposal activities
- Minimum monitoring requirements
- Specific recordkeeping and reporting requirements.

A brief explanation of the requirements that apply to each sewage sludge use or disposal practice is provided below.

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Land Application Requirements

Pollutant Limits

The regulations establish four types of limits that regulate 9 pollutants. Figure 10-1 illustrates which limits apply, based on the final sludge use; conversely, Figure 10-2 illustrates which requirements apply, based on the level of treatment achieved.

- Ceiling Concentration Limits — Express these limits as milligram of pollutant per kilogram of sludge on a dry weight basis that can be land applied.
- Cumulative Pollutant Loading Rates (CPLRs) — Express these limits as the total amount of pollutant (kilograms) in sludge that does not meet pollutant concentration limits that can be applied to an area (hectare) of land. When this loading rate is reached, no additional sludge can be applied to the site.
- Pollutant Concentration Limits — Express these limits as the monthly average concentration of pollutant milligram per kilogram of sludge on a dry weight basis. They apply to sewage sludge sold or given away in a bag or other container and as an alternative limit to CPLRs for bulk sewage sludge.
- Annual Pollutant Loading Rates — Express these limits are the amount of pollutant (kilograms) in a bagged product that does not meet the monthly average pollutant concentration limits that can be applied in a 365-day period on an area (hectare) of land. This loading rate limits the amount of sewage sludge product sold or given away in a bag or other container on a dry weight basis that can be applied each year.

All sewage sludge that is land applied under the requirements of the land application portion of Part 503 must meet the (Table 1) Ceiling Concentration Limits. However, appliers of sewage sludge that meets the "High Quality" (Table 3) Pollutant Concentration Limits do not need to track cumulative loadings of pollutants for this material, while appliers of material that does not meet the "High Quality" Table 3 values but does meet the Table 1 values are required to limit pollutant loadings from sewage sludge application to the (Table 2) Cumulative Pollutant Loading Rates (CPLRs).

Sewage sludge products that are sold or given away by the facility or retailer in bags or other containers must meet the "High Quality" (Table 3) Pollutant Concentration Limits, or meet the (Table 1) Ceiling Concentration Limits and be applied at an annual sewage sludge product application rate that is based on the (Table 4) Annual Pollutant Loading Rate.

Management Practices

The five management practices in 40 *CFR* 503.14 are intended to supplement the pollutant limits and provide additional protection to endangered species and their habitats, surface water, wetlands, groundwater, and human exposure to the sludge. Four are applicable to bulk sludge; one is applicable to bagged or containerized sludge.

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Operational Standards: Pathogen and Vector Attraction Reduction Requirements

There are two categories of pathogen reduction requirements: Class A [40 *CFR* 503.15, 503.32(a)] and Class B [40 *CFR* 503.15, 503.32(b)] (with associated public access and site use restrictions on the use of Class B sludge).

- Class A requirements [40 *CFR* 503.32(a)] result in pathogens, at or below the detection limits of the methods (at the time of regulatory development) and sewage sludge that may be used without site restrictions or limiting public access.

- Class B requirements [40 *CFR* 503.32(b)] significantly reduce (but do not eliminate) the pathogens in the sludge and require a waiting period before the land on which the sludge was applied may be used for certain activities.

Sludge that is sold or given away by the facility or retailer in a bag or other container must meet Class A requirements. Apply only Class A bulk sludge to lawns or home gardens. Apply only Class A or Class B bulk sewage sludge elsewhere (i.e., agricultural land, forest, or reclamation sites).

Under Part 503, six alternative approaches are available for achieving Class A sludge. Three alternatives (with specific site restrictions for use of the treated sludge) are provided for achieving Class B sludge.

EPA retained substantially the same pathogen reduction requirements in the Part 503 regulation as were used as the basis of the Part 257 requirements. Therefore, among the alternatives to achieve Class B sludge is treatment using one of the Processes to Significantly Reduce Pathogens (PSRP). Similarly, Class A sludge may be achieved by using one of the Processes to Further Reduce Pathogens (PFRP).

Land applied sludge is subject under the Part 503 regulations to vector attraction reduction requirements to reduce the characteristics of the sludge that attract disease vectors (i.e., insects that are capable of transporting infectious agents, ultimately to humans). Part 503 requires compliance with one of eight vector attraction reduction treatment alternatives if the sludge will be sold or given away in a bag or other container [40 *CFR* 503.33(a)(3)]. Bulk sewage sludge applied to lawns or home gardens must also meet one of eight vector attraction reduction treatment alternatives [40 *CFR* 503.33(a)2)]. Bulk sewage sludge applied elsewhere must meet one of 10 treatment alternatives [40 *CFR* 503.33(a)1)].

Monitoring, Recordkeeping, and Reporting Requirements

As with other NPDES provisions, while the permitting authority may reduce monitoring frequencies based upon consistent demonstrated performance for at least 2 years, Part 503 requires a minimum monitoring frequency (e.g., once per year). (For example, a case might be made for the minimum monthly or quarterly monitoring requirements for a particular parameter by a larger facility to be reduced based upon consistent performance, but not below a minimum of once per year.)

Part 503 recordkeeping requirements differ depending on the type of pollutant limits applied. Recordkeeping requirements, including certification statements specified in Part 503, are imposed on generators/preparers, while other specific recordkeeping requirements are imposed on appliers. The regulations require the facility to retain the specific information for 5 years,

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except that some information on applicable cumulative pollutant loading rates must be retained by the facility indefinitely.

While all facilities must maintain records, only a subset must report under the Part 503 regulations. Those facilities that must report at least once per year are listed below.

- Class I sludge management facilities
- POTWs with a design capacity equal to or greater than 1 Million Gallons per Day (MGD)
- POTWs serving a population of 10,000 or more.

Surface Disposal Requirements

Surface Disposal includes monofills (sewage sludge-only landfills), dedicated disposal surface application sites, (e.g., where sewage sludge pollutants may be applied under controlled conditions at higher than the agronomic rate for disposal purposes even though there may also be beneficial use aspects), as well as piles or mounds, and impoundments or lagoons where the sewage sludge remains on the land beyond 2 years unless it can be affirmatively documented that such operations are "treatment" or "temporary storage" rather than permanent disposal sites.

Pollutant Limits

The 40 *CFR* 503.23 regulates three pollutants. Limits apply to sewage sludge that is placed on or in a surface disposal site that does not have a liner and leachate collection system. There are no pollutant limits on sewage sludge placed in sewage sludge units equipped with a liner and leachate collection system. The distance between the active sewage sludge unit and the site property line/boundary determine the specific pollutant limits that apply; the closer the distance to the boundary, the more stringent the limits (see Figure 10-3). An owner/operator can request site-specific pollutant limits; the permitting authority established these limits through a permit.

Management Practices

The 40 *CFR* 503.24 established a total of 14 management practice requirements. Many are one-time surface disposal site location restrictions. Others address operational activities (e.g., leachate and runoff collection systems, methane gas monitoring) and post-closure activities.

Operational Standards

Under the Surface Disposal requirements (40 *CFR* 503.25), sewage sludge must meet one of the Class A or Class B pathogen reduction alternatives unless the sewage sludge is covered with soil or other material daily. The inspector should note, however, that the Class B site restrictions only apply to land applied sewage sludge. Surface disposed sludge must also meet one of eleven vector attraction reduction alternatives.

Monitoring, Recordkeeping, and Reporting Requirements

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Regulations require monitoring and recordkeeping requirements (40 *CFR* 503.26 to 503.28), including certification statements, for the sludge generator or final preparer and/or the owner/ operator of the surface disposal site. Regulation require minimum monitoring frequencies based on the volume of sludge disposed. The facility must maintain all records for 5 years. The same classes of facilities identified under the land application section must report at least once per year.

Incineration Requirements

Pollutant Limits

The regulations cover a total of seven pollutants in sewage sludge that is incinerated. Limits for five metals are calculated by the permitting authority based on site-specific factors using the equations specified in 40 *CFR* 503.43. Limits for the other two pollutants (mercury and beryllium) are derived from air emission standards promulgated under 40 *CFR* Part 61. These limits appear in the permit issued to the owner/operator of the sewage sludge incinerator.

Operational Standards

The 40 *CFR* 503 establishes an average monthly standard on the total hydrocarbons or carbon monoxide concentration in the exit gases of an incinerator to protect from excessive emissions of organic pollutants.

Management Practices

The seven management practices in 40 *CFR* 503.45 ensure that certain instruments are correctly installed, calibrated, operated, and maintained; that incinerator maximum combustion temperature and air pollution control equipment operating standards are established; and that endangered species and their habitats are protected. The specific management practice requirements should be established by the permitting authority based on site-specific factors and should appear in the incinerator's permit.

Monitoring, Recordkeeping and Reporting Requirements

The 40 *CFR* 503.47 and 503.48(a), imposes monitoring requirements for sewage sludge to be incinerated on the owner/operator of the incinerator. The 40 *CFR* 503.46 to 503.48 requires monitoring (a) of sewage sludge for pollutant (i.e., seven metals) concentrations; (b) of incinerator stack exit gases for total hydrocarbon or, alternatively, carbon monoxide (CO), oxygen concentrations, and moisture content; and (c) of incinerator combustion temperatures and air pollution control equipment operating parameters. Monitoring requirements to demonstrate compliance with Part 61 beryllium and mercury standards are also likely to be imposed on owners/operators of sewage sludge incinerators (40 *CFR* 503.47(d)(e).

Records required to be maintained by owners/operators of incinerators are specified both in 40 *CFR* 503.47 and site-specific conditions in the NPDES or sludge permit.

As specified in 40 *CFR* 503.48, the same classes of facilities identified under the land application section are required to report at least once per year. Reporting requirements are imposed on owners and operators of sewage sludge incinerators.

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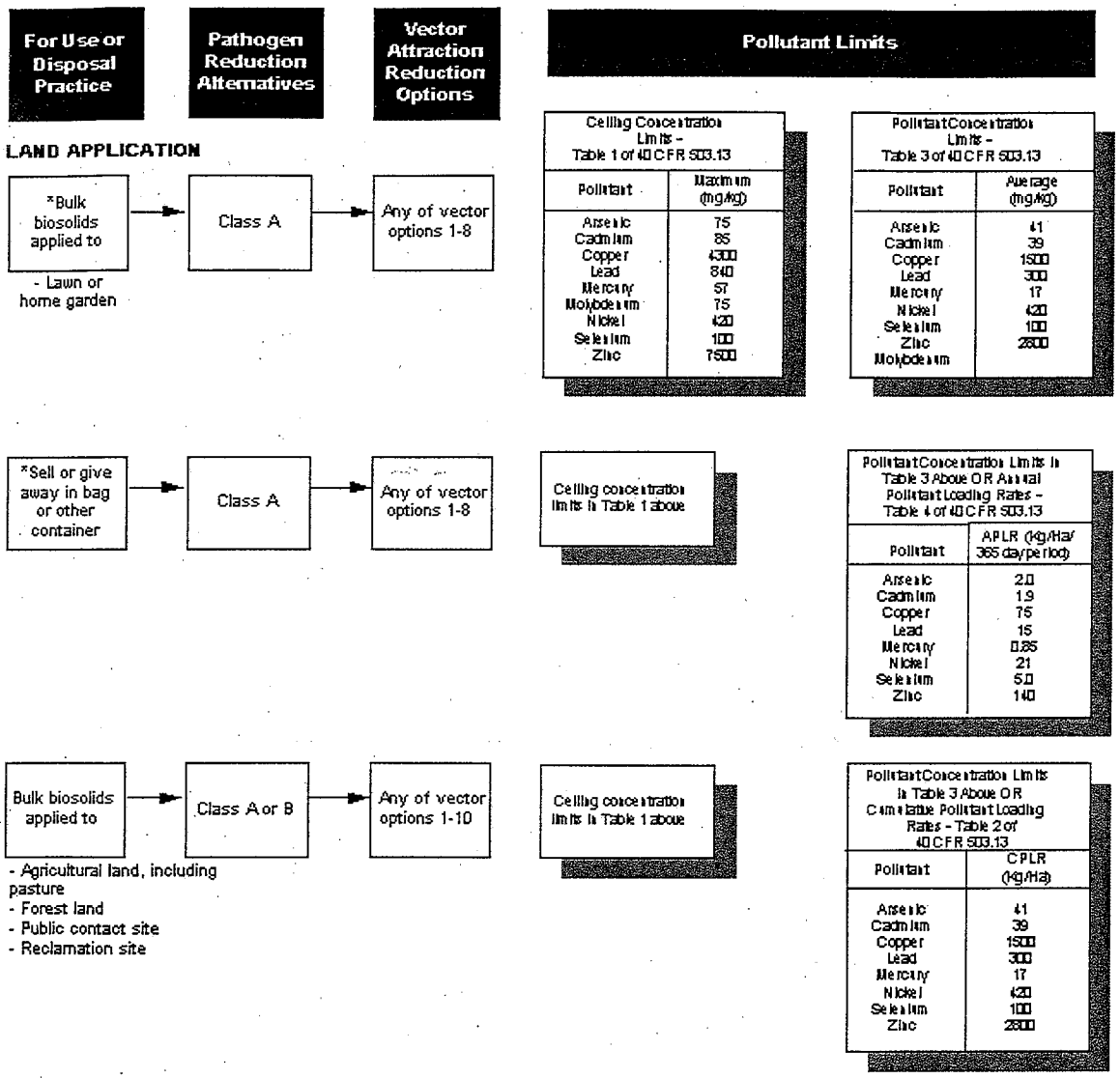
Figure 10-1

Sludge Quality Requirements for Land Application Uses



*Exceptional Quality (EQ) material. General requirements, management practices, site controls, and harvesting restrictions do not apply.

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Figure 10-2

Land Applied Sludge
Requirements Based on Level of Treatment Achieved

SLUDGE TYPE	RESULTING REQUIREMENTS
Exceptional Quality (EQ)	
1) Meets all pollutant concentration limits (Table 2-1, p. 29) 2) Meets any of the Class A alternatives (Table 2-5, p. 37) 3) Meets any of V.A.R. Options 1-8 (Table 2-6, p. 37)	Unregulated for Use Monitoring, Recordkeeping, and Reporting Requirements
Pollutant Concentration (PC)	
1) Meets all pollutant concentration limits (Table 2-1, p. 29) 2) Meets any of the Class B alternatives (Table 2-5, p. 37) 3) Meets any of V.A.R. Options 1-10 (Table 2-6, p. 37)	Site Restrictions (Fig. 2-4, p. 38) Management Practices (Fig. 2-9, p. 45) General Requirements (Fig. 2-8, p. 44) Monitoring, Recordkeeping, and Reporting Requirements
OR	
1) Meets all pollutant concentration limits (Table 2-1, p. 29) 2) Meets any of the Class A alternatives (Table 2-5, p. 37) 3) Meets V.A.R. Option 9 or 10 (Table 2-6, p. 37)	Management Practices (Fig. 2-9, p. 45) General Requirements (Fig. 2-8, p. 44) Monitoring, Recordkeeping, and Reporting Requirements
Cumulative Pollutant Loading Rate (CPLR)	
1) Meets ceiling concentration limits (Table 2-1, p. 29) 2) Meets any Class A or Class B alternative (Table 2-5, p. 37) 3) Meets any of V.A.R. Options 1-10 (Table 2-6, p. 37)	Site Restrictions (Fig. 2-4, p. 38) Management Practices (Fig. 2-9, p. 45) General Requirements (Fig. 2-8, p. 44) Monitoring, Recordkeeping, and Reporting Requirements CPLR Loading Rate Limits (Table 2-1, p. 29)
Annual Pollutant Loading Rate (APLR) **(For solids sold or given away)**	
1) Meets ceiling concentration limits (Table 2-1, p. 29) 2) Meets any of the Class A alternatives (Table 2-5, p. 37) 3) Meets any of V.A.R. Options 1-8 (Table 2-6, p. 37)	Site Restrictions (Fig. 2-4, p. 38) Management Practices (Fig. 2-9, p. 45) General Requirements (Fig. 2-8, p. 44) Monitoring, Recordkeeping, and Reporting Requirements APLR Loading Rate Limits (Table 2-1, p. 29)

NOTE: Tables and page numbers referenced above are from EPA's
A Plain English Guide to the EPA Part 503 Biosolids Rule , September 1994.

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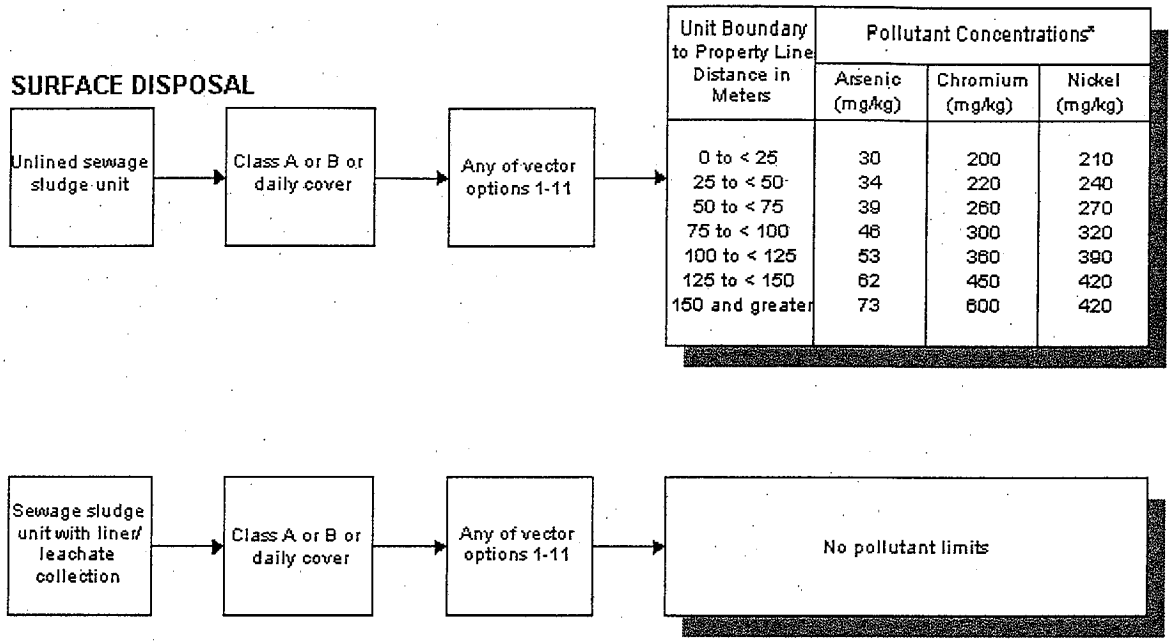
Figure 10-3

Sludge Quality Requirements for Surface Disposal



Unit Boundary to Property Line Distance in Meters	Pollutant Concentrations*		
	Arsenic (mg/kg)	Chromium (mg/kg)	Nickel (mg/kg)
0 to < 25	30	200	210
25 to < 50	34	220	240
50 to < 75	39	260	270
75 to < 100	46	300	320
100 to < 125	53	360	390
125 to < 150	62	450	420
150 and greater	73	600	420

** Site-specific limits may be approved by the permitting authority, if requested.*

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10. B. Sludge (Biosolids) Inspection Procedures

Scope of Inspection Activities

Inspectors should verify compliance with the following general activities:

- Sludge monitoring, recordkeeping, and reporting
- Sludge treatment operations
- Sludge sampling and laboratory Quality Assurance (QA).

EPA intends for the evaluation of sludge management activities to be incorporated into the existing inspection structure so that inspection resources can be used most efficiently. The inspector can identify and investigate problems that might contribute to noncompliance with sludge requirements during any inspection site visit. The Pretreatment Compliance Inspection (PCI), the Compliance Evaluation Inspection (CEI), and the Performance Audit Inspection (PAI) are the most likely vehicles for evaluating compliance with sludge requirements. Examples of how the NPDES inspector may use existing NPDES inspections when evaluating sludge requirements are presented below.

- CSI—The Compliance Sampling Inspection (CSI) is used if the inspector decides that sludge sampling is necessary to determine compliance with applicable requirements.

- CEI—The inspector has historically looked at sludge treatment as part of the Compliance Evaluation Inspection (CEI) because of its effect on wastewater treatment. This evaluation of sludge treatment should be expanded to include a review of sludge monitoring, reporting, and record-keeping, and a more comprehensive evaluation of the Operation and Maintenance (O&M) of sludge treatment processes, to evaluate compliance with sludge permit requirements.

- PAI—The Performance Audit Inspection (PAI) may evaluate compliance with sludge monitoring requirements, and evaluate the permittee's sludge sampling and analytical procedures.

While NPDES inspectors are not required to conduct an in-depth compliance assessment of sludge final use and disposal practices when such practices occur away from the treatment plant, it can help ascertain the vector reduction compliance status at these sites rather than at the Wastewater Treatment Plant (WWTP). In situations where final use and disposal requirements have been established in the facility's NPDES permit (e.g., management practices such as 10-meter buffer zones between the sludge application site and surface waters) and the activity is offsite, the inspector should verify compliance with those requirements through a records review at the facility. As part of a sampling inspection, the inspector may need to sample the sludge to determine compliance with pollutant limits.

EPA intends to focus sludge inspection activities on those aspects of sludge management that the inspector can easily evaluate during an existing NPDES compliance or pretreatment inspection. Inspectors will rely on an evaluation of sludge treatment operations, the observation

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of onsite sludge storage and disposal activities, and the review of sludge monitoring and disposal records to identify actual and potential noncompliance with sludge requirements. Inspectors should document compliance or noncompliance with sludge final use or disposal requirements in accordance with standard NPDES compliance inspection procedures. Any inspection checklist is useful for documenting that all necessary information has been collected. Inspection checklists are included at the end of this chapter. These checklists are based on the checklists in EPA's *Guidance for NPDES Compliance Inspector: Evaluation of Sludge Treatment Processes* (EPA November 1991) and *Guidance for NPDES Compliance Inspector: Verifying Compliance with Sludge Requirements* (EPA November 1991), as modified by EPA Region 8. The checklists should be used in conjunction with the checklist questions found in the 1991 guidance manuals. However, sludge permits may contain additional sludge permit conditions, based on case-by-case considerations, that are not included on the checklist. The inspector should identify additional permit requirements and verify compliance with these conditions as well. To accomplish this, it is recommended that the inspector expand the checklist, if necessary, to ensure that it is specific to the NPDES permit and the sludge final use or disposal activity. The inspector should complete the checklist and should incorporate his/her findings and conclusions in the final inspection report prepared for the facility.

The NPDES compliance inspector should consult EPA's 1991 *Guidance for NPDES Compliance Inspector: Evaluation of Sludge Treatment Processes* when preparing to conduct a sludge inspection. This technical reference presents a detailed examination of sludge unit processes and also contains extensive technical checklists that summarize the most critical elements of sludge thickening, stabilization, conditioning, dewatering, and disinfection. A technical understanding of the proper design and operation of the sludge treatment processes is essential for conducting thorough and informed sludge inspections.

Inspection Preparation

On preparing for the inspection, the inspector should:

- Review the NPDES Permit (or the facility's sludge permit, if applicable). When reviewing the NPDES permit file in preparation for the inspection, identify:
  - Permit conditions applicable to sludge including treatment; general requirements; management practices; and monitoring, reporting, and recordkeeping requirements
  - Any additional requirements in the NPDES permit that may reflect State regulations. Additionally, the NPDES permit may incorporate a separate State permit by reference, in which case the State permit is also enforceable under the Federal CWA.
- Review sludge self-monitoring data
- Become familiar with the sludge disposal practices used
- Review appropriate Federal regulations (i.e., 40 *CFR* Part 503 Regulations, or Part 258 if sludge is disposed of in a municipal solid waste landfill, and any other applicable State or local regulations)

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- Review relevant guidance for background information and implementation procedures (e.g., guidelines on calculating agronomic rate, EPA's Process Design Manuals for Land Application of Municipal Sewage Sludge and Municipal Sludge Landfills, Control of Pathogens and Vector Attraction in Sewage Sludge)
- Verify that records kept by the permittee help in evaluation of compliance with sludge requirements.

Records Review

The Part 503 sludge regulations contain recordkeeping and reporting requirements. The facility's NPDES or sludge permit may have additional recordkeeping or reporting requirements. The inspector should conduct an evaluation of the sludge records and reports found at the facility to determine compliance with these recordkeeping and reporting requirements. The inspector should use the procedures listed below for these routine inspections. If suspected violations are uncovered during the routine evaluation, a more intensive investigation should be conducted.

The inspector should check in the records review process, the evaluation of compliance with sludge recordkeeping requirements on the following:

- Does the facility have all required information available for review?
- Does the facility address all regulated pollutants and sludge use and disposal practices?
- Does the facility have all the current sludge information?
- Does the facility maintain sludge records for at least 5 years (commencing July 20, 1993)?
- Does the facility's information contained in the sludge records support the data submitted to the permitting authority?
- Does the facility's records indicate areas needing further investigation?

The inspector should also identify whether violations of sludge-related permit requirements (e.g., concentration limits and/or management practices) have been reported to the control authority, as required by the permit. Finally, the inspector should verify that the permittee has notified EPA of any changes to sludge use or disposal practices.

Evaluation Procedures

The inspector should first review the permit and fact sheet and list all sludge recordkeeping requirements. Table 10-1 is a list of records that may be relevant for sludge. This list is supplemented by Table 10-2, which describes records relevant to the operation of specific sludge treatment unit processes. Throughout the inspection, compare the facility's operations with the permit conditions to verify that required permit activities for sludge are correct, current, and complete.

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An evaluation of sludge self-monitoring records and/or procedures involves the same elements as an evaluation of their wastewater monitoring data; however, there are some special considerations inherent in sludge sampling. In evaluating the permittee's records, inspectors should look for documentation regarding:

- Regulated Pollutants—As identified in the NPDES permit or applicable Federal or State regulations.

- Monitoring Frequency—As identified in the NPDES permit or applicable Federal or State regulations. The inspector should note that Part 503 establishes minimum monitoring frequencies based on the quantity of sewage sludge used or disposed of.

- Sample Location—The appropriate sampling point is the last treatment process the sludge goes through before leaving the treatment plant for use or disposal. For example, if digested sludge is land applied, the sludge should be sampled as it is transferred from the digester to the truck prior to being hauled offsite. Table 10-3 identifies sludge sampling points appropriate for the various types of treated sludge.

- Sample Types—Grabs or composites may be appropriate depending on the situation, but it is important to note that a grab sample from a lagoon, drying bed, compost pile, or truck must consist of numerous samples collected from various places in the lagoon, bed, pile, or truck and must be combined to make a representative sample.

- Sample Volume—If evaluating the sample collection process or taking samples, the inspector must ensure that the container is not filled completely. Some space should be left to allow for expansion of the sample due to gas production. Rapid cooling of the sample will also reduce gas production. (Refer to Appendix L for specific sample volumes.)

- Sample Containers—Sample containers are generally the same types as those used for collection of wastewater samples, except that sludge sampling containers should be wide mouth bottles. (Refer to Appendix L for a description of the appropriate container material.)

- EPA Sample Identification Methods—Same as for wastewater sampling.

- Preservation and Holding Times—The primary difference in sludge preservation is that samples should not be chemically preserved in the field because the sludge matrix makes it difficult to thoroughly mix the preservative into the sample. However, samples should be iced. (Refer to Appendix L.)

- Chain-of-custody—Same as for wastewater sampling.

- Quality Control—Same as for wastewater sampling.

- Analytical procedures used by lab—The analytical methods used for sludge are different from those used for wastewater. Approved analytical methods are listed in Part 503 (40 *CFR* 503.8). For example, Part 503 requires that analyses for inorganic pollutants use the procedures in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, EPA publication SW-846. The inspector should note the information recorded regarding sample handling and analysis at the laboratory and verify that it is correct. If

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evaluating the laboratory, the procedures are the same as those followed in a PAI. The inspector should look at:

- Analytical procedures
- Laboratory services
- Instruments and equipment
  - Calibration
  - Maintenance
- Supplies
- Quality Assurance/Quality Control (QA/QC)
  - Precision and accuracy of measurement process
  - Data handling and reporting
  - Records retention
  - Personnel qualifications.

- Analytical Results—Verify that results documented in the files are consistent with those reported.

The inspector should verify that reporting requirements are fulfilled according to the permit and applicable regulations. The NPDES permit may or may not have specific reporting requirements; however, the Part 503 sludge standards have specific reporting requirements that apply regardless of whether they appear in the NPDES permit. The May 1989 revisions to the NPDES regulations established required permit conditions regarding notification of change and at least annual reporting of sludge monitoring results. As NPDES permits are reissued, they will contain, at a minimum, these standard conditions as well as conditions specified in Part 503. Based on the applicable requirements, the inspector should verify that:

- Reports contain all required information
- Reports are submitted at the required frequency
- Data are reported in Discharge Monitoring Report (DMR) or other approved form.

Inspectors should review unit operation records to verify compliance with pathogen and vector attraction reduction requirements. Tables 10-4, 10-5, and 10-6 list the records and operating requirements for the Part 503 Class A pathogen reduction alternatives, the Class B pathogen reduction alternatives, and the vector attraction reduction options, respectively. Inspectors are not expected to review each monitoring record, but rather to verify that records are being maintained and are available for review. If a permittee has problems meeting either its pathogen or vector attraction reduction requirements (e.g., fecal coliform or percent volatile solids reduction), the inspector should review treatment operating records to identify potential noncompliance with the particular operating requirements specified in Part 503 for the particular pathogen and vector reduction process employed by the permittee. For example, an inspector might check a treatment facility's pH or temperature records to determine whether the sludge has been maintained at the appropriate pH or temperature for the required duration during treatment.

The inspector should verify that records are available for all disposal practices:

- Volume of sludge disposed of
- Sludge quality data
- Specific records appropriate for demonstrating compliance with the general requirements, management practices, and operational standards.

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The inspector should verify whether records are maintained in accordance with permit requirements. The May 1989 NPDES regulatory revisions created a mandatory permit condition requiring that sludge records be kept for 5 years. The Part 503 regulations establish specific recordkeeping requirements for each party involved in the sewage sludge use or disposal process.

Facility Site Review

Inspection of Solids Handling Unit Processes

Sludge processing arguably poses the greatest challenges in wastewater treatment from the standpoints of design, operation, and maintenance.

When conducting the walk-through visual inspection of the facility, the inspector should be aware of, and look for, physical conditions that are indicative of potential or existing problems. Some of the more common indicators of potential problems are listed in Table 10-7. The presence of these conditions may warrant a more in-depth inspection of the sludge treatment processes. A checklist is provided at the end of this chapter to assist the inspector during the facility site review. The questions on this checklist are sludge-specific and should be asked in conjunction with the Facility Site Review checklist. In addition, many of the questions in the NPDES checklist relate to the overall operation of the facility and therefore, can also be applied to sludge evaluations (e.g., treatment units properly operated and maintained). The inspector should look for conditions that indicate potential or existing problems. If the inspector finds conditions that are a potential problem, this may trigger a more detailed evaluation. EPA has developed guidance and checklists for conducting in-depth evaluations of each of the most common sludge treatment unit processes, *Guidance for NPDES Compliance Inspectors: Evaluating Sludge Treatment Processes*, November 1991.

The inspector should determine whether the facility is operating its sludge treatment and disposal processes in a manner consistent with the requirements established in its NPDES permit. If the inspector discovers conditions at the facility that threaten public health or the environment (e.g., contaminating groundwater or surface water, exposing the public to pathogens or disease vectors, or compromising public safety), the inspector should inform the enforcement staff so that appropriate action can be taken. If knowing endangerment is discovered, the criminal investigations unit should be informed.

Many large-scale operations are conducted outside, such as sludge drying, composting, temporary and long-term storage, and loading and hauling. Inspectors should note these outside operations' exposure to rainfall and runoff collection and treatment methods. If storm water collection devices have been constructed, the inspector should evaluate the performance and maintenance of these devices as well as their design capacity (e.g., the 10-year 24-hour storm event or the 25-year 24-hour storm event). Visual observations can detect obvious problems that may contribute to the contamination of surface water or groundwater such as erosion, breaches of dikes or berms, or cracks in the concrete or asphalt. The inspector should inquire as to whether the capacity of the collection devices has ever been exceeded during any storm event.

The sludge loading area should be inspected to determine how the sludge is being hauled or transported. The inspector should note the size of the truckloads and the number of truckloads

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hauled over a 1-day period (or another time period). These figures are useful to the inspector in verifying the permittee's records and reports on the volume of sludge generated and disposed of.

Sludge Storage

The inspector should also verify that the permittee has adequate storage capacity for its sludge in the event that its preferred disposal method is interrupted for any reason (e.g., noncompliance with cumulative loading rates on the land application site). There are no Federal requirements specifying a minimal storage capacity; the appropriate capacity will vary depending on the amount of sludge generated and the facility's use or disposal option(s). Storage capacity should address normal, routine storage prior to disposal and should anticipate emergency conditions, such as:

- Equipment malfunction
- Inclement weather
- Unanticipated loss of disposal site
  - Farmer decides to discontinue use of sewage sludge
  - Landfill violates requirements and may no longer accept sludge or is required to close.

Some States have developed storage capacity requirements. If the permittee cannot dispose of its sludge in the preferred manner, it should have either adequate storage capacity for its sludge or clearly established plans for alternative methods of disposal.

Sampling and Laboratory Quality Assurance (QA)

The sludge inspection should evaluate the nature, scope, and adequacy of sludge sampling and analysis conducted by the permittee. The most likely, existing inspection vehicle for conducting this evaluation is the PAI, since it involves a detailed assessment of the permittee's self-monitoring activities, including sample collection and laboratory analysis. The findings of the sampling and laboratory QA review should be summarized and included in the final inspection report for the facility.

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Sampling Procedures and Techniques

The inspector's evaluation of the permittee's sludge sampling procedures will address similar criteria as those evaluated in the context of wastewater sampling. The sampling procedure elements that should be evaluated during the inspection include:

- Sample collection techniques
  - Selection of representative sampling sites
  - Sample types
  - Sample volume
  - Sample containers
- EPA sample identification methods
- Sample preservation and holding time
- Chain-of-custody and shipment of samples
- Quality Control (QC)
  - Duplicates
  - Blanks
- Data handling and reporting.

A detailed discussion on evaluating these elements can be found in Chapter Five. While many of these elements are evaluated using the same criteria, regardless of the media being sampled, sludge sample collection techniques and sample preservation are different. The inspector should review EPA's sewage sludge sampling video and refer to EPA's 1989 *POTW Sludge Sampling and Analysis Guidance Manual* for detailed information regarding sludge sampling procedures. Table 10-3 of this document summarizes appropriate sample locations. Appendix L lists sample containers, preservation techniques, and holding times as a quick reference for the inspector. In addition to these references, a few special sludge sampling considerations are described below.

- Equipment. The equipment used to collect sludge samples is different from that used to collect wastewater samples. The automatic composite samplers used to collect wastewater cannot be used to collect sludge samples because the high solids content of the sludge fouls the tubing. The type of equipment used to collect samples of soil or other solid waste material is more appropriate for the collection of sludge samples. Stainless steel buckets, trowels, and augers are typically used to collect solid sludge cake. Graduated glass or plastic pitchers or cylinders, or plastic or stainless steel buckets are used to collect liquid sludge samples.

- Sample Location. If the permit does not identify a specific sludge sampling location, the inspector must select one. (See EPA's sewage sludge sampling video for an overview of this process.) EPA's 1989 *POTW Sludge Sampling and Analysis Guidance Manual* states that for purposes of enforcement, sludge samples must come from the treatment unit process immediately prior to sludge disposal or end use. Often, the last unit process is one of the dewatering processes described in the accompanying technical guidance. Table 10-3, from EPA's 1989 Sampling and Analysis Guidance Manual, suggests appropriate sampling points for a variety of unit processes.

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Table 10-1

Records Relevant for Sludge Operations

Sludge Use/Disposal Records

- Volume
- Type of use and/or disposal options used
- Use/disposal sites
- Loading rates of pollutants (e.g., agronomic) at each land application site

Sludge Operating Records

- Daily operating log
- Equipment maintenance scheduled and completed
- Detention time, operating temperature, or pH to evaluate pathogen reduction

Sludge Monitoring Records

- Constituents/pollutants in sludge
- Mass of sludge generated and disposed of (in dry metric tons per year)

Sludge Sampling and Analytical Data

- Dates, times, and locations of sampling
- Sampling protocols and analytical methods
- Results of analyses
- Dates and times of analyses
- Name(s) of analysis and sampling personnel

Sludge Laboratory Records

- Calibration and maintenance of equipment
- Laboratory bench sheets or logs and calculations
- Quality Assurance/Quality Control (QA/QC) records

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Table 10-2

Operating Records for Specific Unit Processes

THICKENING PROCESSES

Gravity Thickening	Dissolved Air Flotation	Centrifuge
• Overflow volume/rate • Influent flow • Percent solids - Sludge feed - Thickened sludge - Overflow • Sludge blanket depth	• Sludge feed rate • Recycle flow • Daily operating time • Percent solids - Sludge feed - Thickened sludge - Subnatant • Floating sludge depth • Air flow rate • Retention tank pressure • Percent solids capture • Detention time • Air to solid ratio	• Influent sludge flows • Volume cake produced • Percent solids - Sludge feed - Centrate - Sludge cake • Daily operating time

STABILIZATION PROCESSES (Pathogen and/or Vector Attraction Reduction)

Aerobic Digestion	Anaerobic Digestion	Incineration
• Air supply • Solids retention time • Temperature • DO level • pH • Feed sludge - TS, TVS, and pH - Flow rate • Digested sludge - SOUR - TS, TVS, and pH - Flow rate • Supernatant - Flow rate and BOD - TSS and ph	• Detention time • Temperature • pH and alkalinity • Gas production and quality • Volatile acids • Feed sludge - TS, TVS, and pH - Flow rate • Digested sludge - TS, TVS, and pH - Flow rate • Supernatant - Flow rate and BOD - TSS and pH • Cleaning frequency	• Operating schedule • Sludge feed - Solids content - Feed rate - Volatile solids • Combustion temperature • Sludge residence time • Fuel flow • Off-gas oxygen content • Air feed rate • Emission control equipment - Pressure drop • Type of fuel • Volume of ash produced • Stack gas monitoring
Heat Temperature	**Composting**	**Chemical Conditioning/Stabilization**
• Temperature/time • Pressure • Detention time • Feed sludge - TS and TVS - Flow rate - Percent solids • End product volatile solids	• Oxygen concentration • Temperature and time • Turning frequency • Percent sludge solids • Type and amount of bulking agent(s) • Header pressure	• Chemical types and dosage • Mixing • pH • Temperature
Electron Irradiation	**Gamma Irradiation**	
• Sludge feed rate • Electron dosage • Temperature	• Sludge feed rate • Gamma ray source strength	

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Table 10-2

Operating Records for Specific Unit Processes (Continued)

DEWATERING PROCESS

Vacuum Filter	Pressure Filter	Belt Filter Press
• Sludge feed - Total solids • Sludge cake - Total solids • Filtrate - Flow - BOD - TSS • Maintenance • Spare parts	• Sludge feed percent solids • Sludge cake percent solids • Volume of sludge processed • Cycle length • Volume conditioning chemicals • Filtrate - Flow - BOD - TSS	• Loading rate • Operating speed • Feed slurry - Total solids and flow • Dewatered sludge - Total solids - Flow • Filtrate and wash water - BOD and SS - TSS and flow • Preventive maintenance • Polymer
Drying Bed	**Drying Lagoons**	**Heat Drying**
• Sludge loading rate • Quantity in bed • Depth of sludge in bed • Date deposited • Detention time • Ambient temperature • Drying bed construction (i.e., lined) • Undertrain destination • Percent solids of the sludge feed and of the dewatered sludge	• Sludge loading rate • Percent solids - Sludge - Decant • Quantity in lagoon • Depth in lagoon • Date deposited • Drying time • Rainfall	• Operating schedule - Start-up - Shut down • Sludge feed rate • Percent solids - Sludge feed - Dried/Pelletized product • Fuel consumption • Air flow • Drying temperature • Detention time • Stack gas monitoring - Oxygen - Particulates - Carbon monoixde - Carbon dioxide

LEGEND:
DO = Dissolved Oxygen
TS = Total Solids
TVS = Total Volatile Solids
BOD = Biochemical Oxygen Demand
TSS = Total Suspended Solids
SS = Suspended Solids
SOUR = Specific Oxygen Uptake Rate

Table 10-3

Sludge Sampling Points

Sludge Type	Sampling Point

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Anaerobically digested	Sample from taps on the discharge side of positive displacement pumps.
Aerobically digested	Sample from taps on the discharge lines from pumps. If batch digester is used, sample directly from the digester. Two cautionary notes regarding this practice: • If aerated during sampling, air entrains in the sample. Volatile organic compounds may purge with escaping air. • When aeration is shut off, solids separate rapidly in well-digested sludge.
Thickened	Sample from taps on the discharge side of positive displacement pumps.
Heat treated	Sample from taps on the discharge side of positive displacement pumps after decanting. Be careful when sampling heat treatment sludge because of: • High tendency for solids separation • High temperature of samples (frequently >60°C) can cause problems with certain sample containers due to cooling and subsequent contraction of entrained gases.
Dewatered by belt filter press, plate and frame press, centrifuge, or vacuum filter press	Sample from sludge cake discharge chute and conveyor. Alternatively, sample from collection container or storage bin for the dewatered sludge; sample from many locations within the storage bin and at various depths, collect equal samples from each point, and combine them to form one sample of the total storage bin.
Dewatered or air dried in drying beds, or bin or truck bed	Divide bed into four quadrants, collect equal sample volume from the center of each quadrant, and combine them to form one sample of the total bed. Each grab sample should include the entire depth of the sludge (down to the sand).
Composted	Collect full core samples from randomly selected sites in the pile. Sample directly from front-end loader or other conveyance device as the sludge is being loaded into trucks to be hauled away.

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- Sample Collection Techniques. Obtaining a representative sample of sludge is difficult when the sludge is not flowing through a pipe or along a conveyer. To obtain a representative sample of sludge from a sludge bed or lagoon, a compost pile, or a truck, several samples have to be taken from various places in the pile and "combined" to make a representative sample.

- Sample Preservation. Samples of solid sludge are not usually preserved in the field because it is difficult to thoroughly mix the preservative throughout the sludge sample. It is best to preserve sludge samples that are high in solids at the laboratory. The appropriate field preservative outlined in Appendix L is to chill the sample to 4°C. Note, some exemptions do exist such as a sample for the Specific Oxygen Uptake Rate (SOUR) should be kept at the same temperature as the aerobic digestor and analyzed within 30 minutes of sample.

Laboratory Analysis and Quality Assurance

During a PAI, the inspector is already conducting an in-depth evaluation of the permittee's laboratory analytical techniques and QA/QC procedures. The following elements are evaluated during this inspection:

- Permittee sample handling procedures in the laboratory
- Laboratory analysis techniques
  - Permittee laboratory analytical procedures (Analytical methods specified by 40 *CFR* Part 503 or other methods established in the permit)
  - Laboratory services
  - Instruments and equipment
  - Supplies
- QA/QC
  - Precision and accuracy of the measurement process
  - Data handling and reporting
  - Sludge records retention (for 5 years)
  - Personnel qualifications.

Again, many of these elements are evaluated according to the same criteria regardless of the sample being analyzed. The inspector is referred to Chapter Seven and the 1990 *NPDES Compliance Monitoring Inspector Training Module on Laboratory Analysis* for general guidance on inspecting the permittee's laboratory procedures. There are some differences in sample preparation and analytical techniques for sludge with which the inspector should be familiar.

In conducting the sludge component of the PAI, the inspector should closely evaluate the permittee's sample preparation procedures. The sludge matrix is more complex and variable than the wastewater matrix; therefore, the laboratory's development of sample preparation techniques is of particular concern.

The NPDES permit may require the permittee to analyze sludge for conventionals, inorganic pollutants, metals, and pathogens (depending on the ultimate sludge disposal practice). For example, sludge that is going to be land applied will be analyzed for 9 metals and nitrogen to determine the appropriate application rate. Table 10-8 lists the constituents required to be monitored by Part 503. 40 *CFR* 503.8 contains a listing of approved analytical methods and

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volatile solids reduction calculations that must be used for monitoring sludge quality. The analytical methods for metals are not the same as those used for the analysis of wastewater.

Appendix L contains the required analytical method, the maximum allowable sample holding times, sample preservation techniques, sample containers, sample preparation methods, and additional comments that may be pertinent to the analytical method.

The inspector should keep the following points in mind when reviewing the permittee's lab and analytical results:

- The Part 503 standards are expressed on a dry weight basis. Laboratory results for sludge are typically reported in one of two forms, wet weight (i.e., mg/L) or dry weight (i.e., mg/kg). Watch out for mg/Kg units that are wet weight rather than dry weight. The laboratory should be providing the results on a dry weight basis. In the event that the laboratory results are reported on a wet weight basis (i.e., in mg/L), the results for each pollutant in each sample must be recalculated to determine the dry weight concentration. To accomplish this conversion, the percent total solids in the sludge sample must be known. Thus, the lab must analyze the sample for percent solids using Method 2540G of *Standard Methods*, 18th Edition.

  The following equation can be used to determine the dry weight concentration because the equation uses the assumption that the specific gravity of water and sewage sludge are both equal to one. However, this assumption holds true only when the solids concentration in the sludge is low. The calculated dry weight concentration may vary slightly from the actual concentration as the solids content increases because the density of the sewage sludge may no longer be equal to that of water. This concern does not arise when the solids content of sludge is usually low. EPA is aware of this potential problem and may make a determination regarding this matter at a later date.

  Determine the pollutant concentration on a dry weight basis using the following abbreviated conversion:[1]

$$\text{PC (dry, mg/kg)} = \frac{\text{PC (wet, mg/L)}}{\text{(\% total solids)}}$$

  where PC = Pollutant concentration

  A unit conversion is incorporated into the equation.

- For metals, a common analytical error is that labs conduct the metals analyses using analytical methods developed for water and wastewater. Analytical methods for water and wastewater are found in *Standard Methods,* while the solid waste analytical methods are found in *Test Methods for Evaluating Solid Wastes* (EPA SW-846). For sludge samples, all metals must be analyzed by SW-846 methods. If you find non-

[1] *Analytical Methods Used in the National Sewage Sludge Survey.* August 1988. U.S. EPA Office of Water Regulations and Standards (WH-552), Industrial Technology Division, Washington, DC.

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detects for the metal concentrations, in general the laboratory is not following the method requirement of digesting equivalent to 1gm dry weight of solid.

- Also for metals, note that more than one SW-846 method is provided for each pollutant. The difference between the methods is usually the equipment used [i.e., direct aspiration, furnace, or Inductively Coupled Plasma (ICP) scan] and the level of detection desired. Each of the three methods is EPA-approved, but certain sample characteristics may require one to be used instead of another.
- SW-846 Method 3050 or equivalent, is the required preparation method for all metals except mercury (using equivalent to 1 gram dry weight).

- In contrast to the metals, many of the additional inorganic parameters [e.g., nitrite, Total Kjeldahl Nitrogen (TKN), etc.] require methods that are found in *Standard Methods for the Examination of Water and Wastewater.* There are several reasons for this, one being that there is no method for the parameter that is specific to solid waste.

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Table 10-4

Recordkeeping Requirements for Class A Pathogen Reduction Alternatives

Alternative A1—Time and Temperature
• Analytical results for density of *Salmonella sp.* bacteria or fecal coliform (most probable number) • Sludge temperature • Time (days, hours, minutes) temperature maintained
Alternative A2—Alkaline Treatment
• Analytical results for density of *Salmonella sp.* bacteria or fecal coliform (most probable number) • Sludge pH • Time (hours) pH maintained above 12 (at least 72 hours) • Sludge temperature • Percent solids in sludge after drying (at least 50 percent)
Alternative A3—Analysis and Operation
• Analytical results for density of *Salmonella sp.* bacteria or fecal coliform (most probable number) • Analytical results for density of enteric viruses (plaque forming unit/4 grams total solids) prior to pathogen reduction and, when appropriate, after treatment • Analytical results for density of viable helminth ova (number/4 grams total solids) prior to pathogen reduction and, when appropriate, after treatment • Values or ranges of values for operating parameters to indicate consistent pathogen reduction treatment
Alternative A4—Analysis Only
• Analytical results for density of *Salmonella sp.* bacteria or fecal coliform (most probable number) • Analytical results for density of enteric viruses (plaque forming unit/4 grams total solids) • Analytical results for density of viable helminth ova (number /4 grams total solids)

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Table 10-4

Recordkeeping Requirements for Class A Pathogen Reduction Alternatives (Continued)

<table>
<tr><th colspan="2">Alternative A5—Processes to Further Reduce Pathogens (PFRP)</th></tr>
<tr><td>• Heat Drying
- Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number)
- Moisture content of dried sludge <10 percent
- Logs documenting temperature of sludge particles or wet bulb temperature of exit gas exceeding 80°C

• Thermophilic Aerobic Digestion
- Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number)
- Dissolved oxygen concentration in digester >1 mg/L
- Logs documenting temperature maintained at 55-60°C for 10 days

• Heat Treatment
- Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number)
- Logs documenting sludge heated to temperatures > 180°C for 30 minutes

• Pasteurization
- Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number)
- Temperature maintained at or above 70°C for at least 30 minutes</td><td>• Composting
- Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number)
- Description of composting method
- Logs documenting temperature maintained at or above 55°C for 3 days if within vessel or static aerated pile composting method
- Logs documenting temperature maintained at or above 55°C for 15 days if windrow compost method
- Logs documenting compost pile turned at least five times during the 15day period, if windrow compost method

• Gamma Ray Irradiation
- Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number)
- Gamma ray isotope used
- Gamma ray dosage at least 1.0 megarad
- Ambient room temperature log

• Beta Ray Irradiation
- Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number)
- Beta ray dosage at least 1.0 megarad
- Ambient room temperature log</td></tr>
<tr><th colspan="2">Alternative A6—PFRP Equivalent</th></tr>
<tr><td colspan="2">• Operating parameters or pathogen levels as necessary to demonstrate equivalency to the PFRP
• Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number)</td></tr>
</table>

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Table 10-5

Recordkeeping Requirements for Class B Pathogen Reduction Alternatives

Alternative B1—Fecal Coliform Count
• Number of samples collected during each monitoring event • Analytical results for density of fecal coliform for each sample collected
Alternative B2—Processes to Significantly Reduce Pathogens (PSRP)
• Aerobic Digestion - Dissolved oxygen concentration - Volatile solids content before and after digestion - Mean residence time of sludge in digester - Logs showing temperature was maintained for sufficient period of time (ranging from 60 days at 15°C to 40 days at 20°C) • Air Drying - Description of drying bed design - Depth of sludge on drying bed - Drying time in days - Daily average ambient temperature • Anaerobic Digestion - Volatile solids content before and after digestion - Mean residence time of sludge in digester - Temperature logs of sludge in digester • Composting - Description of composting method - Daily temperature logs documenting sludge maintained at 40°C for 5 days - Hourly readings showing temperature exceeded 55°C for 4 consecutive hours • Lime Stabilization - pH of sludge immediately and then 2 hours after addition of lime
Alternative B3—PSRP Equivalent
• Operating parameters or pathogen levels as necessary to demonstrate equivalency to PSRP

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Table 10-6

Recordkeeping Requirements for Vector Attraction Reduction Sludge Processing Options

Option 1—Volatile Solids (VS) Reduction	**Option 5—Aerobic Processing (Thermophilic Aerobic Digestion/ Composting)**
• Volatile solids concentration of raw and final sludge streams (mg/kg) • Calculations showing 38 percent reduction in volatile solids	• Sludge detention time in digester/composting • Temperature logs showing average temperature above 45°C and minimum temperature above 40°C for 14 consecutive days
Options 2 and 3—Bench-Scale VS Reduction	**Options 6—Alkaline Treatment**
• Description of bench-scale digester • Time (days) that sample was further digested in bench-scale digester (30 days for aerobically and 40 days for anaerobically digested sludge) • Temperature logs showing temperature maintained at 20°C for aerobically or between 30°C and 37°C for anaerobically digested sludge • Volatile solids concentration of sludge (mg/kg) before and after bench-scale digestion	• Logs demonstrating hours pH of sludge/ alkaline mixture was maintained (12 for 2 hours and 11.5 for an additional 22 hours) • Amount of alkaline added to sludge (lbs or gals) • Amount of sludge treated
Option 4—Specific Oxygen Uptake Rate	**Options 7 and 8—Drying**
• Dissolved oxygen readings for sludge sample over 15-minute intervals (mg/L) • Temperature logs showing test was corrected to 20°C • Total solids for sludge sample (g/L) • SOUR calculations (mg/g)	• Results of percent solids (dry weight) test • Presence of unstabilized solids generated during primary treatment

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Table 10-7

Sludge Handling Process Evaluation

General Indicators of Problems

- Inadequate sludge removal from clarifiers or thickeners
- Poor dewatering characteristics of thermal treated sludge
- Thickened sludge too thin
- Fouling of overflow weirs on gravity thickeners
- Air flotation skimmer blade binding on beaching plate
- Substantial down-time of sludge treatment units
- Sludge disposal inadequate to keep treatment system in balance
- Mass balance inappropriate (ratio of sludge wasted should be 0.65-0.85 lbs of sludge per lb of BOD removed)
- Sludge decant or return flows high in solids*
- Odors
- Improper loading rates

Anaerobic Digestion Problems

- Inoperative mechanical or gas mixers
- Inoperative sludge heater or low temperature*
- Floating cover of digester tilting
- Inadequate gas production*
- Inoperative gas burner
- Supernatant exuding sour odor from either primary or secondary digester*
- Excessive suspended solids in supernatant
- Supernatant recycle overloading the WWTP
- pH problems*

Aerobic Digestion Problems

- Excessive foaming in tank*
- Objectionable odor in aerobically digested sludge*
- Insufficient dissolved oxygen in digester
- Digester overloaded
- Clogging of diffusers in digester
- Mechanical aerator failure in digester
- Inadequate supernatant removal from sludge lagoons
- Solids accumulation in tank

*Indicates serious problems with the sludge handling process.

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Table 10-7

Sludge Handling Process Evaluation (Continued)

Sludge Dewatering Problems

Drying Beds
- Poor sludge distribution on drying beds
- Vegetation in drying beds (unless reed design)
- Dry sludge remaining on drying beds
- Inadequate drying time on drying beds*
- Some unused drying beds
- Dry sludge stacked around drying beds where runoff may enter navigable waters
- Filtrate from sludge drying beds returned to front of plant

Centrifuge
- Excessive solids in fluid phase of sample after centrifugation*
- Inadequate dryness of centrifugal sludge cake*
- Excessive vibration or other mechanical problems

Filter Press
- High level of solids in filtrate from filter presses or vacuum filters*
- Thin filter cake caused by poor dewatering
- Vacuum filter cloth binding
- Low vacuum on filter
- Improperly cleaned vacuum filter media
- Sludge buildup on belts and/or rollers of filter press
- Excessive moisture in belt filter press sludge cake*
- Difficult cake discharge from filter presses
- Filter cake sticks to solids-conveying equipment of filter press
- Frequent media binding of plate filter press
- Sludge blowing out of filter press
- Insufficient run time of sludge dewatering equipment

*Indicates serious problems with the sludge handling process.

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Table 10-7

Sludge Handling Process Evaluation (Continued)

Sludge Stabilization Problems

Lagoon
- Objectionable odor from sludge lagoon
- Damage to dikes around sludge drying lagoons
- Unlined sludge lagoons
- Sludge lagoons full, overflowing sludge back to plant or to natural drainage
- Deep rooted vegetation on dikes or berms

Composting
- Piles that give off foul odor
- Inoperable blower
- Temperature does not reach 122-140°F (50-60°C)
- Uncontrolled storm water runoff

Heat Drying/Pelletizing
- Excess moisture in sludge feed
- Insufficient air flow or drying temperature achieved
- Inadequate drying of final product (excess moisture in final product)
- Excess odors associated with treatment area
- Excess odors associated with treated product

Alkaline Stabilization
- Insufficient amount of lime (or other alkaline additive) used to assure pH is raised sufficiently
- Inadequate mixing provided to assure good contact of lime (or other alkaline additive) with sludge solids
- pH problems*
- Excess odors associated with treatment area
- Excess odors associated with treated product
- Excessive lime dust around treatment equipment

Incineration
- Objectionable odors associated with treatment area
- Evidence of excessive dust (ash) around unit
- Visible smoke or dust exhaust from unit
- Lack of compliance with air permit parameters
- Spilling or leaking sludge from dewatered sludge transfer equipment

*Indicates serious problems with the sludge handling process.

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Table 10-7

Sludge Handling Process Evaluation (Continued)

Sludge Disposal Problems
• Sludge constituents not analyzed before disposal
• Sludge not transported in appropriate and approved vehicle
• Surface runoff of sludge at land application site
• Liquid sludge (i.e., less than 10 percent solids) applied to landfill site
• Sludge fails paint filter test
• Inadequate coverage of sludge in subsurface plow injection system
• Objectionable odors generated at land application site*
• Slow drying of soil-sludge mixture in subsurface injection system
• Sludge ponding at land application sites
• Flies breeding, vectors, and/or odors at landfill site
• Inadequate burial of sludge at landfill site
• Excessive erosion at sludge sites
• Sludge disposed of in nonpermitted sites
• Disposal not in accordance with Federal, State, or local regulations
• Sludge lagoons full and overflowing*
• Inadequate runoff control at landfill or land application sites

*Indicates serious problems with the sludge handling process.

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Table 10-8

Pollutants Monitored for Land Application, Surface Disposal, and Incineration

Pollutant	Land Application	Surface Disposal (unlined units)	Incineration
Arsenic	✓	✓	✓
Beryllium			✓
Cadmium	✓		✓
Chromium		✓	✓
Copper	✓		
Lead	✓		✓
Mercury	✓		✓
Molybdenum	✓		
Nickel	✓	✓	✓
Selenium	✓		
Zinc	✓		
Nitrogen series	✓		

Organism to Be Monitored	Allowable Level in Sludge
Fecal Coliform[1]	1,000 Most Probable Number (MPN) per gram (Class A) of total solids (dry weight)
Salmonella sp.[1] bacteria (in lieu of fecal coliform)	3 MPN per 4 grams total solids (dry weight)
Enteric Viruses[2]	Less than one plaque-forming unit per 4 grams total solids (dry weight)
Viable Helminth[2] Ova	Less than one viable helminth ovum per 4 grams of total solids (dry weight)
Fecal Coliform[3]	Less than 2×10^6 MPN or less than 2×10^6 colony-forming units per gram of total solids (dry weight) (expressed as geometric mean of the results of 7 individual samples)

[1]All Part 503 Class A Alternatives 1, 2, 3, 4, 5, 6
[2]Class A Alternatives 3 and 4 only
[3]Class B, Alternative 1

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10. C. References and Sludge Inspection Checklist

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SLUDGE INSPECTION CHECKLIST

A. PERMIT VERIFICATION

Yes No N/A	1.	Are 40 *CFR* Part 503 sludge use and disposal requirements contained in a current NPDES permit, in a separate "sludge only" NPDES permit, in a RCRA Subtitle C permit, or in a CAA permit? [503.3(a)(1) or (2)] (1)
	2.	Sludge use and disposal practice(s):
Yes No N/A		a. Land Application ____ [503.10]
		Bulk Sewage Sludge ____ [503.11(e)]
		Bulk Material Derived from Sewage Sludge ____ [503.11(e)]
		Or
		Sold or Given Away in a Bag or Other Container ____ [503.11(e)]
Yes No N/A		b. Surface Disposal ____ [503.20]
Yes No N/A		c. Sewage Sludge Incineration ____ [503.40]
Yes No N/A		d. Onsite or Offsite Storage ____ [503.9(y)]
		Date storage began ____ ended ____
		(Maximum time allowed: 2 years from February 19, 1993)
Yes No N/A		e. Other (list)_____
Yes No N/A	3.	Each sludge use or disposal practice is permitted? [503.3(a)(1)] (1)
Yes No N/A	4.	Notification is given to EPA/State of new or different sludge disposal method? [Permit]
Yes No N/A	5.	Number and location of disposal sites/activities are as described in the permit or fact sheet or land application plan (40 *CFR* Part 501)? [Permit]
Comments:		

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SLUDGE INSPECTION CHECKLIST (Continued)

B. RECORDKEEPING AND REPORTING EVALUATION

Yes No N/A	1.	Self-monitoring data are available for all regulated pollutants? [503.17], [503.27], [503.43]
Yes No N/A	2.	Pathogen and vector attraction reduction method description and certification statement available? [503.17], [503.27]
Yes No N/A	3.	Records are available for all use or disposal practices? [503.17], [503.27], [503.47]
Yes No N/A	4.	Accurate records of sludge volume or mass are maintained, when appropriate? [503.25], [503.47]
Yes No N/A	5.	Monitoring and analyses are performed more often than required by permit? If so, results are reported in the permittee's self-monitoring report? [Permit]
Yes No N/A	6.	Unit operations records verify compliance with pathogen and vector attraction reduction requirements, when appropriate? [503.15], [503.25]
Yes No N/A	7.	Self-monitoring is conducted at the frequency specified in the permit, in 503.16 Table 1 (land application), or in 503.26 Table 1 (surface disposal)? [503.16], [503.26] or [503.46 Table 1 (incineration)] (Production dependent 0-289 mtpy: 1/yr., 290-1499 mtpy: 1/qtr., 1500-14999 mtpy: ½ mo., 15000 mtpy and greater, 1/mo.) mtpy-metric ton per year
Yes No N/A	8.	Facility reports sludge monitoring data at the frequency specified in the permit? (Only for Class I facilities, total design flow >1 mgd, or serving >10,000 people) [503.18], [503.28], [503.48]
Yes No N/A	9.	Sludge records are maintained for at least 5 years? [503.17], [503.27], [503.47]
Yes No N/A	10.	Sludge data are reported on Discharge Monitoring Report (DMR) or approved form? [Permit]
Yes No N/A	11.	Sludge records are adequate to assess compliance with annual and/or cumulative pollutant loading rates or other established permit limits? [503.13(a) (2) (i)], [503.13(a) (4) (ii)]
Comments:		

A010778

SLUDGE INSPECTION CHECKLIST (Continued)

C. SLUDGE SAMPLING AND ANALYSIS EVALUATION

Yes No N/A	1.	Sludge samples are taken at locations specified in the permit? [Permit]
Yes No N/A	2.	Sludge sample locations are appropriate for obtaining representative samples? [503.8(a)]
Yes No N/A	3.	Sampling and analysis are conducted for parameters specified in the permit or in 40 *CFR* Part 503? [Permit], [503.13], [503.23], [503.46]
	4.	Sample collection procedures
Yes No N/A		a. Adequate sample volumes are obtained?
Yes No N/A		b. Proper preservation techniques are used?
Yes No N/A		c. Containers conform to appropriate analytical method specified in 40 *CFR* 503.8?
Yes No N/A		d. Samples analyzed in the appropriate time frames in accordance with 40 *CFR* 503.8?
Yes No N/A	5.	Are results reported on a dry weight basis? [503.13], [503.23], [503.43] (Dry weight concentration = Wet weight concentration/Decimal fraction of solids) e.g. A sludge containing 20 mg/l Cu and having 5% solids. Dry weight Cu (mg/kg) = $\frac{20 \text{ mg/1}}{0.05}$ = 400 mg/kg
Yes No N/A	6.	Sample is refrigerated subsequent to compositing?
Yes No N/A	7.	Chain-of-custody procedures are employed?
Yes No N/A	8.	Analytical methods used are approved methods of 40 *CFR* 503.8?
Comments:		

A010779

SLUDGE INSPECTION CHECKLIST (Continued)

D. UNIT PROCESSES

General Sludge Processes

Yes No N/A	1.	Sludge process control parameters maintained as appropriate?
Yes No N/A	2.	Adequate equipment redundancy (e.g., back-up units)?
Yes No N/A	3.	Adequate sludge storage capacity?
Yes No N/A	4.	Contingency plan for sludge disposal practice?
Yes No N/A	5.	Solids handling operation adequate to manage volume of sludge?
Comments:		

Drying Beds, Gravity Thickener, Centrifuge, and Dissolved Air Floatation

Yes No N/A	1.	Is primary unstabilized sludge fed to the thickener, centrifuge or drying bed? If yes, list percentage of unstabilized sludge _____.
Yes No N/A	2.	What is the average % solids of the sludge before thickening, drying or centrifuging? _____ % after? _____ %
Yes No N/A	3.	Is sludge mixed with other materials before or after thickening?
Yes No N/A	4.	For sludge containing unstabilized solids, is the percent solids greater than 90% prior to mixing with other materials?
Yes No N/A	5.	For sludge containing no unstabilized solids, is the percent solids greater than 75% prior to mixing with other materials?
Comments:		

A010780

SLUDGE INSPECTION CHECKLIST (Continued)

D. UNIT PROCESSES (Continued)

Anaerobic Digestion

	1.	Sludge fed to digester(s) includes: ___Primary ___Secondary ___Combined
	2.	Digester(s) operating mode: ___high rate ___ low rate
Yes No N/A	3.	Digester(s) are operated at proper temperature [mesophilic: 95°F (35°C) and thermophilic: 131°F (55°C)? List operating mode: ___ mesophilic ___ thermophilic
Yes No N/A	4.	Temperature monitoring location and frequency sufficient to demonstrate compliance with Class B pathogen reduction requirements for PSRP? Average Temperature: ____°C or °F
Yes No N/A	5.	Solids Retention Time (SRT) or Mean Cell Residence time (MCRT) calculated properly?*
Yes No N/A	6.	SRT or MCRT sufficient to demonstrate compliance with Class B pathogen reduction requirements for PSRP? Average SRT or MCRT: ____days *For batch operated digesters with no recycle: SRT or MCRT = Mass of solids in digester, kg / Solids removed, kg/day This formula can be used to estimate SRT or MCRT for all digester systems. For calculating SRT or MCRT for other system configurations, use the WEF Manual of Practice or other references. Always write down the calculation used by the facility no matter what the configuration is.
Comments:		

A010781

SLUDGE INSPECTION CHECKLIST (Continued)

D. UNIT PROCESSES (Continued)

Aerobic Digestion

	1. Sludge fed to digester(s) includes: ___Primary ___Secondary ___Combined
	2. Digester(s) operating mode: ___high rate ___ low rate
Yes No N/A	3. Digester(s) are operated at proper temperature [cryophilic: <50°F (<10°C), mesophilic: 50-108°F (10-42°C), and thermophilic: >108°F (42°C)]? List operating mode: ___ cryophilic ___ mesophilic ___ thermophilic
Yes No N/A	4. Temperature monitoring location and frequency sufficient to demonstrate compliance with Class B pathogen reduction requirements for PSRP or with Class A pathogen reduction requirements for PFRP (Thermophilic aerobic digestion only)? Average Temperature: _____°C or °F
Yes No N/A	5. Solids Retention Time (SRT) or Mean Cell Residence time (MCRT) calculated properly?*
Yes No N/A	6. SRT or MCRT sufficient to demonstrate compliance with Class B pathogen reduction requirements for PSRP or with Class A pathogen reduction requirements for PFRP (Thermophilic digestion only)? Average SRT or MCRT: _____days
Yes No N/A	7. Aerobic conditions verified through dissolved oxygen monitoring? *For batch operated digesters with no recycle: SRT or MCRT = Mass of solids in digester, kg / Solids removed, kg/day This formula can be used to estimate SRT or MCRT for all digester systems. For calculating SRT or MCRT for other system configurations, use the WEF Manual of Practice or other references. Always write down the calculation used by the facility no matter what the configuration is.
Comments:	

A010782

SLUDGE INSPECTION CHECKLIST (Continued)

D. UNIT PROCESSES (Continued)

Composting

		1. Type of composting performed: ____ In vessel ____ Static piles ____ Windrows
		2. Type of sludge composted: ____ Primary ____ Secondary ____ Combined
Yes No N/A		3. Is the moisture content monitored?
Yes No N/A		4. Is compost mixed? Method? _____ Frequency of turnings? _____
Yes No N/A		5. Is oxygen content monitored?
Yes No N/A		6. Is temperature monitored?
Yes No N/A		7. Are total and total volatile solids monitored?
		8. Active phase ____ days Curing phase ____ days
Yes No N/A		9. Is site runoff treated? Where? _____
Yes No N/A		10. Temperature monitoring location and frequency sufficient to demonstrate compliance with Class B pathogen reduction requirements for PSRP or with Class A pathogen reduction requirements for PFRP?
Yes No N/A		11. Temperature and/or oxygen monitoring sufficient to determine compliance with vector attraction reduction requirements?
Comments:		

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SLUDGE INSPECTION CHECKLIST (Continued)

E. LAND APPLICATION OF SEWAGE SLUDGE

Yes No N/A	1.	Sewage sludge or material derived from sewage sludge is land applied to: Agricultural Land _____ Forest _____ Reclamation Site _____ Lawn or Home Garden _____ Public Contact Site (park, etc.) _____
Yes No N/A	2.	Do monitoring results show pollutant concentrations below values shown in 40 *CFR* 503.13(b)(1) Table 1? [503.13(a)(1)] [2]
Yes No N/A	3.	Do monitoring results show pollutant concentrations below values shown in 40 *CFR* 503.13(b)(3)? [3]
	4.	Classifications of Sewage Sludge with respect to Pathogens: [503.30] [4] Class A _____ Class B _____ Unknown _____
Yes No N/A	5.	Are Class A Pathogen reductions requirements met? [503.15(a)] [4]
	6.	Indicate which method is used to meet Class A requirements: [503.32(a)] ___ Fecal Coliform <1000 MPN/g total solids, or Salmonella <3 MPN/4 g total solids, and Time/Temperature requirements. [503.32(a)(3)] ___ Fecal Coliform <1000 MPN/g total solids, or Salmonella <3 MPN/4 g total solids, and pH requirements. [503.32(a)(4)] ___ Fecal Coliform <1000 MPN/g total solids, or Salmonella <3 MPN/4 g total solids, and enteric viruses or helminth ova reduction requirements. [503.32(a)(5)] ___ Fecal Coliform <1000 MPN/g total solids, or Salmonella <3 MPN/4 g total solids, and enteric viruses or helminth ova density requirements. [503.32(a)(6)] ___ Fecal Coliform <1000 MPN/g total solids, or Salmonella <3 MPN/4 g total solids, and Process to Further Reduce Pathogens (PFRP). [503.32(a)(7)] and [503 Appendix B] [5] ___ Fecal Coliform <1000 MPN/g total solids, or Salmonella <3 MPN/4 g total solids, and equivalent PFRP. [503.32(a)(8)] and [503 Appendix B] [5]
Yes No N/A	7.	Are Class B Pathogen reduction requirements met? [503.32(b)] [4]
	8.	Indicate which method(s) is used to meet Class B requirements: ___ Geometric mean of seven Fecal Coliform samples with <2,000,000 MPN/g total solids or <2,000,000 Colony Forming Units/g total solids. [503.32(b)(2)] ___ Treated by Process to Significantly Reduce Pathogens (PSRP). [503.32(b)(3)] and [503 Appendix B] [5] Treated by equivalent PSRP. [503.32(b)(4)] and [503 Appendix B] [5]

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SLUDGE INSPECTION CHECKLIST (Continued)

E. LAND APPLICATION OF SEWAGE SLUDGE (Continued)

Yes	No	N/A	
			9. For Class B sludge which is land applied, are Site Restrictions practiced? [503.32 (b)(5)] [4]
Yes	No	N/A	10. Indicate Site Restrictions practiced where applicable: ___ Food crops (above ground) are harvested >14 months after application of sewage sludge? [503.32(b)(5)(i)] ___ Food Crops (below ground) are harvested >20 months after application of sewage sludge when sludge stays on land for >4 months prior to incorporation into soil? [503.32(b)(5)(ii)] ___ Food Crops (below ground) are harvested >38 months after application of sewage sludge when sludge stays on land for <4 months prior to incorporation into soil? [503.32(b)(5)(iii)] ___ Food Crops, feed crops, and fiber crops are harvested >30 days after application of sewage sludge? [503.32(b)(5)(iv)] ___ Animal grazing allowed on land only >30 days after application of sewage sludge? [503.32(b)(5)(v)] ___ Turf grown on land where sewage sludge was applied placed on high public expose land or lawn is harvested >1 year after application of sewage sludge? [503.32(b)(5)(vi)] ___ Public access is restricted to land with a potential for high public exposure for 1 year? [503.32(b)(5)(vii)] ___ Public access is restricted to land with a potential for low public exposure for 30 days? [503.32(b)(5)(viii)]
Yes	No	N/A	11. Is a Vector Attraction Reduction method practiced? [503.15(c)] [6]
Yes	No	N/A	12. Indicate Vector Attraction Reduction method: [503.33(b)] ___ 38% Volatile Solids Reduction. [503.33(b)(1)] [7] ___ 40 day test - Volatile Solids reduced <17%. [503.33(b)(2)] (Anaerobic Digestion Only) ___ 30 day test - Volatile Solids reduced <15%. [503.33(b)(3)] (Aerobic Digestion Only) ___ Specific Oxygen Uptake Rate (SOUR) <1.5 mg/hr/gm TS @ 20°C. [503.33(b)(4)] ___ Aerobic Process for >14 days @ >40°C with average sludge temperatures >45°C. [503.33(b)(5)] ___ pH >12 for 2 hours and pH >11.5 for 22 hours [503.33(b)(6)] ___ Sludge (with no unstabilized solids) contains >75% Total Solids prior to mixing with other materials. [503.33(b)(7)] ___ Sludge (contains unstabilized solids) contains >90% Total Solids prior to mixing with other materials. [503.33(b)(8)]

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SLUDGE INSPECTION CHECKLIST (Continued)

E. LAND APPLICATION OF SEWAGE SLUDGE (Continued)

	___ Subsurface Injection. [503.33(b)(9)] ___ Soil Incorporation. [503.33(b)(10)]
Yes No N/A	13. Are general requirements (503.12) and management practices (503.14) applied for sludge not meeting Table 3 pollutant concentrations, Class pathogen reduction requirements, and vector attraction reduction methods? [503.10], [503.12], [503.14]
Yes No N/A	14. Indicate management practices where applicable: ___ No threatened or endangered species present or critical habitat affected at the location(s) where bulk sludge is applied. ___ Bulk sludge not applied to frozen or snow covered ground. ___ Bulk sludge applied >10 meters from waters of the U.S. ___ Bulk sludge applied at a rate equal to or less than agronomic rate. ___ Label affixed on bag or information sheet provided to user of sold and given away sludge indicating name of sludge preparer, application instructions, and maximum annual whole sludge application rate.
Yes No N/A	15. Indicate general requirements practiced where applicable: ___ Sludge is not applied to a site where the cumulative pollutant loading or annual application rate has been reached. ___ Notification given to the sludge applier regarding total nitrogen content of the sludge. ___ Sufficient information required to comply with 40 *CFR* Part 503 is given to preparers/appliers/land owners. ___ Written notification given to permitting authority (including States) regarding the location of land application sites, appropriate NPDES permit numbers.
Yes No N/A	16. Description of how management practices are met for each land application site available?
Comments:	

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SLUDGE INSPECTION CHECKLIST (Continued)

Land Application Footnotes

(1) Permits are not required. Part 503 is self-implementing. Part 503 does not cover industrial sludges or grit and screenings.

(2) 503.13(b)(1), Table 1 values must be met to land apply sludge:

Table 1 (mg/kg)

Arsenic	75	Lead	840	Nickel	420
Cadmium	85	Mercury	57	Selenium	100
Copper	4300	Molybdenum	75	Zinc	7500

(3) 503.13(b)(3), Table 3 must be met for any sludge applied to a lawn or home garden. For bulk sludge, Table 3 must be met or the sludge is subject to cumulative loading limits in 503.13(b)(2). For sewage sludge sold and given away in a bag or other container, Table 3 must also be met or the sludge is subject to annual pollutant loadings in 503.13(b)(4). This also signals that additional recordkeeping requirements of 503.12 and 503.17 apply.

Table 3 (mg/kg)

Arsenic	41	Lead	300	Selenium	100
Cadmium	39	Mercury	17	Zinc	2800
Copper	1500	Nickel	420		

(4) Class A requirements must be met when bulk sludge is land applied to a lawn or home garden, or when sewage sludge is sold or given away in a bag or other container. Also, Class A requirements or Class B requirements combined with appropriate site restrictions must be met for when bulk or bulk material derived from sludge is applied to agricultural land, reclamation site, forest, or public contact site.

(5) Process to Significantly Reduce Pathogens (PSRP) includes Aerobic Digestion, Air Drying, Anaerobic Digestion, Composting, and Lime Stabilization. Process to Further Reduce Pathogens (PFRP) includes Composting, Heat Drying, Heat Treatment, Thermophilic Aerobic Digestion, Beta Ray Irradiation, Gamma Ray Irradiation, and Pasteurization. Each process has required operating conditions to demonstrate compliance. See 503 Appendix B and Unit Process Checklists.

(6) One of the methods 503.33(b)(1)-(10) must be used when land applying bulk sewage sludge to agricultural land, forest, a public contact site, or a reclamation site. One of the methods 503.33(b)(1)-(8) must be met when land applying bulk sludge to a lawn or home garden, or when sewage sludge or derived material is sold or given away in a bag or other container.

(7) Volatile solids reduction through the sludge treatment train [only] is generally calculated using the Van Kleek equation.:

Other Variations of this formula are presented in the document Environmental Regulations and Technology-Control of Pathogens and Vector Attraction in Sewage Sludge, EPA-625/R-92/013. See document for specific calculations. Website: http://www.epa.gov/ORD/NRMRL/Pubs/1992/625R92013.html

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SLUDGE INSPECTION CHECKLIST (Continued)

F. SURFACE DISPOSAL

Yes No N/A	1. Does each Surface Disposal Unit (SDU) have a liner and leachate collection system?
	2. Smallest distance from active SDU boundary to property boundary is _____ ft.
Yes No N/A	3. For an active SDU (property boundary is greater that 150 meters from SDU) and without a liner or leachate collection system, do monitoring results show pollutant concentrations below values shown in 40 *CFR* 503.23(a)(1) Table 1? [503.23(a)(1)][1]
Yes No N/A	4. For an active SDU without a liner and leachate collection system (property boundary is less than 150 meters from SDU), do monitoring results show pollutant concentrations below values shown in 40 *CFR* 503.23(a)(2) Table 2? [503.23(a)(1)][2]
Yes No N/A	5. Are management practices employed? [503.24]
Yes No N/A	6. List management practices where applicable: ___ No threatened or endangered species present or critical habitat affected at the location where bulk sludge is surface disposed. ___ Surface disposal unit shall not restrict flow of base flood. ___ If in seismic impact zone, design will withstand recorded horizontal ground acceleration. ___ Located > 60 meters from any fault displaced in Holocene time. ___ Not located in unstable area or wetlands. ___ Runoff collection and treatment with 25-year 24-hour storm runoff event storage capacity. ___ Leachate collection system operated and maintained for 3 years after closure of the surface disposal unit. ___ Leachate treated and disposed of in accordance with applicable requirements, i.e., NPDES permit. ___ Methane is contained under covered units at a concentration less than 25% of the LEL for methane. ___ Methane is contained under a final cover placed on a closed unit maintained at a concentration less than 25% of the LEL for methane for three years after closure. ___ Methane concentration at the property line is maintained at a concentration less than the LEL for methane for three years after closure of the unit. ___ No feed or food crops grown on active unit. [3] ___ No animal grazing allowed on active unit. [3]

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SLUDGE INSPECTION CHECKLIST (Continued)

F. SURFACE DISPOSAL (Continued)

	___ Public access restricted for the period of time while a unit is active and for three years after last active unit in a site closes. ___ Sludge placed in an active unit does not contaminate groundwater aquifers. (4)
Yes No N/A	7. Classification of Sewage Sludge with respect to Pathogens: [503.30] Class A _____ Class B _____ Unknown _____
Yes No N/A	8. Are Class A Pathogen reductions requirements met? [503.15(a)] (5)
	9. Indicate which method is used to meet Class A requirements: [503.32(a)] ___ Fecal Coliform <1000 MPN/g total solids, or Salmonella <3 MPN/4 g total solids, and Time/Temperature requirements. [503.32(a)(3)] ___ Fecal Coliform <1000 MPN/g total solids, or Salmonella <3 MPN/4 g total solids, and pH requirements. [503.32(a)(4)] ___ Fecal Coliform <1000 MPN/g total solids, or Salmonella <3 MPN/4 g total solids, and enteric viruses or helminth ova reduction requirements. [503.32(a)(5)] ___ Fecal Coliform <1000 MPN/g total solids, or Salmonella <3 MPN/4 g total solids, and enteric viruses or helminth ova density requirements. [503.32(a)(6)] ___ Fecal Coliform <1000 MPN/g total solids, or Salmonella <3 MPN/4 g total solids, and Process to Further Reduce Pathogens (PFRP). [503.32(a)(7)] and [503 Appendix B] ___ Fecal Coliform <1000 MPN/g total solids, or Salmonella <3 MPN/4 g total solids, and equivalent PFRP. [503.32(a)(8)] and [503 Appendix B] (7)
Yes No N/A	10. Are Class B Pathogen reduction requirements met? [503.32(b)] (5)
	11. Indicate which method(s) is used to meet Class B requirements: ___ Geometric mean of seven Fecal Coliform samples with <2,000,000 MPN/g total solids or <2,000,000 Colony Forming Units/g total solids. [503.32(b)(2)] ___ Treated by Process to Significantly Reduce Pathogens (PSRP). [503.32(b)(3)] and [503 Appendix B] (6) ___ Treated by equivalent PSRP. [503.32(b)(4)] and [503 Appendix B] (6)
Yes No N/A	12. Is a Vector Attraction Reduction method practiced? [503.25(b)] (7)
Yes No N/A	13. Indicate Vector Attraction Reduction method: [503.33(b)] ___ 38% Volatile Solids Reduction. [503.33(b)(1)] ___ 40 day test - Volatile Solids reduced <17%. [503.33(b)(2)] (Anaerobic Digestion Only)

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SLUDGE INSPECTION CHECKLIST (Continued)

F. SURFACE DISPOSAL (Continued)

	___ 30 day test - Volatile Solids reduced <15%. [503.33(b)(3)] (Aerobic Digestion Only) ___ Specific Oxygen Uptake Rate (SOUR) <1.5 mg/hr/gm TS @ 20°C. [503.33(b)(4)] ___ Aerobic Process for >14 days @ >40°C with average sludge temperatures >45°C. [503.33(b)(5)] ___ pH >12 for 2 hours and pH >11.5 for 22 hours [503.33(b)(6)] ___ Sludge (with no unstabilized solids) contains >75% Total Solids prior to mixing with other materials. [503.33(b)(7)]
	___ Sludge (contains unstabilized solids) contains >90% Total Solids prior to mixing with other materials. [503.33(b)(8)]
	___ Subsurface Injection. [503.33(b)(9)] ___ Soil Incorporation. [503.33(b)(10)] ___ Sludge covered with soil or other material at the end of the day. [503.33(b)(11)]
Yes No N/A	14. Have any SDUs been closed?
Yes No N/A	15. Has facility submitted closure and post closure plan for any active SDU 180 days prior to closing? [503.22(c)]
Comments:	

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SLUDGE INSPECTION CHECKLIST (Continued)

Surface Disposal Footnotes

(1) Table 1 of 503.23(a)(1) must be met for all sludge placed in an active surface disposal unit with a distance of greater than 150 meters from the boundary of the surface disposal unit to the property line. Site-specific limits can also be set by the permitting authority in accordance with 503.23(b).

Table 1 (mg/kg - dry weight basis)

Arsenic	73	Chromium	600	Nickel	420

(2) Table 2 of 503.23(a)(2) must be met for all sludge placed in an active surface disposal unit with a distance of less than 150 meters from the boundary of the surface disposal unit to the property line. Site-specific limits can also be set by the permitting authority in accordance with 503.23(b).

Table 2 (mg/kg - dry weight basis)

Distance between unit boundary and property line (m)	Pollutant Concentration (mg/kg)		
	Arsenic	Chromium	Nickel
0 to less than 25	30	200	210
25 to less than 50	34	220	240
50 to less than 75	39	260	270
75 to less than 100	46	300	320
100 to less than 125	53	360	390
125 to less than 150	62	450	420

(3) Unless specific approval from the permitting authority has been obtained by the facility.

(4) Facility must have results of groundwater monitoring study developed by a qualified groundwater scientist or a certification from a qualified groundwater scientist to demonstrate no contamination.

(5) Facility must meet Class A pathogen reduction requirements of 503.32(a) or Class B 503.32(b)(2) through (b)(4) unless vector attraction reduction method 503.33(b)(11), covering sludge at the end of the day, is used.

(6) Process to Significantly Reduce Pathogens (PSRP) includes Aerobic Digestion, Air Drying, Anaerobic Digestion, Composting, and Lime Stabilization. Process to Further Reduce Pathogens (PFRP) includes Composting, Heat Drying, Heat Treatment, Thermophilic Aerobic Digestion, Beta Ray Irradiation, Gamma Ray Irradiation, and Pasteurization. Each process has required operating conditions to demonstrate compliance. See 503 Appendix B and Unit Process Checklist.

(7) Facility must meet vector attraction reduction requirements of 503.33(b) to surface dispose sludge.

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SLUDGE INSPECTION CHECKLIST (Continued)

G. SEWAGE SLUDGE INCINERATION

Yes No N/A	1. Does the incinerator meet the definition of a sewage sludge incinerator?
Yes No N/A	2. Do sewage sludge monitoring results show pollutant concentrations below permit limits?
Yes No N/A	3. Does THC monitoring show concentrations below 100 ppm (monthly average)?
Yes No N/A	4. Are there instruments installed that continuously measure and record THC (or alternatively CO), oxygen concentration, moisture content, and combustion temperatures?
Yes No N/A	5. Is the THC instrument calibrated as required by 503.45 (once every 24-hour period using propane) or the permit?
Yes No N/A	6. Are the other instruments calibrated as required by the permit?
Yes No N/A	7. Are the instruments operated and maintained as specified by the permit?
Yes No N/A	8. How many times was the incinerator operated at above the maximum combustion temperature specified in the permit? _____ For how long was the incinerator in operation above the maximum combustion temperature? _____
Yes No N/A	9. How many times was the incinerator operated outside the range of the air pollution control devices operating parameters specified in the permit? _____ For how long was the incinerator in operation outside the ranges? _____
Yes No N/A	10. Are the following records maintained:
Yes No N/A	Concentration of lead, arsenic, cadmium, chromium, and nickel in the sewage sludge fed to the sewage sludge incinerator.
Yes No N/A	THC concentrations in the exit gas.
Yes No N/A	Information that indicates NESHAP for beryllium in Subpart C of 40 *CFR* Part 61 are met.
Yes No N/A	Information that indicates NESHAP for mercury in Subpart E of 40 *CFR* Part 61 are met.
Yes No N/A	Combustion temperatures, including maximum combustion temperature.
Yes No N/A	Values for air pollution control device operating parameters.
Yes No N/A	Oxygen concentration.
Yes No N/A	Information used to measure moisture content in the exit gas.
Yes No N/A	Sewage sludge feed rate.

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SLUDGE INSPECTION CHECKLIST (Continued)

G. SEWAGE SLUDGE INCINERATION (Continued)

Yes No N/A	Stack height of incinerator.
Yes No N/A	Dispersion factor for the site.
Yes No N/A	Control efficiency for lead, arsenic, cadmium, chromium, and nickel.
Yes No N/A	Risk specific concentration for chromium (if applicable).
Yes No N/A	Calibration and maintenance log for the instruments used to measure THC (or CO), oxygen concentration, moisture content, and combustion temperatures.
Yes No N/A	Are these records maintained for 5 years?
Yes No N/A	11. Have all instances of noncompliance been reported as specified by the permit?
Comments:	

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11. STORM WATER

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S. Construction Control Source BMP Questions
T. Notice of Intent (NOI) Form
U. Rain Zones of the United States
V. Typical "C" Coefficients
W. Notice of Termination (NOT) Form
X. No Exposure Certification Form

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11. A. Background and History

Regulation Overview (40 CFR 122.26)

In addition to materials in this chapter, inspectors must be familiar with Chapter 1 - "Introduction" & Chapter 2 - "Inspection Procedures."

The 1972 amendments to the Federal Water Pollution Control Act (also known as the Clean Water Act or CWA) prohibited the discharge of any pollutants to navigable waters from a point source unless the discharge was authorized by a National Pollutant Discharge Elimination System (NPDES) permit. At the time of the 1972 amendments to the CWA, sewage treatment plant outfalls and industrial process wastewater were easily identified as point sources responsible for contributing to the degradation of water quality. However, as pollution control measures were instituted, it became evident that more diffuse sources, such as agricultural and storm water runoff, were also contributing to the problem. In response to this concern, the Water Quality Act (WQA) of 1987 added Section 402(p) to the CWA and required the Environmental Protection Agency (EPA) to establish a comprehensive two-phased approach to address storm water discharges.

1987 Amendments to CWA
402(p) Municipal and industrial storm water discharges

(1) General rule - prohibits permits for discharges composed entirely of storm water prior to October 1, 1994 with some exceptions
(2) Exceptions - Identifies five types of storm water discharges that are to be permitted prior to October 1, 1994
(3) Permit requirements - identifies permitting approach for industrial and municipal storm water discharges
(4) Permit application requirements - identifies application requirements for industrial and municipal storm water discharges
(5) Studies - identifies requirement for report to Congress on other sources of storm water discharges
(6) Regulations - requires regulations for permitting other types of storm water discharges to protect water quality

In response to section 402(p)(2) of the Act, Phase I Storm Water regulations were promulgated on November 16, 1990 (55 FR 47990). The regulations specified that the following five storm water discharges must apply for a NPDES permit:

(A) A discharge subject to a NPDES permit before February 4, 1987
(B) A discharge associated with industrial activity (including construction activities >5 acres)
(C) A discharge from a municipal separate storm sewer system serving a population of 250,000 or more (large MS4s)
(D) A discharge from a municipal separate storm sewer system serving a population of 100,000 or more but less than 250,000 (medium MS4s) and
(E) A discharge that an NPDES permitting authority determines to be contributing to a violation of a water quality standard or a significant contributor of pollutants to waters of the United States.

Consistent with Section 402(p)(6) of the Act, EPA Promulgated Phase II Storm Water regulations on December 8, 1999 (64 FR 68722). The Phase II regulations are designed to protect water quality from other types of storm water discharges not already covered by Phase I regulation. Phase II adds regulated small municipal separate storm sewers systems (MS4s)

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and small construction (disturbing between 1 and 5 acres) to those entities required to obtain permit coverage for storm water discharges.

Storm water regulations are codified primarily in 40 CFR 122.26 but also are addressed in several other locations in the Federal regulations. A summary of these sections is provided in Table 11-1. ***The storm water regulations apply to discharges both to waters of the United States and to municipal separate storm sewer systems (MS4s). Storm water discharges to sanitary sewer systems or to combined sewer systems are not covered by the storm water regulations.***

EPA's NPDES Storm Water Program focuses on three distinct types of regulated entities: industrial facilities, construction sites, and municipal separate storm sewers systems (MS4s). For clarity, the remainder of this chapter discusses these three types of permitted entities separately. Two tables are attached as additional references: Table 11-2 NPDES Storm Water Permit Application and Issuance Deadlines; and Table 11-3, Summary of the Federal Permit Requirements Under the NPDES Storm Water Program.

Regarding Table 11-2, Section 402(p)(4) of the CWA identifies specific deadlines for the issuance or denial of all storm water permits. However, since EPA was unable to promulgate its regulations by the statutory deadline, the regulations require issuing or denying all storm water permits within one year of the permit application regulatory deadline consistent with Congress' intent. Section 402(p)(4) also specifies that permits shall provide for compliance as expeditiously as practicable, but in no event later than 3 years after the permit issuance date.

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Table 11-1
Summary of Storm Water Permitting Regulations

40 CFR 122 - EPA Administered Permit Programs: The National Pollutant Discharge Elimination System	
122.1	Purpose and scope
122.21	Application for a permit
122.22	Signatories to permit applications and reports
122.26(a)	Permit requirements
122.26(b)	Definitions
122.26(c)	Application requirements for storm water discharges associated with industrial activity
122.26(d)	Application requirements for large and medium municipal separate storm sewer discharges
122.26(e)	Application deadlines
122.26(f)	Petitions
122.26(g)	Conditional exclusion for "no exposure" of industrial activities and materials to storm water
122.28	General permits
122.30	What are the objectives of the storm water regulations for small MS4s?
122.31	As a Tribe, what is my role under the NPDES storm water program?
122.32	As an operator of a small MS4, am I regulated under the NPDES storm water program?
122.33	If I am an operator of a regulated small MS4, how do I apply for an NPDES permit and when do I have to apply?
122.34	As an operator of a regulated small MS4, what will my NPDES MS4 storm water permit require?
122.35	As an operator of a regulated small MS4, may I share the responsibility to implement the minimum control measures with other entities?
122.36	As an operator of a regulated small MS4, what happens if I don't comply with the application requirements in 122.33 through 122.35?
122.37	Will the small MS4 storm water program regulations at 122.32 through 122.36 and 122.35 of this chapter change in the future?
122.42	Additional conditions applicable to specified categories of NPDES permits
122.44	Establishing limitations, standards, and other permit conditions
122.62	Modifications or revocation and reissuance of permits
40 CFR Part 123 - State Program Requirements	
123.25	Requirements for permitting
123.35	As the NPDES permitting authority for regulated small MS4s, what is my role?
40 CFR Part 124 - Procedures for Decision making	
124.52	Permits required on a case-by-case basis
Appendix E	Rainfall zones of the United States
Appendix F	Incorporated places with populations greater than 250,000 according to latest decennial census by Bureau of Census
Appendix G	Incorporated places with populations greater than 100,000 and less than 250,000 according to latest decennial census by Bureau of Census
Appendix H	Counties with unincorporated urbanized areas with a population of 250,000 or more according to the latest decennial census by the Bureau of Census
Appendix I	Counties with unincorporated urbanized areas greater than 100,000, but less than 250,000 according to the latest decennial census by the Bureau of Census

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Table 11-2

NPDES Storm Water Permit Application and Issuance Deadlines

Type of Application/ Type of Discharge	Permit Application	Permit Coverage Deadline
Industrial Storm Water		
Individual Permit Application Existing facilities	October 1, 1992	October 1, 1993
New facilities	180 days prior to commencement of industrial activity	1 year after receipt of complete permit application
New construction facilities	90 days prior to commencement of construction	1 year after receipt of complete permit application
General Permit Application[1] Existing facilities	October 1, 1992	As specified in GP
New facilities	90 days prior to commencement of discharge unless specific general permit specifies otherwise	As specified in GP

[1]Facilities applying for general permits must submit notices of intent (NOIs), rather than permit applications.

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Table 11-3

Summary of Federal Permit Requirements Under the NPDES Storm Water Program

	Municipal Separate Storm Sewer Systems (MS4s)	Construction Activity	Industrial Activity
Phase I Requirements (November 16, 1990)	**Medium and Large MS4s** (*122.26*(d)) • Establish adequate legal authority to control discharges to storm sewer, inspect, and enforcement. • Identify major storm water sources and locations of outfalls, and provide characterization data of discharges. • Develop Storm Water Management Program: - Controls for residential and commercial activities - Illicit discharge detection and elimination program - Controls for municipal and industrial activities - Construction site controls • Assess control and perform fiscal analysis • Submit annual report	**Category (x) Construction Activity (5+Acres)** CGP: • Storm Water Pollution Prevention Plan (SWPPP) - Site description - Description of BMPs for erosion and sediment, post-construction storm water management, and other controls - Self-evaluation and recordkeeping	**Ten Categories of Industrial Activity (Categories (i)-(ix), (xi))** MSGP: • SWPPP - Site evaluation - Description of appropriate storm water management BMPs - Self-evaluation, monitoring, recordkeeping, and, in some circumstances, reporting • If discharging into a medium or large MS4, notify the MS4 operator

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Table 11-3

Summary of Federal Permit Requirements Under the NPDES Storm Water Program

(Continued)

	Regulated Small MS4	Small Construction Activity (≥1 and <5 acres)	Industrial
Phase II Requirements (December 8, 1999)	• Storm Water Management Program: - Public education and outreach - Public participation efforts - Illicit discharge detection and elimination program - Construction runoff control program for construction activity disturbing 1 acre or greater - Post-construction runoff control program for construction activity disturbing 1 acre or greater - Good housekeeping/ pollution prevention for municipal operations • Conduct assessment of identified BMPs and measurable goals for each minimum control measure • Submit periodic program assessment reports	• Similar to category (x) Construction Activity requirements above • Small construction waivers requirement	• Conditional no exposure waiver

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11. B. Storm Water Discharges Associated with Industrial Activity (Not Including Construction)

Applicability (Who is Covered)

The storm water regulations identify 11 categories of facilities that are associated with industrial activity (40 *CFR* 122.26(b)(14)(i)-(xi)). EPA defines these categories of industrial activity using a combination of standard industrial classification codes and facility activities. A description of these 11 categories is provided in Figure 11-1. One of the 11 categories, category (x), construction activity, is discussed separately in Section 11.C because of the significant difference in site activity and requirements from the other 10 industrial categories.

EPA estimates that nationwide more than 150,000 industrial facilities are required to obtain permit coverage for storm water discharges associated with industrial activity.

The NPDES regulations, at 40 CFR 122.26(b)(14) define "storm water discharges associated with industrial activity." Specifically, the phrase means "the discharge from any one conveyance which is used for collecting and conveying storm water and which is directly related to manufacturing, processing, or raw materials storage areas at an industrial plant." For the 10 categories of industries identified in 40 CFR 122.26(b)(14)(i)-(ix), and (xi), the term includes, but is not limited to, storm water discharges from the following:

- Industrial plant yards
- Immediate access roads and rail lines used or traveled by carriers of raw materials, manufactured products, waste material, or by-products used or created by the facility
- Material handling sites
- Refuse sites
- Sites used to apply or dispose of process wastewaters (as defined at 40 *CFR* Part 401)
- Sites used for storage and maintenance of material handling equipment
- Sites used for residual treatment, storage, or disposal

Material handling activities include storage loading and unloading, transportation, or conveyance of any raw material, intermediate product, final product, by-product, or waste product. The term excludes areas located on plant lands separate from the plant's industrial activities such as the office buildings and accompanying parking lots as long as the drainage from the excluded areas is not mixed with storm water drained from any of the manufacturing, processing, or raw material storage areas.

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- Shipping and receiving areas
- Manufacturing buildings
- Storage areas (including tank farms) for raw materials and intermediate and finished products
- Areas where industrial activity has taken place in the past and significant materials remain and are exposed to storm water.

One of the first questions that must be answered by the inspector when evaluating the applicability of the storm water permitting regulations to a specific facility is whether the facility performs any industrial activities subject to the storm water permitting requirements. Often, this decision hinges upon the facility's primary SIC code, which is based on the primary activity occurring at the site. (See Table 11-4 for a list of primary SIC codes covered by the storm water permitting requirements.) Where multiple activities are conducted at a site, with each activity having a distinct SIC code, EPA recommends using the value of receipts or revenues with the activity generating the most revenue or employing the most people being the primary activity of the facility. If the SIC code for this primary activity is identified in 40 *CFR* 122.26(b)(14), then the facility is subject to the storm water permitting requirements. If, however, the facility's primary activity is not included in 40 *CFR* 122.26(b)(14), the facility is not subject to the permitting requirements even if the facility conducts secondary activities that are identified therein. The approach is different for industrial sectors identified with narrative rather then SIC codes. In these instances, any activity performed that meets the narrative description is required to obtain permit coverage for those specific activities. For more information on compliance assistance for transportation, construction, auto recyclers, etc. go to www.assistancecenters.net.

Exemption for Mining or Oil and Gas Facilities

Storm water runoff from oil and gas exploration, production, processing, transmission, and treatment operations and mining operations are exempt from CWA permitting requirements provided that the runoff is not contaminated with, or does not come into contact with, any overburden, raw material, intermediate products, finished product, byproduct, or waste products located on the site of such operations.

Federal regulations at 40 CFR §122.26(c)(1)(iii) specify that storm water discharges from oil and gas exploration, production, processing, or treatment operations, or transmission facilities do need permit coverage if the facility has had a discharge of storm water (A) resulting in the discharge of a reportable quantity for which notification is or was required pursuant to 40 CFR 117.21, 40 CFR 302.6 or 40 CFR 110.6 or (B) that contributes to a violation of a water quality standard.

Consistent with 40 CFR §122.26(c)(1)(iv), a discharge composed entirely of storm water from a mining operation is not required to submit a permit application unless the discharge has come into contact with any overburden, raw material, intermediate products, finished product, byproduct, or waste products located on the site of such operations.

Note that the CWA exemption for oil, gas, and mining operations does not apply to construction activities related to those operations. Currently, construction activities at oil, gas and mining

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operations which exceed five acres, or are part of a larger common plan of development, are required to obtain permit coverage, either under a state or federal construction permit. Effective March 10, 2005, construction activities at oil, gas and mining operations which exceed one acre will be required to obtain permit coverage. An informational brochure is available on EPA's Region VI website on Stormwater Best Management Practices (BMP) titled "*Your Oil and Gas Construction Activities May Need Coverage Under the Clean Water Act's Stormwater Program!*"

No exposure means all industrial materials and activities are protected by a storm resistant shelter to prevent exposure to rain, snow, snowmelt, and/or runoff. Industrial materials or activities include, but are not limited to, material handling equipment or activities, industrial machinery, raw materials, intermediate products, by-products, final products, or waste products.

Conditional No Exposure Exclusion

The Phase II Conditional No Exposure Exclusion significantly expands the scope of the original no exposure eligibility requirements. Under the conditional no exposure exclusion, operators of industrial facilities in any of the 10 categories of "storm water discharges associated with industrial activity," have the opportunity to certify to a condition of "no exposure" if their industrial materials and operation activities are not exposed to storm water. As long as the condition of "no exposure" exists at a certified facility, the operator is excluded from NPDES industrial storm water permit requirements. The conditional no exposure exclusion replaces the previous "light industry" no exposure exemption included under the Phase I Storm Water Program.

Permit Applications for Storm Water Discharges Associated With Industrial Activity

Industrial facilities have two permit options for storm water discharges - coverage under (1) a general permit or (2) an individual permit. Most industrial facilities have permit coverage under a general permit because it is the most efficient permit option for permitting large number of facilities with similar discharge characteristics. Where EPA is the NPDES permitting authority, the Multi-Sector General Permit (MSGP), most recently issued on October 30, 2000 (65 FR 64746), is the general permit available to facility operators. The MSGP covers 30 industrial sectors. Standard Industrial Classification (SIC) codes and narrative descriptions identify the industrial facilities within each of the 30 sectors. The EPA MSGP is available for use in areas only where EPA is the permitting authority. Similar general permits may be available in NPDES authorized states. Information related to general and individual permits is presented below.

General Permit/Notice of Intent

To apply for permit coverage under the MSGP, a facility operator must complete and submit to the appropriate NPDES permitting authority a Notice of Intent (NOI) form. The NOI requests a variety of basic facility information, including latitude/longitude of the facility, and information related to the Endangered Species Act and the National Historic Preservation Act. The deadline for submission of an NOI requesting coverage under the MSGP-2000 was January 29, 2001 for existing sources. (The MSGP-2000 preamble and permit contain conflicting information regarding the deadline. EPA published a technical correction that contains the correct deadline of January 29, 2001 [66 FR 1675] January 9, 2001.)

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Under EPA's current MSGP, new facilities and those facilities that change ownership or operators must submit an NOI at least 48 hours prior to commencement of the industrial activity at the site or change in ownership/operator.

To discontinue permit coverage, a facility operator must complete and submit to the appropriate NPDES permitting authority a Notice of Termination (NOT) form. The most recent version of the NOT form is available in Addendum E of the Federal Register containing the MSGP-2000.

Individual Permits

There are certain circumstances where a general permit is either not available or not applicable to a specific facility. Examples of when an individual permit is the only option include:

- The NPDES permitting authority requires a facility operator to apply for individual permit coverage.
- The facility operator is unable to certify eligibility with the conditions of the general permit.

In these situations, a facility operator must obtain coverage under an individual permit that the NPDES permitting authority will develop with requirements specific to that facility.

Establishing Eligibility

Endangered Species Act

EPA's NOI requires the facility to certify that the industrial activity will not impact endangered or threatened species or designated critical habitats protected under the Endangered Species Act (ESA). This certification is unique to EPA's NOI and is not a requirement of most NPDES-delegated States' NOIs. All dischargers applying for coverage must provide application on the NOI form including: (1) whether there are listed species in proximity to the storm water or allowable non-storm water discharges or discharge-related activity; (2) under which option of the MSGP they claim eligibility for permit coverage (outlined in Addendum A of the Final Reissuance of National Pollutant Discharge Elimination System (NPDES) Storm Water Multi-Sector General Permit for Industrial Activities dated October 30, 2000), and (3) certification that their storm water and allowable non-storm water discharges and discharge related activities are not likely to jeopardize listed species, or certification that they are otherwise eligible for coverage due to a previous authorization under the ESA. Permittees should consult with state Fish and Wildlife Service (FWS) and National Marine Fisheries Service (NMFS) offices to make these determinations of eligibility.

> ***"Discharge-related activities"*** are defined to include activities which cause, contribute to or result in storm water and allowable non-storm water point source discharges, and measures such as the siting, construction and operation of BMPs to control, reduce or prevent pollution in the discharges. Discharge-related activities are included for compliance with ESA requirements to consider the effects of activities which are related to the activity which is permitted, *i.e.*, the storm water and non-storm water discharges.

National Historic Preservation Act

The National Historic Preservation Act (NHPA) requires Federal agencies to take into account the effects of Federal undertakings, including NPDES general permits. An applicant is eligible for permit coverage only if: (1) the applicant's storm water discharges and BMPs to control storm water runoff do not affect a historic property, or (2) the applicant has obtained, and is in

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compliance with a written agreement between the applicant and the State Historic Preservation Officer (SHPO) or Tribal Historic Preservation Officers (THPO) that outlines all measures to be taken by the applicant to mitigate or prevent adverse effects to the historic property. NHPA guidance and a list of SHPO and THPO addresses are included in Addendum B of the Final Reissuance of National Pollutant Discharge Elimination System (NPDES) Storm Water Multi-Sector General Permit for Industrial Activities dated October 30, 2000. An electronic listing of the "National Register of Historic Places," as maintained by the National Park Service, can be accessed at http://www.nps.gov.

Storm Water Pollution Prevention Plan Requirements/Office Review

The operator (or applicant) must prepare a Storm Water Pollution Prevention Plan (SWPPP) for the facility before submitting a Notice of Intent for permit coverage. The SWPPP must be signed by a responsible corporate official such as a president, vice president, or general partner as identified in the MSGP. This SWPPP is to be kept at the facility at all times (or other local location accessible to the EPA, a State, Tribal or Territorial agency with jurisdiction over water quality protection; local government officials; or the operator of a MS4 receiving discharges from the site) and must be submitted for review when requested by EPA or by the operator of the municipal separate storm sewer system when the facility discharges to a municipal separate storm sewer.

For large or complex facilities, the inspector should request a copy of the SWPPP prior to inspection to be more familiar with the facility during the inspection. Otherwise, the inspector will obtain a copy of and review the SWPPP or at least parts of the SWPPP during the inspection. At a minimum, the inspector should review the site map prior to conducting the field inspection to understand the site and the existing/planned storm water controls. Depending on the time available for the inspection and the size of the SWPPP, the inspector may need to complete the remaining portion of the SWPPP review only when he or she returns to the office.

In reviewing the SWPPP, the inspector must evaluate whether it contains all of the required elements specified in the permit (e.g., the MSGP, the State General Permit in NPDES authorized States, or an individual permit issued to the facility). Typically, the MSGP requires that the SWPPP identify potential sources of pollution which may be reasonably expected to affect the quality of storm water discharges and describe and ensure implementation of practices used by the facility to reduce the pollutants in its storm water discharges. (Reviewing the SWPPP implementation is covered in the next section.) The MSGP-2000 lists the following specific items that must be included in the SWPPP:

- ***Pollution Prevention Team*** - identifying individuals responsible for developing, implementing, maintaining, and revising the SWPPP
- ***Description of industrial activities*** at the facility
- ***General location map*** depicting the facility and location of receiving waters
- ***Legible site map*** indicating:
  - direction of storm water flow
  - location of existing structural Best Management Practices (BMPs)
  - location of all surface water bodies
  - location of potential pollutant sources and where significant materials are exposed to precipitation

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  - location where major spills or leaks have occurred
  - locations of activities exposed to precipitation, including fueling stations, vehicle and equipment maintenance and/or cleaning areas, etc.
  - locations of storm water outfalls and outline of areas draining to such outfalls
  - location and description of non-storm water discharges
  - location of activities exposed to precipitation to include processing and storage areas, access roads, etc.
  - location and source of runoff from adjacent property containing significant quantities of pollutants of concern.
- ***Receiving waters and wetlands***
- ***Summary of potential pollutant sources***
- ***Areas of spills and leaks during prior three-year period***
- ***Summary of sampling data***
- ***Storm water controls*** to include a description of existing and planned BMPs.

These items are detailed in Section 4.2 of the MSGP-2000, which covers the general requirements for a SWPPP. In addition, the MSGP contains sector-specific SWPPP requirements which are found in Section 6 of the MSGP. The NPDES Industrial Storm Water Worksheet found in Appendix P also lists these items. Finally, a State General Permit may contain additional items. The inspector must have the applicable State general permit for storm water discharges associated with industrial activities.

NOTE: As defined in 40 CFR 122.26(b)(12), significant materials include, but are not limited to: raw materials; fuels; materials such as solvents, detergents, and plastic pellets; finished materials such as metallic products; raw materials used in food processing or production; hazardous substances designated under CFR Section 101(14) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); any chemical the facility is required to report pursuant to Section 313 of Title III of Superfund Amendments and Reauthorization Act (SARA); fertilizers; pesticides; and waste products such as ashes, slag, and sludge that have the potential to be released with storm water discharges.

The SWPPP may incorporate or may be incorporated into other plans that the facility prepared for other permits or programs including Spill Prevention Control and Countermeasure (SPCC) Plans, or BMP Programs.

Additional Requirements for EPCRA 313 Facilities

The MSGP also includes special requirements for facilities subject to reporting requirements under Emergency Planning and Community Right-to-Know (EPCRA) (also known as Title III of the Superfund Amendments and Reauthorization Act (SARA) of 1986). Potential pollutant sources for which the facility has reporting requirements under EPCRA 313 must be identified in the summary of potential pollutant sources in the facility's SWPPP.

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SWPPP Implementation/In the Field

In the field, the inspector should verify that the map and description of potential pollutant sources in the SWPPP reflect current conditions. In addition, the inspector should verify that measures and controls described in the SWPPP, are being implemented as described in the SWPPP. These measures and controls will include items such as:

- Good housekeeping or upkeep of industrial areas exposed to storm water
- Preventive maintenance of storm water controls and other facility equipment
- Spill prevention and response procedures to minimize the potential for and the impact of spills
- Inspections of areas where industrial materials or activities are exposed to storm water, including evaluation of existing BMPs
- Employee training on pollution prevention measures and controls and recordkeeping (described in detail below).

The MSGP may also require that facilities:

- Identify areas with a high potential for erosion and the stabilization measures or structural controls to be used to limit erosion in these areas
- Implement traditional storm water management measures (e.g., oil/water separators, vegetative swales, detention ponds) where they are appropriate for the site.

Implementation of SWPPPs requires facilities to implement BMPs and train employees on how to carry out the goals of the SWPPP. The inspector should evaluate any implementation schedules developed by the facility for carrying out the SWPPP (e.g., deadlines for putting improved housekeeping measures into practice). The inspector should also determine whether appropriate individuals have been assigned to implement the specific aspects of the SWPPP and whether these individuals are aware of the requirements of that designation. If the SWPPP requires installation of structural controls, the inspector should verify that the controls are in place and in good working order or that the facility is on an appropriate schedule for construction of the structural control measures. The inspector should also ensure that management approves of the implementation schedule and strategy and is aware of the SWPPP process.

In addition, employee training on the components and goals of the Storm Water Pollution Prevention Plan must be performed at all levels of responsibility. The inspector should verify that there are training programs and that the training focuses on spill prevention and response, good housekeeping practices, materials management, and also, how to do inspections and monitoring.
Specific inspector questions, that may be appropriate at a given industrial site, are contained in the NPDES Industrial Storm Water Worksheet found in Appendix P. Site-specific Best Management Practices (BMPs) for industrial activities are summarized in Figure 11-2.

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Monitoring (including Self-Inspections)

Self-Inspections

The SWPPP must have provisions for two tiers of inspections to be performed by the facility. The first tier consists of quarterly visual examination of storm water discharges, looking for indications of storm water pollutants in the discharge. Quarterly visual monitoring is intended to determine the need for maintenance, good housekeeping, or other BMPs. The second tier of inspection is the comprehensive site evaluation, which requires qualified personnel to:

- Look for evidence of pollutants entering the drainage system
- Evaluate the performance of pollution prevention measures
- Identify areas where the SWPPP should be revised to reduce the discharge of pollutants
- Document both the routine inspections and the annual site evaluation in a report.

The compliance site evaluation can be done less frequently than the routine inspection (but not less than once per year). The inspector should verify that documentation of both the routine inspections and the comprehensive site compliance evaluation is included in the SWPPP.

Monitoring Requirements

There are several distinct categories of monitoring requirements and numeric effluent limitations that the facility may be subject to under the MSGP-2000: (1) monitoring for numeric limitation, (2) benchmark monitoring, (3) biannual monitoring for metal mining facilities, and (4) specific monitoring by a State, Tribe, or Territory. The monitoring requirements and numeric limitations applicable to the facility depend on a number of factors including (1) the types of industrial activities generating storm water runoff from the facility, and (2) the State or Tribe where the facility is located. Depending on the facility's sector (identified in MSGP Section 1.2.1), different monitoring requirements and numeric limitations apply. The MSGP-2000 established monitoring requirements only for certain classes of industrial sites. These requirements are based on analysis of the types of pollutants potentially discharged from the different industrial sectors. State NPDES permitting authorities are authorized to include more stringent monitoring conditions; therefore, the inspector should review the facility's permit to identify the site-specific requirements.

For specific monitoring requirements, the inspector should review EPA's most current MSGP (where applicable), the State NPDES permit, or the facility-specific individual permit. The permit will contain specific conditions as to the sample type, location, frequency, as well as the specific parameters that must be analyzed. If it is necessary for the inspector to collect samples, the inspector should refer to Chapter Five of this manual and to EPA's *Guidance Manual for the Monitoring and Reporting Requirements of the NPDES Storm Water Multi-Sector General Permit*, EPA 833-B-99-001, January 1999 for specific details on sampling and analyses.

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Table 11-4

SIC Codes Regulated for Storm Water Discharges

SIC	Description
MINING	
10	Metal mining
12	Coal mining
13	Oil and gas extraction
14	Mining and quarrying or nonmetallic minerals, except fuels
MANUFACTURING	
20	Food and kindred products
21	Tobacco products
22	Textile mill products
23	Apparel and other finished products made from fabrics and similar materials
24	Lumber and wood products, except furniture
2434	Wood kitchen cabinets
25	Furniture and fixtures
26	Paper and allied products
265	Paperboard containers and boxes
267	Converted paper and paperboard products, except containers and boxes
27	Printing, publishing, and allied industries
28	Chemicals and allied products
283	Drugs
285	Paints, varnishes, lacquers, enamels, and allied products
29	Petroleum refining and related industries
30	Rubber and miscellaneous plastic products
31	Leather and leather products
311	Leather tanning and finishing
32	Stone, clay, glass, and concrete products
323	Glass products, made of purchased glass
33	Primary metals industry
34	Fabricated metal products, except machinery and transportation equipment
3441	Fabricated structural metal
35	Industrial and commercial machinery and computer equipment
36	Electronic and other electrical equipment and components, except computer equipment
37	Transportation equipment
373	Ship and boat building and repairing
38	Measuring, analyzing, and controlling instruments; photographic, medical and optical goods; watches and clocks
39	Miscellaneous manufacturing industries
TRANSPORTATION, COMMUNICATIONS, ETC.	
40	Railroad transportation
41	Local and suburban transit and interurban highway passenger transportation
42	Motor freight transportation and warehousing
4221	Farm product warehousing and storage
4222	Refrigerated warehousing and storage
4225	General warehousing and storage
43	United States Postal Service
44	Water transportation
45	Transportation by air
WHOLESALE TRADE	
50	Wholesale trade - durable goods
5015	Motor vehicle parts, used
5093	Scrap and waste material
51	Wholesale trade - nondurable goods
5171	Petroleum bulk stations and terminals

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Figure 11-1

Industrial Categories Associated With Industrial Activity

The eleven categories engaging in industrial activity are described below. Descriptions of Standard Industrial Classification [SIC] codes applicable to the storm water regulations are provided in Table 11-4.

(i) Facilities subject to storm water effluent limitations guidelines, new source performance standards, or toxic pollutant effluent standards under 40 CFR subchapter N (except facilities with toxic pollutant effluent standards which are exempted under category (xi) below;

(ii) Facilities classified as SIC 24 (except 2434), 26 (except 265 and 267), 28 (except 283), 29, 311, 32 (except 323), 33, 3441, and 373;

(iii) Facilities classified as SIC 10 through 14 (mineral industry) including active or inactive mining operations (except for areas of coal mining operations no longer meeting the definition of a reclamation area under 40 CFR 434.11(l) because the performance bond issued to the facility by the appropriate SMCRA authority has been released, or except for areas of non-coal mining operations which have been released from applicable State or Federal reclamation requirements after December 17, 1990) and oil and gas exploration, production, processing, or treatment operations, or transmission facilities that discharge storm water contaminated by contact with or that has come into contact with, any overburden, raw material, intermediate products, finished products, byproducts or waste products located on the site of such operations; (inactive mining operations are mining sites that are not being actively mined, but which have an identifiable owner/operator; inactive mining sites do not include sites where mining claims are being maintained prior to disturbances associated with the extraction, beneficiation, or processing of mined materials, nor sites where minimal activities are undertaken for the sole purpose of maintaining a mineral claim);

(iv) Hazardous waste treatment, storage, or disposal facilities, including those that are operating under interim status or a permit under subtitle C of RCRA;

(v) Landfills, land application sites, and open dumps that receive or have received any industrial wastes (waste that is received from any of the facilities described under this subsection) including those that are subject to regulation under subtitle D of RCRA;

(vi) Facilities involved in the recycling of materials, including metal scrapyards, battery reclaimers, salvage yards, and automobile junkyards, including but not limited to those classified as SIC 5015 and 5093;

(vii) Steam electric power generating facilities, including coal handling sites;

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Figure 11-1

Industrial Categories Associated With Industrial Activity

(Continued)

(viii) Transportation facilities classified as SIC 40, 41, 42 (except 4221-25), 43, 44, 45, and 5171 which have vehicle maintenance shops, equipment cleaning operations, or airport deicing operations. Only those portions of the facility that are either involved in vehicle maintenance (including vehicle rehabilitation, mechanical repairs, painting, fueling, and lubrication), equipment cleaning operations, airport deicing operations, or which are otherwise identified under paragraphs (i)-(vii) or (ix)-(xi) of this section are associated with industrial activity;

(ix) Treatment works treating domestic sewage or any other sewage sludge or wastewater treatment device or system, used in the storage, treatment, recycling, and reclamation of municipal or domestic sewage, including land dedicated to the disposal of sewage sludge that are located within the confines of the facility, with a design flow of 1.0 million gallons a day (mgd) or more, or required to have an approved pretreatment program under 40 CFR Part 403. Not included are farm lands, domestic gardens or lands used for sludge management where sludge is beneficially reused and which are not physically located in the confines of the facility, or areas that are in compliance with section 405 of the CWA;

(x) Construction activity including clearing, grading and excavation activities except: operations that result in the disturbance of less than five acres of total land area which are not part of a larger common plan of development or sale;

(xi) Facilities under SIC 20, 21, 22, 23, 2434, 25, 265, 267, 27, 283, 285, 30, 31 (except 311), 323, 34 (except 3441), 35, 36, 37 (except 373), 38, 39, 4221-4225, (and which are not otherwise included within categories (i)-(x).

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Figure 11-2

Site-Specific Industrial Storm Water BMPs

Flow Diversion Practices: Flow diversion is practiced to channel storm water away from industrial activities to prevent storm water contact with industrial pollutants. Additionally, flow diversion may be used to channel polluted storm water directly to a treatment facility.

Flow diversion practices include storm water conveyances (e.g., channels, gutters, drains, and sewers), diversion dikes, and graded areas and pavement.

Exposure Minimization Practices: Exposure minimization is practiced to eliminate or minimize the contact of storm water with industrial activities and its pollutants. If contact of storm water with pollutants is minimized, the costs of collecting and treating and storm water and the environmental releases that occur will be reduced.

Exposure minimization practices include containment diking, curbing, drip pans, collection basins, sumps, covering, vehicle positioning, and loading and unloading by air pressure or vacuum.

Mitigative Practices: Mitigation is practiced to clean up or recover a substance (i.e., potential pollutant) before it comes in contact with storm water. Mitigation is a second step after pollution prevention.

Mitigative practices include sweeping, shoveling, excavation practices, vacuum and pump systems, sorbents, and gelling agents.

Other Preventative Practices: Other preventative practices can be taken to limit/prevent the exposure of storm water to industrial activities. These practices may be either structural or procedural measures taken to reduce/eliminate exposure.

Other preventative practices include preventative monitoring practices, dust control (land disturbances and demolition areas), dust control (industrial activities), signs and labels, security, area control procedures, and vehicle washing.

Sediment and Erosion Prevention Practices: Sediment and erosion prevention can be accomplished using seven general practices: vegetate the site, minimize soil exposure to storm water, keep runoff from disturbed areas, stabilize disturbed soils, slow down runoff, provide drainage ways for runoff, and remove sediment from the runoff before it leaves the site.

Sediment and erosion prevention practices include vegetative practices, structural erosion prevention, and sediment control practices.

Infiltration Practices: Infiltration practices are measures that increase the infiltration of storm water runoff into the ground through the use of very porous soils. Infiltration practices may also reduce the velocity of storm water, thereby minimizing erosion potential of the runoff.

Infiltration practices include vegetated filter strips, grassed swales, level spreaders, infiltration trenches, and porous pavements/concrete grids and modular pavements.

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11. C. Storm Water Discharges Associated with Construction Activity

Applicability (Who is Covered)

Construction activity plays a major role in the degradation of water quality. Construction activities are a major contributor of sediment discharges to our rivers, streams, and wetlands. In the 1998 National Water Quality Inventory, States reported that siltation is the largest cause of impaired water quality in rivers and streams and the third largest cause of impairment in lakes. Sediment-laden discharges can result in aquatic habitat destruction, and detrimental changes to hydrologic patterns, including increased natural stream flows and excessive flooding. Total suspended solids (TSS) concentrations from uncontrolled construction sites have been found to be more than 150 times greater than the concentration from undeveloped land.

Large Construction Activity

As mentioned earlier, the Phase I Rule identifies eleven categories of industrial activity in the definition of "storm water discharge associated with industrial activity" that must obtain an NPDES storm water discharge permit (see Section 11.B). Category (x) of this definition includes construction activity (including clearing, grading, and excavation) that results in a total land disturbance of 5 acres or greater. Disturbance of less than 5 acres are also regulated under category (x) if they are part of a "larger common plan of development of sale" with a planned disturbance of 5 acres or greater. Phase I construction activity is commonly referred to as "large" construction activity. The Phase I rule requires all operators of large construction activity to obtain a NPDES storm water discharge permit before discharging storm water runoff to a municipal separate storm sewer system or waters of the United States, unless covered by the United States Army Corps of Engineers 404 permit.

Construction activities can include road building, construction of residential houses, office buildings, industrial sites, or demolition.

Land Disturbance means exposed soil due to clearing, grading, or excavation activities.

Larger common plan of development or sale describes a situation in which multiple construction activities occurs on a contiguous area.

An operator is the person or persons that has either operational control of construction project plans and specifications, or day-to-day operational control of activities necessary to ensure compliance with storm water permit conditions.

Small Construction Activity

In 1992, the Court of Appeals for the Ninth Circuit remanded for further proceedings the portion of EPA's Phase I storm water regulation related to category (x) construction activity (*NRDC v. EPA*, 966 F.2d) (9thCir. 1992). EPA responded to the court's decision by designating under Phase II storm water discharges from construction site activities that ultimately will result in a

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land disturbance of equal to or greater than 1 and less than 5 acres as "storm water discharges associated with small construction activity" (see 40 *CFR* 122.26(b)(15)). The Phase II rule specifies all operators of small construction must be covered under an NPDES storm water discharge permit by March 10, 2003 before discharging storm water runoff to a municipal separate storm sewer system or waters of the United States after that date.

Construction activities disturbing less than 1 acre are also included in Phase II of the NPDES storm water program if they are part of a larger common plan of development or sale with a planned disturbance of equal to or greater than 1 acre and less than 5 acres, or if they are designated by the NPDES permitting authority. The NPDES permitting authority or EPA may designate construction activities disturbing less than 1 acre based on potential for contribution to a violation of a water quality standard or for significant contribution of pollutants to waters of the United States.

Small Construction Waivers

Small construction activity does not require permit coverage where the construction operator can certify one of two waivers. Small construction activities disturbing less than 1 acre that are designated by the permitting authority are not eligible for these waivers. Under the Phase II Rule, NPDES permitting authorities have the option of providing a waiver from Phase II coverage and requirements to operators of small construction activity who certify to one of two conditions:

(1) Low predicted rainfall potential (i.e., activity occurs during a negligible rainfall period), where the rainfall erosivity factor ("R" in the Revised Universal Soil Loss Equation [RUSLE]) would be less than 5 during the period of construction activities; or

(2) A determination that storm water controls are not necessary based on either:

(A) A "total maximum daily load" (TMDL) that address the pollutant(s) of concern[1] for construction activities; or

(B) An equivalent analysis for non-impaired waters that determines allocations are not needed to protect water quality based on consideration of instream concentrations, expected growth in pollutant concentrations from all sources, and a margin of safety.

In order to qualify for the Rainfall Erosivity Factor Waiver, the construction site operator must determine the value of the rainfall erosivity factor - R factor in the RUSLE and then certify to the permitting authority that the factor is less than 5 during the period of construction. A construction site operator will need site-specific data to calculate the values for rainfall erosivity using RUSLE. Calculations may also be made online by going to that waiver section at: http://www.epa.gov/npdes/stormwater/cgp.cfm.

In order to qualify for the Water Quality Waiver, the operator of the construction site would need to certify that the facility's construction activity will take place, and the storm water discharges

[1]Pollutants of concern include sediment or a parameter that addresses sediment (such as total suspended solids, turbidity, or siltation) and any other pollutant that has been identified as a cause of impairment of a receiving waterbody.

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will occur, within the area covered by the TMDLs or equivalent analysis. A certification form is provided by EPA and would likely be provided by the NPDES permitting authority.

Inspector should verify that the construction project qualifies for a waiver.

Permit Applications for Storm Water Discharges Associated With Construction Activity

Operators of both small and large construction activities must obtain coverage under a NPDES construction storm water permit. Where EPA is the NPDES permitting authority, the Construction General Permits (CGP) are the only permit option available. In areas where EPA is not the NPDES permitting authority, other types of construction storm water permits may be required, so it is important to check with the appropriate NPDES permitting authority. Many State NPDES permitting authorities have issued general permits for construction activities. State construction general permits will also be referred to as CGPs through-out the chapter. See www.cicacenter.org/swp2.html for list of state General Permits.

General Permit/Notice of Intent

As stated above, the CGP is the only general permit available to operators of large construction activities in areas where EPA is the NPDES permitting authority. The CGP for areas where EPA is the permitting authority is published in the *Federal Register.* Much like the industrial facilities that apply for general permits, operators of construction sites that apply for permit coverage under the CGP are required to complete, certify, and submit to the appropriate NPDES permitting authority a Notice of Intent (NOI) Form. The NOI requests a variety of information, including information related to the Endangered Species Act (similar to what is described in the Permit Applications for Storm Water Discharges Associated with Industrial Activity section of this chapter). In order to discontinue permit coverage, an operator of a construction activity must complete and submit to the appropriate NPDES permitting authority a Notice of Termination (NOT) Form upon satisfying the appropriate permit conditions described in the CGP. This permit presents operators with all requirements up front, allowing facility operators to become familiar with, and prepare for, activities such as storm water pollution prevention plan implementation and regular inspections, prior to applying for permit coverage. The key component of the CGP is the development and implementation of a construction storm water pollution prevention plan (SWPPP). For sites with multiple operators, EPA encourages these operators to develop one comprehensive SWPPP with specific requirements for each operator identified. Some of the other requirements include conducting regular inspections and reporting releases of reportable quantities of hazardous substances. Operators must also comply with local, State, or Tribal construction runoff control programs.

NOIs must be submitted in the time frame specified in the applicable general permit (e.g., at least 7 days prior to commencement of construction.) Electronic filing of NOI's (E-NOI) is now available for non-authorized states see http://cfpub.epa.gov/npdes/stormwater/enoi.cfm.

EPA's regulations allow permitting authorities to authorize discharges under general permit for small construction sites without submitting an NOI where the permitting authority finds that NOIs would be inappropriate. While EPA does not currently implement this allowance, some states have opted to regulate small construction that way (i.e. no NOI required).

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Individual Permit (Phase II and Phase I)

In the event that an operator of a small construction activity chooses to apply for an individual permit, or if the NPDES permitting authorities denies coverage under general permits and requires the operator to submit an individual NPDES permit application (based on information such as water quality data), or if any of the discharges of storm water associated with small construction activity identified in 40 CFR 122.26(b)(15) that are not authorized by the general permit, the operator is subject to the individual application requirements found at *CFR*122.26(c)(1)(ii).

Establishing Eligibility

Endangered Species Act

EPA's NOI requires certification that the construction activity will not impact endangered or threatened species protected under the Endangered Species Act (ESA). As mentioned above, this NPDES certification requirement is unique to EPA's NOI. All dischargers applying for coverage must include in the application information on the NOI form: (1) whether listed species are in proximity to the storm water or allowable non-storm water discharges or discharge-related activity; (2) under which option of the CGP they claim eligibility for permit coverage, and (3) certification that their storm water and allowable non-storm water discharges and discharge related activities are not likely to jeopardize listed species, or are otherwise eligible for coverage due to a previous authorization under the ESA. The permittee should consult with applicable state Fish and Wildlife service and National Marine Fisheries Service offices to make these determinations of eligibility.

Storm Water Pollution Prevention Plan Requirements

The Storm Water Pollution Prevention Plan as required in the CGP must be prepared prior to submission of the NOI. The construction project must comply with the provisions of the SWPPP throughout the construction period and must be signed by a responsible official such as the president, vice president, or general partner. The construction facility must keep the SWPPP on-site throughout the entire construction period. The SWPPP must be submitted for review only when requested by EPA, although some permitting authorities may require submission at the SWPPP along with the NOI.

For large or complex construction sites the inspector should request a copy of the SWPPP prior to inspection to ensure familiarity with the site during the inspection. This may not always be possible where we want to ensure there is no advance notice of an inspection. Otherwise, the inspector will obtain a copy of and review the SWPPP or at least parts of the SWPPP during the inspection. At a minimum, the inspector will need to review the site map prior to conducting the field inspection to understand the site and the existing/planned storm water controls. Depending on the time available for the inspection and the size of the SWPPP, the inspector may need to complete the remaining portion of the SWPPP review when he or she return to the office.

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In reviewing the SWPPP, the inspector must evaluate if it contains all of the required elements specified in the permit (either the most current EPA CGP, the applicable State permit in NPDES-authorized States, or an individual permit issued to the site). The CGP requires that the SWPPP identify potential sources of pollution which may reasonably be expected to affect the quality of storm water discharges and describe and ensure implementation of practices which the operator will use to reduce the pollutants in its storm water discharges. (Reviewing the SWPPP implementation is covered in the next section.) The following items are required typically in the SWPPP:

- A description of the nature of the construction activity
- A sequence (schedule) of major construction activity
- An estimate of the total area of the site and of the area to be disturbed
- Any existing data on the quality of storm water discharge from the site
- The name of the receiving water
- Any information on the type of soils at the site
- A site map indicating drainage patterns and slopes after grading activities are complete, areas of soil disturbance, areas which will not be disturbed, the location of stabilization measures and structural and non-structural controls, locations of offsite material, waste, borrow, equipment storage areas, and surface waters at the discharge outfalls
- Location and description of any discharge associated with industrial activity other than construction
- Copy of permit requirements
- Information on listed endangered or threatened species or critical habitat in proximity to site
- Measures and controls to prevent or minimize pollution of storm water.

Typically, measures and controls must include the following three (3) types:

(1) Erosion and Sediment Controls

Construction phase erosion and sediment controls should be designed to retain sediment onsite to the extent practicable and all control measures must be selected, installed, and maintained in accordance with manufacturer's specifications and good engineering practices. In addition, practices must be included for interim and permanent stabilization for the site, including a schedule of when the practices will be implemented. When construction activities temporarily or permanently cease on a portion of the site, stabilization measures must be initiated by the 14th day for erosion control. However, if the site will be redisturbed within 21 days this requirement is waived.

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A site with more than 10 disturbed acres of common drainage must provide a temporary/permanent sediment basin with 3,600 cubic feet of storage per acre drained. When a sediment basin is not attainable, the SWPPP should identify all equivalent sediment controls.

The SWPPP must include a description of structural practices to divert flows from exposed soils, store flows or otherwise limit runoff and the discharge of pollutants from exposed areas of the site to the degree attainable.

(2) Storm Water Management

The permittee must consider installing measures (storm water detention structures, infiltration measures, etc.) to control pollutants after construction is complete (i.e., post-construction). Velocity dissipation devices must be installed in outfall channels to prevent erosion.

(3) Other Controls

The SWPPP must ensure that construction waste is not carried by storm water into the receiving waters. Measures must be taken to prevent construction vehicles from tracking soil off the construction site and to reduce the dust generation at the construction site. The operator must comply with State and/or local sanitary sewer or septic system regulations.

Where State and local programs for sediment and erosion control, storm water management, or site permits exist, the operator must certify that the SWPPP reflects and is in compliance with the requirements of the applicable State or local program.

This SWPPP must also specify that operator personnel must inspect the construction site at least once every 7 days or at least every 14 days and within 24 hours of a rainfall of 0.5 inches or more. Areas with sites that have been finally stabilized or sites that are located in arid (i.e., less than 10 inches of rain per year) or semi-arid (10 to 20 inches of rain per year) areas must be inspected at least once a month. The inspector must prepare a report documenting his/her findings on the conditions of the controls and stabilized areas. The inspector should verify that documentation of the routine inspections is included in the SWPPP.

The worksheet provided in Appendix R can be use to evaluate specific elements of the Storm Water Pollution Prevention Plan for construction activities.

SWPPP Implementation/In the Field

Are They Doing What The SWPPP Indicates?

When conducting the field inspection of a construction site, inspector should note several items:

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- The opening conference with the owner/operator is extremely important. Often at larger residential construction sites, there will be multiple builders side-by-side with no delineation between them but each one of them is responsible for one or more aspects of SWPPP implementation. It is also important to identify the permittee and or co-permittees and their respective responsibilities under the permit. In some cases, the permittee is the developer who then passes along responsibility for aspects of the SWPPP implementation to the individual builders.

- It is absolutely necessary to review the site map before conducting the inspection because if the inspector does not know the site boundaries, it is difficult to identify and evaluate the runoff potential.

- Review construction sequence and BMP sequence given in the SWPPP - verify that these have been met.

- The closing conference provides an opportunity to describe deficiencies found and identify areas of concern (e.g., parts of a SWPPP missing; inspections not being done; silt fence not installed; discharge to a storm drain, etc...). Given the transient nature of most construction sites it is important to share information with the site owner/operator as quickly as possible (e.g., prior to issuance of final inspection report) so that any environmental harm can be minimized.

In the field, the inspector should verify that the description of potential pollutant sources in the SWPPP reflects current conditions. In addition, the inspector should verify that measures and controls described in the SWPPP are being implemented as described in the SWPPP.

Implementation of SWPPPs require facilities to implement BMPs and train employees on how to carry out the goals of the SWPPP. The inspector should evaluate any implementation schedules developed by the facility for carrying out the SWPPP (e.g., deadlines for putting improved housekeeping measures into practice). The inspector should also determine whether appropriate individuals have been assigned to implement the specific aspects of the SWPPP and whether these individuals are aware of the requirements of that designation. If the SWPPP calls for the installation of structural controls, the inspector should verify that the controls are in place and in good working order or that the facility is on an appropriate schedule for construction of the structural control measures. The inspector should also ensure that management approves of the implementation schedule and strategy and is aware of the SWPPP process.

An example of problems that an inspector may observe during a construction site inspection includes:

- Failure to self-inspect

- Silt fences improperly located, falling over, or ripped so that the fence is not functioning properly

- Poor housekeeping: oil stains on soil; over turned drums, uncovered pails containing liquids; cluttered equipment storage with leaking fluids; fuel tanks with no containment

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- Storm drain inlets: covered with sediment/debris; ruptured gravel bags with loss of gravel into drain; no protection
- Trackout pads: filled with soil and not effective; dirt on roads.
- No cement washout

A worksheet that can help guide the inspector through the field inspection is presented in Appendix R. Site-specific BMPs for construction activities are summarized in Figure 11-3.

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Figure 11-3

Site-Specific Construction Storm Water BMPs

Stabilization Practices: Stabilization is practiced to control erosion due to unvegetated areas. Stabilization reduces erosion potential in four ways: (1) by shielding the soil surface from direct erosive impact of raindrops, (2) by improving the soil's water storage porosity and capacity, (3) by slowing the runoff and allowing the sediment to drop out or deposit; and (4) by physically holding the soil in place with plant roots. Vegetative (e.g., grasses, trees, or shrubs) covers are the most common type of stabilization.

Stabilization practices include temporary seeding, mulching, geotextiles, chemical stabilization, permanent seeding and planting, buffer zones, preservation of natural vegetation, sod stabilization, stream bank stabilization, soil retaining measures, and dust control.

Structural Erosion and Sediment Control Practices: Structural erosion and sediment control diverts storm water flows away from exposed areas, conveys runoff, prevents sediments from moving offsite, and reduces the erosive forces of runoff waters.

Structural erosion and sediment control practices include earth dikes, drainage swales, interceptor dikes and swales, temporary stream crossing, temporary storm drain diversion, pipe slope drains, subsurface drains, silt fence, gravel or stone filter berm, storm drain inlet protection, sediment trap, temporary sediment basin, outlet protection, check dams, surface roughening, and gradient terraces.

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11. D. Storm Water Discharges From Municipal Separate Storm Sewer Systems

Applicability (Who is Covered)

In addition to regulating discharges from the 11 categories of sites with industrial activities, the storm water program regulates discharges from municipal separate storm sewer systems (MS4s).

The November 16, 1990, regulations identify a two-part storm water permit application process for medium (serving a population of 100,000 or more, but fewer than 250,000) and large (serving a population of more than 250,000) MS4s in 40 *CFR* 122.26(d), pursuant to 402(p)(2)(C)-(D) of the CWA. The regulations identify 220 cities and counties that meet this requirement (and allow for case-by-case designations of other municipal storm sewers to be included in these systems). In addition to the designated counties and cities, other entities may be regulated such as Departments of Transportation or flood control districts. To date, a total of approximately 1,000 entities (cities, counties, DOTs, etc.) are covered under 270 permits nationwide. Part 1 applications for municipal storm sewer systems were due to EPA on November 18, 1991, (large systems) and May 18, 1992 (medium systems). Part 2 applications for these permittees were due to EPA on November 16, 1992, (large systems) and May 17, 1993 (medium systems). No new medium or large MS4s will be permitted under the Phase I requirements. All future MS4s are to obtain permit coverage under the Phase II regulations.

The Phase II Final Rule, published in the Federal Register on December 8, 1999, requires NPDES permit coverage for storm water discharges from certain regulated small MS4s. Only a select subset of small MS4s, referred to as regulated small MS4s, require an NPDES storm water permit. Small MS4s are defined as any MS4 that is not a medium or large MS4 covered by Phase I of the NPDES Storm Water Program. Regulated small MS4s are defined as all small MS4s located in "urbanized areas" (UAs) as defined by the Bureau of the Census, and those small MS4s located outside of a UA that are designated by NPDES permitting authorities. A small MS4 can be designated by the permitting authority as a regulated small MS4 in one of two ways. One, the small MS4 located outside of a UA is designated as a regulated small MS4 by the NPDES permitting authority because its discharges cause, or have the potential to cause, an adverse impact on water quality. Two, the small MS4 located outside of a UA contributes substantially to the pollutant loadings of a *physically interconnected* MS4 regulated by the NPDES storm water program. Note: The NPDES permitting authority was required to designate small MS4s meeting the designation criteria by December 9, 2002, or by December 8, 2004, if a watershed plan is in place.

Waivers

Permitting authorities may waive "automatically designated" Phase II dischargers if the dischargers meet the necessary criteria. Two waiver options are available to operators of automatically designated small MS4s if discharges do not cause, or have the potential to cause water quality impairment. Note: the waivers are granted by the NPDES authority. The operator

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of the regulated small MS4 cannot determine that the facility meets the waiver criteria. If the permitting authority is not proactive in assessing small MS4s for potential waivers, an operator may petition for a waiver assessment. If a permitting authority decides to grant waivers, it must have done so by December 9, 2002, to coincide with the expected issuance of the small MS4 general permit. If the permit authority chooses to phase in permit coverage based on a comprehensive watershed plan, then regulated small MS4s may be waived on the same schedule. The phase-in of permit coverage and waivers is to be completed no later than March 8, 2007.

The first waiver option applies where:

(1) the jurisdiction served by the system is less than 1,000 people;

(2) the system is not contributing substantially to the pollutant loadings of a physically interconnected regulated MS4; and

(3) if the small MS4 discharges any pollutants identified as a cause of impairment of any water body to which it discharges, storm water controls are not needed based on wasteload allocations that are part of an EPA approved or established "total maximum daily load" TMDL that addresses the pollutant(s) of concern.

The third criterion of this waiver option need only be met if the small MS4 is discharging into a impaired water body and the discharge contains a pollutant or pollutants cause the impairment (i.e., the "pollutants of concern").

The second waiver option applies where:

(1) the jurisdiction served by the system is less than 10,000 people;

(2) an evaluation of all waters of the U.S. that receive a discharge from the system shows that storm water controls are not needed based on wasteload allocations that are part of the EPA approved or established TMDL that addresses the pollutant(s) of concern or an equivalent analysis; and

(3) it is determined that future discharges from the small MS4 do not have the potential to result in exceedences of water quality standards.

The NPDES permitting authority is required to periodically review any waivers granted to MS4 operators to determine whether any information required for granting the waiver has changed. Minimally, such a review needs to be conducted once every five years.

Permit Applications for Storm Water Discharges From Municipal Separate Storm Sewer Systems

Permits must be obtained for all discharges from large, medium, and regulated small municipal separate storm sewer systems (and designated others as determined on a case-by-case basis). The permitting authority may issue one system-wide permit covering all discharges from

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municipal separate storm sewer systems or issue distinct permits for appropriate categories of discharges. Also, the permitting authority may issue permits for other municipal separate storm sewer systems on a system-wide or categorical basis. EPA did not develop baseline general permits for storm water discharges from municipal separate storm sewer systems, because of the differing nature of discharges from municipal separate storm sewer systems in different parts of the country and the varying water quality impacts of municipal storm sewer discharges on receiving waters. Based on permit application requirements, these permits will likely address applicability, legal authority, source identification, discharge characterization, management programs, control and impact assessments, and financial commitments. In many instances, these permits will be unique to the individual permittee; therefore, a definitive discussion of the permit requirements for the municipal separate storm sewer system permittees is not possible.

Unlike the Phase I program that primarily utilizes individual permits for medium and large MS4s, the Phase II approach allows operators of regulated small MS4s to choose from as many as three permitting options: (1) general permits, (2) individual permits, or (3) modification of an existing Phase I Individual Permit (Co-Permittee Option). It must be noted that the NPDES permitting authority reserves the authority to determine which options are available to the regulated small MS4s. Operators of "automatically designated" regulated small MS4s in urbanized areas submit their Notices of Intent within 90 days of permit issuance. Operators of regulated small MS4s designated by the permitting authority must submit their permit applications within 180 days of notice. Full implementation of MS4's program is required within 5 years of permit issuance.

General permits for regulated small MS4s are strongly encouraged by EPA. The Phase II program has been designed specifically to accommodate a general permit approach. General permits prescribe one set of requirements for all applicable permittees. General permits are drafted by the NPDES permitting authority, then published for public comment before being finalized and issued. A NOI serves as the application for the general permit. The regulated small MS4 operator complies with the permit application requirements by submitting an NOI to the NPDES permitting authority that describes the storm water management program, including best management practices (BMPs) and measurable goals. The operator has the flexibility to develop an individualized storm water program that addresses the particular characteristics and needs of its system, provided the requirements of the general permit are satisfied. Permittees also can choose to share responsibilities for meeting the Phase II program requirements. Those entities choosing to do so may submit jointly with the other municipalities or governmental entities an NOI that identifies who will implement which minimum measures within the area served by the MS4.

Individual permits are required for Phase I medium and large MS4s, but not recommended by EPA for Phase II program implementation. Individual permits prescribe a particular set of requirements for a particular permittee or a group of co-permittees. Individual permits require the submission of a more comprehensive application than an NOI that is submitted under a general permit. Once the permit application is received, an individual permit is drafted by the NPDES permitting authority, then published for public comment before being finalized and issued. The Phase II rule allows a regulated small MS4 to submit an individual application for coverage under either the Phase II MS4 program (see 122.34) or the Phase I MS4 program (see 122.26(d)). For individual coverage under Phase II, the permittee must follow Phase II application requirements and provide an estimate of square mileage served by the system and any additional information requested by the NPDES permitting authority. The permittee electing to apply for coverage under Phase I program must follow the permit application requirements

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detailed at 122.26(d). The NPDES permitting authority may allow more than one regulated entity to apply for an individual permit (i.e., co-permittees).

Two permitting options tailored to minimize duplication of effort can be incorporated into both the general permit and the individual permit by the NPDES permitting authority. First, the permitting authority can recognize in the permit that another governmental entity is responsible under an NPDES permit for implementing any or all minimum measures. Responsibility for implementation of the measure(s) would rest with the other governmental entity, thereby relieving the permittee of its responsibility to implement that particular measure(s). Second, the NPDES permitting authority can include conditions in a general permit that direct a permittee to follow the requirements of an existing qualifying local program rather than the requirements of a minimum measure. A qualifying local program is defined as a local, State, or Tribal municipal storm water program that imposes requirements that are equivalent to those of Phase II MS4 minimum measures. The permittee remains responsible for the implementation of the minimum measure through compliance with the qualifying local program.

The operator of a regulated small MS4 could participate as a limited co-permittee in a neighboring Phase I MS4's storm water management program by seeking a modification of the existing Phase I individual permit. A list of Phase I medium and large MS4s can be obtained from the EPA Office of Wastewater Management (OWM) or downloaded from the OWM, web site at http://www.epa.gov/npdes. The permittee must follow Phase I permit application requirements (with some exclusions). The permittee must comply with the applicable terms of the Phase I individual permit rather than the minimum control measures in the Phase II Final Rule.

A summary of the permit application deadlines is presented in Table 11-3. The Transportation Act of 1991 modified the application deadlines for industrial activities owned or operated by municipalities (i.e., types of industrial activities covered by MSGP). The Phase II Rule required industrial activities operated by municipalities with populations less than 100,000 to obtain permit coverage to no later than March 10, 2003, (unless the NPDES permitting authority chooses to phase-in permit coverage on a watershed basis and establishes other deadlines). As such, all industrial activities defined in 122.26(b)(14) are now required to obtain coverage, unless waived.

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Storm Water Management Program (SWMP) Development

Phase I Completed as Part of the Permit Application

The storm water management program (SWMP) is considered to be the most important requirement of a MS4 permit. Existing structural and non-structural prevention and control measures on discharges from municipal separate storm sewers must be described in Part 1 of the permit application.

The discussion that follows provides a general discussion of SWMP requirements for MS4s. The inspector will have to review the facility's permit for specific considerations. Each MS4 covered by a permit must develop a SWMP, tailored to system-specific conditions and designed to control the amount of pollutants in storm water discharges from the system. The permitting authority has the right to review and request changes in the SWMP. Summaries of necessary components of these programs for MS4s are provided below for both large- and medium-size municipalities.

Management programs must describe priorities for implementing controls and should be based on the following four requirements:

1. Describe structural and source control measures to be implemented during the life of the permit to reduce pollutants from runoff from commercial and residential areas that is discharged from the MS4s. The description must be accompanied by an estimate of the expected reduction of pollutant loads and a proposed schedule for implementing such controls. At a minimum, the description should include:

    - Maintenance activities and a maintenance schedule for structural controls.
    - Planning procedures to develop, implement, and enforce controls to reduce discharges from areas of new development and significant redevelopment after construction is complete.
    - Practices for operating and maintaining public streets, roads, etc., and procedures for reducing the impact as a result of deicing activities.
    - Procedures to ensure that flood management projects assess the impacts on the water quality of receiving water bodies and that existing structural flood control devices have been evaluated if retrofitting is possible for additional pollutant removal.
    - Program to monitor pollutants in runoff from operating or closed municipal landfills or other treatment, storage, or disposal facilities for municipal waste, that identifies priorities and procedures for inspections and establishing and implementing control measures for such discharges.
    - Program to reduce to the MEP pollutants in discharges from the application of pesticides, herbicides, and fertilizers. This may include educational activities, permits, certifications, and other measures for commercial applicators and

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distributors, and controls for application in public right-of-ways and at municipal facilities.

2. Describe programs, including a schedule, to detect and remove (or to require the discharger to the municipal separate storm sewer system to obtain a separate NPDES permit for) illicit discharges and improper disposal into the storm sewer. At a minimum, the proposed program should include:

   - Inspection procedures, to implement and enforce an ordinance, order, or similar means to prevent illicit discharges to the municipal separate storm sewer system
   - Procedures to conduct on-going field screening activities during the life of the permit
   - Procedures to be followed to investigate portions of the separate storm sewer system that indicate a reasonable potential of containing illicit discharges or other sources of non-storm water
   - Procedures to prevent, contain, and respond to spills that may discharge into the municipal separate storm sewer
   - Program to promote, publicize, and facilitate public reporting of the presence of illicit discharges or water quality impacts associated with discharges from MS4s
   - Educational activities, public information activities, and other appropriate activities to facilitate the proper management and disposal of used oil and toxic materials
   - Controls to limit infiltration of seepage from municipal sanitary sewers to MS4s.

3. Describe programs to monitor and control pollutants in storm water discharges to municipal systems from municipal landfills; hazardous waste treatment, disposal, and recovery facilities; industrial facilities that are subject to section 313 of SARA Title III; and industrial facilities that the municipal permit applicant determines are contributing a substantial loading to the MS4s. The program should include:

   - Priorities and procedures for inspections and establishing and implementing control measures for such discharges
   - Monitoring program for storm water discharges associated with industrial facilities identified in 3., to be implemented during the term of the permit, including the submission of quantitative data.

4. Describe programs to implement and maintain structural and non-structural best management practices to reduce pollutants in storm water runoff from construction sites to the municipal separate storm sewer system. This program should include:

   - Procedures for site planning that incorporate consideration of potential water quality impacts
   - Requirements for non-structural and structural best management practices

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- Procedures for identifying priorities for inspecting sites and enforcing control measures that consider the nature of the construction activity, the topography, and the characteristics of soils and receiving water quality

- Appropriate educational and training measures for construction site operators.

Phase II Completed as Part of the Permit Application or Notice of Intent

The Phase II regulations require regulated small MS4s to develop SWMPs similar, but not identical, to those developed by medium/large MS4s. Consistent with the requirements for medium/large MS4 requirements, small MS4 permits require at a minimum that the permittee develop, implement, and enforce a SWMP designed to reduce the discharge of pollutants from the MS4 to the maximum extent practicable (MEP), to protect water quality, and to satisfy the appropriate water quality requirements of the Clean Water Act. Slightly different from the Phase I requirements, the Phase II requirements for SWMPs include the six minimum control measures described below:

(1) Public education and outreach on storm water impacts that distribute educational materials to the community or conduct equivalent outreach activities about the impacts of storm water discharges on water bodies and the steps that the public can take to reduce pollutants in storm water runoff.

(2) Public involvement/participation on storm water controls, at a minimum, complying with State, Tribal and local public notice requirements.

(3) Illicit discharge detection and elimination program that includes:
- a storm sewer system map, showing the location of all outfalls and the names and location of all waters of the United States that receive discharges from those outfalls;
- an ordinance or other regulatory mechanism, that effectively prohibits non-storm water discharges into the storm sewer system
- appropriate enforcement procedures and actions;
- a plan to detect and address non-storm water discharges, including illegal dumping, to the system; and
- outreach that informs public employees, businesses, and the general public of hazards associated with illegal discharges and improper disposal of waste.

(4) Construction site storm water runoff control program to reduce pollutants in any storm water runoff to your small MS4 from construction activities that result in a land disturbance of greater than or equal to one acre. The program must include the development and implementation of, at a minimum:
- an ordinance or other regulatory mechanism to require erosion and sediment controls, as well as sanctions to ensure compliance;
- requirements for construction site operators to implement appropriate erosion and sediment control best management practices;
- requirements for construction site operators to control waste such as discarded building materials, concrete truck washout, chemicals, litter, and sanitary waste at the construction site that may cause adverse impacts to water quality;
- procedures for site plan review which incorporate consideration of potential water quality impacts;
- procedures for receipt and consideration of information submitted by the public, and
- procedures for site inspection and enforcement of control measures.

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(5) Post-construction storm water management program in new development and redevelopment for projects that disturb greater than or equal to one acre, including projects less than one acre that are part of a larger common plan of development or sale, that discharge into the MS4. The controls must include strategies which include a combination of structural and/or non-structural best management practices (BMPs) appropriate for the community; use an ordinance or other regulatory mechanism to address post-construction runoff from new development and redevelopment projects to the extent allowable under State, Tribal or local law; and ensure adequate long-term operation and maintenance of BMPs.

(6) Pollution prevention/good housekeeping for municipal operations that includes a training component and has the ultimate goal of preventing or reducing pollutant runoff from municipal operations. Your program must include employee training to prevent and reduce storm water pollution from activities such as park and open space maintenance, fleet and building maintenance, new construction and land disturbances, and storm water system maintenance.

As part of the small MS4 NOI submission to the permitting authority, the MS4 is required to submit the BMPs that will be implemented for each of the six minimum control measures listed above. In addition, the NOI must identify the measurable goals for each of the BMPs, including, as appropriate, the months and years in which the MS4 will take the required actions, including interim milestones and the frequency of the action. The NOI must also identify the person or persons responsible for implementing or coordinating the SWMP.

SWMP Implementation/In the Field

The inspector should verify that the storm water management program is being implemented as appropriate to meet the current circumstances in the municipality. Implementation of management programs requires facilities to implement a variety of control measures, programs, procedures, and training of various individuals on how to carry out the goals of the program. The inspector should evaluate any implementation schedules developed by the municipality for carrying out the program and determine whether appropriate individuals have been assigned to implement the specific aspects of the program and if these individuals are aware of the requirements of that designation. The inspector should evaluate the municipality's inspection and enforcement program for industrial facilities and construction sites. In addition, the inspector should verify whether the municipality's dry weather screening program is being implemented according to the permit schedule. If the program calls for the installation or maintenance of structural controls, the inspector should verify that the controls are in place and in good working order or that the facility is on an appropriate schedule for construction of the structural control measures.

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12. COMBINED SEWER OVERFLOWS

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Related Websites

Office of Wastewater Management (OWM) Homepage: http://www.epa.gov/owm

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12. A. Background and History of the CSO Policy

In addition to materials in this chapter, inspectors must be familiar with Chapter 1 - "Introduction" & Chapter 2 - "Inspection Procedures".

As defined in the CSO Control Policy, a combined sewer system (CSS) is "a wastewater collection system owned by a state or municipality [as defined by Section 502(4) of the Clean Water Act] which conveys sanitary wastewater (domestic, commercial and industrial wastewaters) and storm water through a single-pipe system." During precipitation events (e.g., rainfall or snowmelt), the volume of sanitary wastewater and storm water runoff entering CSSs often exceeds the capacity of the system to transport the combined wastewaters to the publicly-owned treatment works (POTWs). When this happens, these systems are designed to overflow directly to surface waters. These overflows are combined sewer overflows (CSOs). Some CSOs occur infrequently; others, with every precipitation event. Because CSOs contain raw sewage and contribute pathogens, solids, debris, and toxic pollutants to receiving waters, CSOs can create serious public health and water quality concerns. CSOs have caused or contributed to beach closures, shellfish bed closures, contamination of drinking water supplies, and other environmental and public health problems.

Approximately 772 communities in the U.S. have CSSs that have 9,471 permitted CSO outfalls that are regulated by 859 NPDES permits. CSOs are point sources subject to NPDES permit requirements including the technology-based and water quality-based requirements of the Clean Water Act (CWA). CSOs are not subject to the secondary treatment requirements that are applicable to POTWs., but are subject to BAT/BCT requirements based upon a BPJ case by case determination.

EPA's 1994 CSO Control Policy (59 *FR* 18688, April 19, 1994) "represents a comprehensive national strategy to ensure that municipalities, permitting authorities, water quality standards authorities and the public engage in a comprehensive and coordinated effort to achieve cost effective CSO controls that ultimately meet appropriate health and environmental objectives." Under the Policy, CSO communities were expected, through requirements in their NPDES permit or in another enforceable mechanism, to:

- Implement nine minimum controls (NMC) that may be considered minimum BAT/BCT, based on the permitting authority. These NMC are measures that can reduce CSOs and their water quality impacts without significant engineering studies or major construction. CSO communities were expected to implement the NMC by January 1, 1997

- Develop a long-term CSO control plan (LTCP) generally within 2 years of NPDES permit issuance or the issuance date of another enforceable mechanism requiring the CSO community to develop a LTCP

- Implement the LTCP. Implementation of the individual CSO controls may be phased based on the relative importance of adverse impacts of the CSOs on water quality standards, priority projects identified in the LTCP, and on the permittee's financial capability

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- Implement a post-construction compliance monitoring program.

Permitting and enforcement authorities are expected to take enforcement action against dry weather CSO discharges.
As outlined in the CSO Policy, the nine minimum CSO controls are listed in Table 12-1 and the elements of the LTCP are listed in Table 12-2. The major approach to CSO control, outlined in EPA's CSO Control Policy, is to:

- Eliminate CSOs to sensitive areas wherever possible (where not possible, provide treatment).
- Coordinate the review and revision of water quality standards with development of long-term CSO control plans.
- Evaluate a reasonable range of alternatives that could achieve the necessary level of control/treatment, and select the controls to be implemented based on cost/ performance evaluations.
- Develop an implementation schedule based on the relative impacts on WQS and designated uses, on the priority of projects identified in the LTCP, and on the permittee's financial capability.
- Maximize treatment of wet weather flows at the POTW.

Since the CSO Control Policy was published, EPA has released guidance documents on the following six implementation areas: long-term control plans, the nine minimum controls, screening and ranking, funding options, permit writing, and financial capability and schedule development (see the References section and/or the CSO Website (http://www.epa.gov/npdes/cso) for more information).

In the Consolidated Appropriations Act for Fiscal Year 2001, P.L. 106-554, Congress amended the Clean Water Act by adding Section 402(q) to require, among other things, that all permits, orders, and decrees issued to control CSOs, after enactment of the Consolidated Appropriations Act, shall conform to EPA's 1994 CSO Control Policy. EPA and State NPDES permitting authorities should refer to Section IV, Expectations for Permitting Authorities, of the Policy. This section of the policy presents the major elements that should be in NPDES permits to implement the Policy and ensure protection of water quality.

State and EPA NPDES permitting authorities continue to work with permittees to incorporate CSO conditions into NPDES permits and through other enforceable mechanisms, such as administrative or judicial orders.

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Table 12-1

Nine Minimum CSO Controls

• Proper operation and regular maintenance programs for the sewer system and the CSOs
• Maximum use of the collection system for storage
• Review and modification of pretreatment requirements to ensure that CSO impacts are minimized
• Maximization of flow to the POTW for treatment
• Prohibition of CSOs during dry weather
• Control of solid and floatable materials in CSOs
• Establishment of pollution prevention programs
• Public notification to ensure that the public receives adequate notification of CSO occurrences and CSO impacts
• Monitoring to effectively characterize CSO impacts and the efficacy of CSO controls

Table 12-2

Elements of the Long-Term CSO Control Plan

• Characterization, monitoring, and modeling of the combined sewer system
• Public participation
• Consideration of sensitive areas
• Evaluation of alternatives
• Cost/performance considerations
• Operational plan
• Maximizing treatment at the existing POTW treatment plant
• Implementation schedule
• Post-construction compliance monitoring program

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12. B. CSO Inspection Procedures

Each municipality's specific CSO requirements will be contained in a NPDES permit, an enforcement order or a consent decree. CSO conditions will be specific to that permittee. However, the inspection of one CSS may involve visits to more than one municipality, depending on the configuration and possible shared responsibility for the system. Before conducting the inspection, the inspector should determine the authorities responsible for operation of the system and define the scope of the inspection. The inspector will obtain information to determine compliance in the following areas:

- CSO prevention during dry weather
- Implementation of the nine minimum CSO controls
- Adherence to a schedule for development, submission, and implementation of a Long-Term CSO Control Plan, including any interim deliverables
- Adherence to schedule for implementation of the CSO controls selected from the LTCP
- Elimination or relocation of overflows from identified sensitive areas, as defined in the approved LTCP
- Narrative, performance-based or numerical, water quality-based effluent limitations
- Monitoring program, including baseline information on frequency, duration, and impacts of CSOs

Preparation

As stated above, the requirements for CSO control will most likely be found in the NPDES permit, or in some cases, in an enforcement order, such as an Administrative Order or Judicial Order, or a Consent Decree. Inspectors should review the permit (and permit amendments) and other enforceable mechanisms (e.g., consent orders) issued to the permittee. The inspector should be aware that in some cases the CSSs and CSO structures (i.e., pump stations) may be permitted separately from the POTW. The inspector may find:

- Requirements to implement and document implementation of technology-based controls (i.e., nine minimum controls) by the date specified in the permit or enforceable mechanism.
- Requirement to submit a report documenting the implementation of the nine minimum controls; the report will usually be required within 2 years of permit issuance.
- Requirements for the development, submission, and implementation of the Long-Term CSO Control Plan. Where the permittee is in the phase of developing a LTCP, there will usually be a schedule for the development and submission of the plan, either in the permit or other appropriate enforceable mechanism. Where the permittee has completed a LTCP, there will be narrative requirements pertaining to the

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implementation, operation, and maintenance of the selected CSO controls described in the LTCP. There will also be an implementation schedule for CSO controls either in the permit or in an appropriate enforceable mechanism.

- Water quality-based effluent limits for CSOs. Numeric limits may not be found in the initial permits when the permittee is developing or implementing its LTCP. Instead, there will be a requirement to immediately comply with applicable WQSs expressed in the form of a narrative limitation. Permittees that have completed and are implementing their LTCPs may have one of the following permit conditions for CSOs:

  - A maximum number of overflow events per year for specified design conditions

  - Minimum percentage capture of combined sewage by volume for treatment under specified design conditions

  - Minimum percentage reduction of the mass of pollutants discharged for specified design conditions

  - Other performance-based standards and requirements.

- Requirements to implement a post-construction compliance monitoring program. This will be required for permittees that have completed and are implementing their LTCPs.

- Requirement to re-assess overflows to sensitive areas. This will only be imposed in those cases where elimination or relocation of CSOs from sensitive areas were proven not to be physically possible or economically achievable.

- Conditions establishing requirements for maximizing the treatment of wet weather flows at the treatment plant.

Other documents that the inspector should review are any CSO reports submitted by the permittee. The permittee may have submitted information in response to a CWA Section 308 information collection request on CSOs. The permittee may have submitted CSO monitoring plans or a report characterizing its CSOs, a report documenting implementation of the nine minimum CSO controls, or a Long-Term CSO Control Plan. Other documents and/or information that should be reviewed, if available, include:

- citizen complaints
- correspondence
- Notices of Violation
- annual capacity reports
- facility reports describing CSO discharge points and overflow problems
- inspection reports
- noncompliance notification reports describing overflows (usually attached to DMRs)
- proximity of overflows to drinking water sources
- potential for impact to human health or the environment.
- list of significant industrial users and a map showing their connection to CSS and location of nearby CSOs.

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Reviewing these permittee reports will help the inspector become knowledgeable about the permittee's specific CSO problems and existing CSO controls. The inspector should make copies of those documents that (1) establish enforceable CSO requirements, (2) provide evidence that an enforceable requirement has been violated or (3) provide evidence of environmental problems related to CSOs. The inspector should make sure that EPA has a complete copy of noncompliance notification reports for the last five years, indicating the date, time, duration, flow rate, cause, and actions to correct, prevent, and mitigate each overflow from the facility. The inspector should also have a map or other document that provides the location of each CSO discharge point and identifies the receiving stream to which the overflow discharges.

Onsite Records Review

The inspector should review the following CSO records:

- Log books, reports, or internal memos describing maintenance and operation activities concerning the sewer system and CSO outfalls
- CSO outfall flow records
- Monitoring data on CSOs, collection system, or receiving stream
- Records pertaining to installation of CSO controls
- Feasibility studies
- Capital project summaries (description and cost of each project).

Record keeping requirements vary by facility depending on the specific CSO controls the facility has selected and is implementing. If the permittee has submitted a report documenting implementation of the nine minimum CSO controls, the inspector should review appropriate records kept at the facility to verify the information in this report. Examples of possible records that might be kept to document the implementation of the nine minimum CSO controls are listed in Table 12-3. These examples are provided as illustrations and not requirements. The inspector should use the facility's permit or other enforceable document as a guide to determine what specific records the facility is required to keep and maintain. The facility's CSO Operations and Maintenance manual and CSO control plan can provide the inspector with insight into the specific types of records the facility would have.

Interviews

As with all of the NPDES compliance inspections, interviews with appropriate personnel with firsthand knowledge of CSO activities can be useful in obtaining factual information. The inspector should interview the person in the highest position of authority responsible for the day-to-day development or implementation of the LTCP. Other personnel, such as the collection crew or others involved in inspecting, operating, and maintaining CSOs or CSO

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controls should also be interviewed. It is particularly important that the inspector obtain written statements (see Chapter Two) where personnel are providing information that is not or cannot be substantiated by the facility's records or the inspector's own observations.

If the facility is developing or implementing a LTCP, the inspector may want to interview those personnel responsible for that plan. Generally, the facility will be under a schedule with distinct activities and milestones established. This schedule may be in the permit, but will more likely be in an enforcement order. Any schedules submitted by the permittee in a report or in its LTCP should not be referred to, as these are not enforceable schedules. The inspector should focus on verifying those LTCP development or implementation activities that (1) the permittee has reported have been developed/implemented and (2) the permittee was required to have developed/implemented according to a schedule in the permit or enforcement order.

The following are examples of relevant questions that the inspector can use to obtain a general understanding of the facility. Other questions relevant to the specific nine minimum controls are listed in Table 12-4. The inspector should add to these questions based on the specific requirements in the facility's permit. For example, if the permit requires submission of a "CSO Characterization Report" within 180 days of the permit issuance, the inspector should request the report and verify whether or not the report was submitted within the established time frame.

- What type of technology is used to control CSO discharges? Describe regulator mechanisms used, including size, type, presence or absence of backflow devices, and location.
- How are overflows monitored and reported? What instrumantation is used? Is there any "real time" data collected? How quickly can an operator adjust flow? Remotely?
- Describe the system, identifying the older and new facilities that are used.
- What communities are served by the treatment plant?
- Is the collection system gravity fed or are pumps used? If pumping stations are used, how many are there and where are they located?
- What flows does the municipality receive from other municipalities? Are these upstream systems combined sewer systems or separate sanitary systems? What kinds of overflow problems have the upstream municipalities reported? What agreements are in place establishing which municipality has authority and duty to maintain various parts of the sewer system?
- How many overflows have occurred in the collection system, induding contributing jurisdictions, within the last five years?
- What is the most common cause of overflows?
- Where are the potential CSO point discharges located? Are any located at pump stations? What receiving stream does each CSO discharge to?
- What is a typical monthly rate of CSO incidents?
- What samples have been taken of overflows? (Ask to see sample results.)
- What steps is the municipality taking to comply with the CSO requirements in its permit? If the municipality is planning to meet a different schedule than that required in the permit, what is its time line?

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Facility Site Inspection

An inspection of the CSO outfalls should be included in a NPDES compliance inspection in order to get a complete picture of how the overall publicly-owned treatment works (wastewater treatment plant and collection system) is performing. This is especially true if the inspection's focus or one of its objectives to investigate compliance with CSO requirements. In such cases, an inspection of CSO structures, CSO treatment systems, or key areas of the collection system is necessary. If the intent of the inspection is to observe CSO treatment, it may be necessary to schedule this inspection during or immediately after a wet weather event. These outfalls would be located throughout the collection system and, therefore, may be several miles from the facility.

It is not necessary to inspect all of the CSO outfalls. The inspector can select a few either randomly or on the basis of location (closest to the plant) or other selection criteria. For example, the inspector may want to inspect those outfalls that treat solids and floatables to evaluate the operation and maintenance of the controls. The inspector might also select the largest (in discharge volume) outfalls, those that most frequently discharge (during wet weather), or those that are known to have an impact on water quality. Conversely, the inspector may want to select those outfalls that are subject to few inspections by the permittee.

If the inspector observes any dry weather CSO discharges, a photographic record should be made (see Chapter Two), and in depth interviews should be conducted and statements obtained from facility personnel.

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Table 12-3

CSO Records

Nine Minimum CSO Controls	Examples of Records/Documentation
Proper operation and regular maintenance program	• Standard Operating Procedures, Operations and Maintenance Manual, or similar manual or plan • Log of sewer system cleaning, flushing, or debris removal • Log of repair or maintenance of regulators • Log of lift station malfunctions and repairs made • Log of preventive maintenance of interceptor lift stations and pumps • Work orders for corrective activities • Log of inspections of lift stations, sewer lines, and regulators
Maximum use of collection system for storage	• Hydraulic study of system and evaluation of alternatives to maximize wet weather flow storage capacity • Records of installation of in-line devices such as dams, regulators, and gates to retard flow • Installation of separate sanitary and storm water lines • Replacement of undersized pipes • Adjustment of regulator settings or upgrading/adjusting pumping rates at lift stations • Off-line temporary storage
Review and modification of the pretreatment program	• Inventory of nondomestic discharges • Assessment of significance of nondomestic discharges on CSO and receiving waters • Pretreatment controls to reduce/eliminate industrial contaminants during wet weather

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Table 12-3

CSO Records (Continued)

Nine Minimum CSO Controls	Examples of Records/Documentation
Maximization of flows to the POTW for treatment	• Summary of analyses conducted • Maximum wet weather flow Wastewater Treatment Plant (WWTP) can receive without pass-through or interference • Description of modifications to be implemented
Prohibition of dry weather overflows (DWOs)	• Log of inspections of CSOs during dry weather and observations made during these inspections • Log of Dry Weather Overflow (DWO) reports submitted
Control of solids and floatable materials in CSOs	• Installation of screens or booms • Source control activities such as regular street cleaning, highly visible anti-litter programs
Pollution prevention	• Street sweeping, anti-litter campaigns
Public notification	• CSO outfalls are posted with signage • Date and proof of public notice, procedure (by newspaper, radio), public notice information
Monitoring of CSOs	• Identification of outfall locations (i.e., latitude and longitude or street address) • Number and location of overflow events including duration, volume, and pollutant loadings • Receiving stream data and impact (e.g., beach closings, fish kills) • Monitoring plan

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Table 12-4

CSO Interview Questions

Nine Minimum CSO Controls	Examples of Interview Questions
Proper operations and regular maintenance program	• How often are CSO discharge locations inspected? Who conducts the inspections? What records do they keep? How is corrective action assured when a problem is discovered? How are the operability and reliability of regulators verified? • Do the pump stations have backup power? Is there any telemetric alarm warning system? Is any other type of redundancy built into the collection system to minimize the occurrence of overflows? • What is the municipality's budget for collection system operation? For collection system maintenance? How much was spent last year on collection system operation and maintenance? • How many people are dedicated to maintaining the collection system? • What improvements are planned? Are these projects funded? What is the process for funding capital improvements? • How are personnel trained? • How often is the Operations & Maintenance plan reviewed? When was the last revision?
Maximum use of collection system for storage	• What steps are taken to maximize use of the collection system for storage? (e.g., install dams, weirs, and regulators)
Review and modification of the pretreatment program	• When were the pretreatment requirements last reviewed to ensure minimization of CSO impacts from upstream Industrial Users? What changes have been made to the program to accomplish this goal? What percentage of total flow comes from nondomestic sources? How is the impact of untreated industrial pollutants from CSOs addressed in the pretreatment program?
Maximization of flows to the POTW for treatment	• What steps are taken to maximize flow to the POTW? • What are the bottlenecks in the sewer system? What facilities in the system are critical to the performance of the CSS? • What are the capabilities of major interceptors and pumping stations delivering flows to the treatment POTW? • How do wet weather flows to the POTW compare with dry weather flows? • How does the current total flow compare to the design capacity? • What, if any, unused treatment facilities are used to store wet weather flows?

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Table 12-4

CSO Interview Questions (Continued)

Nine Minimum CSO Controls	Examples of Interview Questions
Prohibition of dry weather overflows (DWOs)	• What has the municipality done to eliminate dry weather overflows? • How does the municipality identify dry weather overflows? If inspections are used, how often are the inspections performed? • Describe the most recent cleaning, sewer repair, or regulator repair performed to alleviate a dry weather overflow. • How does the municipality determine which dry weather overflows could endanger health or the environment?
Control of solids and floatable materials in CSOs	• How does the municipality keep solids and floatables out of the CSO discharge? • If solids and floatables do reach the receiving waters, how does the municipality remove them?
Pollution prevention	• What pollution prevention measures (e.g., street cleaning, public education, waste collection or recycling) does the municipality take to keep contaminants from entering the sewer system?
Public notification	• How has the public been notified of the location of CSO discharge points? How does the municipality notify the public of overflow incidents? When was the last notification? • What is the internal mechanism for reporting sewage overflows? How does this information reach the permitting authority?
Monitoring of CSOs	• How does the municipality monitor CSOs? How does the municipality use this monitoring to characterize the impacts of CSOs? How does the municipality use this monitoring to evaluate the effectiveness of CSO controls? Does the municipality monitor CSO flow rates? • What information from other groups (e.g., Coast Guard or local volunteer groups) does the municipality collect on water quality or use of waters affected by CSOs (e.g., beach closings, fish kills, etc.)? • Which CSO receiving waters are the most sensitive? Why? (e.g., drinking water)

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12. C. References and Checklist

References

Federal Register. September 8, 1989. National CSO Control Strategy: Notice. Volume 54, No. 37370.

U.S. Environmental Protection Agency. 1993. *Manual: Combined Sewer Overflow Control.* Washington, D.C. EPA 625/R-93-007

Federal Register. April 19, 1994. *Combined Sewer Overflow Control Policy; Notice. Volume 59, No. 75.*

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U.S. Environmental Protection Agency. September 1995. *Combined Sewer Overflows Guidance for Permit Writers.* EPA 832-B-95-008

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U.S. Environmental Protection Agency. March 1996. *The Enforcement Management System National Pollutant Discharge Elimination System (Clean Water Act) Chapter X: Setting Priorities for Addressing Discharges from Separate Sanitary Sewers.*

U.S. Environmental Protection Agency. Summer 1996. *Sanitary Sewer What are they and how can we reduce them?* EPA 832-K-96-001.

U.S. Environmental Protection Agency. 1997. *Combined Sewer Overflows Guidance on Financial Capability and Schedule Development.* EPA 832-B-97-004

U.S. Environmental Protection Agency. January 1999. *Combined Sewer Overflows Guidance For Monitoring And Modeling.* EPA 832-B-99-002

U.S. Environmental Protection Agency. April 2000. *Compliance and Enforcement Strategy for CSOs and SSOs.*

U.S. Environmental Protection Agency. June 2000. *Benefits of Protecting Your Community From Sanitary Sewer Overflows.* EPA 832-F-00-005.

U.S. Environmental Protection Agency. June 2001. *Evaluating POTW Capacity, Management, Operation, and Maintenance Programs.*

U.S. Environmental Protection Agency. July 31, 2001. *Guidance: Coordinating CSO Long-term Planning with Water Quality Standards Reviews.* EPA-833-R-01-002.

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CSO EVALUATION CHECKLIST

A. IDENTIFICATION OF CSOs

Yes No N/A	1. Are all CSO points identified?
Yes No N/A	2. Does facility have maps/schematics of Combined Sewer System (CSS) depicting location of all CSO discharge points?
Yes No N/A	3. Is each CSO discharge point located by longitude, latitude, and street address on appropriate maps?

B. DRY WEATHER OVERFLOWS

Yes No N/A	1. Are the locations of all dry weather CSOs known by permittee?
Yes No N/A	2. Does permittee have records of quantitative loads and flows on all dry weather CSO events?
Yes No N/A	3. Has notification been given to EPA/State of all dry weather CSO discharges?
Yes No N/A	4. Are there any unreported dry weather CSOs?

C. RECORDS

	1. Are the following records kept for CSO events?
Yes No N/A	• Location
Yes No N/A	• Frequency of discharge
Yes No N/A	• Flow magnitude
Yes No N/A	• Discharge pattern
Yes No N/A	• Total volume of discharge
Yes No N/A	• Duration of the event
Yes No N/A	• Pollutant characterization
Yes No N/A	• Correlation with rainfall records
Yes No N/A	• Specific causes of overflows
Yes No N/A	• Flow collected/flow diverted?
Yes No N/A	2. Are records of CSO flows maintained?
Yes No N/A	3. Are records accurate?

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CSO EVALUATION CHECKLIST

D. OPERATION AND MAINTENANCE

Yes No N/A	1.	Is there a CSS O&M manual and does it address O&M of CSO structures?
Yes No N/A	2.	Does the facility conduct inspections of the CSS and CSO structures?
Yes No N/A	3.	Are these inspections documented? Does documentation include results of various types of inspections, dates and times, corrective action taken if problems were found?
Yes No N/A	4.	Is a log book of maintenance and repair on the CSS and CSO structures maintained? Does this note the type of problem (or indicate routine maintenance), repair made, or maintenance activity conducted, date?

E. COMPLIANCE SCHEDULES

	1.	Is permittee meeting CSO compliance schedule for:
Yes No N/A		• Implementing nine minimum CSO controls?
Yes No N/A		• Developing LTCP?
Yes No N/A		• Implementing LTCP?
Yes No N/A	2.	Has permittee requested an extension of time?

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13. SANITARY SEWER OVERFLOWS

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Related Websites

Office of Wastewater Management (OWM) Homepage: http://www.epa.gov/owm

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13. A. Overview of SSOs

In addition to materials in this chapter, inspectors must be familiar with Chapter 1 - "Introduction" & Chapter 2 - "Inspection Procedures".

Sanitary sewer collection systems are designed to remove wastewater from homes and other buildings and convey it to a proper treatment facility and disposal location. The collection system is critical to successful performance of the wastewater treatment process. EPA estimates that collection systems in the U.S. have a replacement value of $1 to $2 trillion. Under certain conditions, poorly designed, built, managed, operated, and/or maintained systems can pose risks to public health and the environment. These risks arise from sanitary sewer overflows (SSOs) from the collection system. SSOs are discharges of wastewater (including that combined with rainfall induced infiltration/inflow) from a separate sanitary sewer prior to treatment at the wastewater treatment plant. SSOs typically release untreated sewage into basements or out of manholes and onto city streets, playgrounds, and into streams.

Effective and continuous management, operation, and maintenance, as well as ensuring adequate capacity and performing rehabilitation, when necessary, are critical to maintaining collection system capacity and performance while extending the life of the system. Many sanitary sewer collection systems, however, have received minimal maintenance over the years resulting in deteriorated sewers with subsequent overflows, cave-ins, hydraulic overloads at treatment plants, and other safety, health, and environmental problems. As one of the most serious and environmentally threatening problems, sanitary sewer overflows are a frequent cause of water quality violations and are a threat to public health and the environment. Beach closings, flooded basements, closed shellfish beds and hydraulically overloaded wastewater treatment plants are some symptoms of collection systems with inadequate capacity and improper management, operations, and maintenance.

Even though separate sanitary sewer systems are designed to collect and transport all the sewage that flows into them, SSOs can still occur. Frequent SSOs typically indicate that something is wrong with the system. Problems contributing to SSOs include:

- **Deteriorating Sewer System:** Many sewer authorities neglect to plan and fund long-term sewer rehabilitation and replacement projects.
- **Infiltration and Inflow (I&I):** This involves too much rainfall or snowmelt infiltrating through the ground into leaky sanitary sewers, excess water inflowing through roof drains connected to sewers, broken pipes, or badly connected sewer service lines. Unlike combined sewers, sanitary sewers are not intended to collect or convey rainfall or to drain property.
- **Undersized Systems:** Sewers and pumps are too small to carry sewage from newly-developed subdivisions or commercial areas.
- **Pipe Failures:** Pipe failures result from blocked, broken or cracked pipes. Sections of pipe settle or shift so that pipe joints no longer match, sediment and other material build up causing pipes to break or collapse.
- **Pump Station Failures:** This results from pump failures, power failures, and inadequate wet well capacity.

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- **Sewer Service Connections:** Discharges occur at sewer service connections to houses and other buildings.
- **Pipe Blockages:** Grease and tree roots are the primary causes of sewer blockages.
- **Vandalism and construction-related spills.**

From a compliance standpoint, Chapter X of the Enforcement Management System *Setting Priorities for Addressing Discharges from Separate Sanitary Sewers,* establishes a series of guiding principles and priorities for use by EPA Regions and National Pollutant Discharge Elimination System (NPDES) States in responding to separate sanitary sewer discharge violations. Chapter X states:

> "For a person to be in violation of the Clean Water Act: 1) a person must own, operate, or have substantial control over the conveyance from which the discharge of pollutants occurs, 2) the discharge must be prohibited by a permit, be a violation of the permit language, or not be authorized by a permit, and 3) the discharge must reach waters of the United States. In addition, discharges that do not reach waters of the United States may nevertheless be in violation of Clean Water Act permit requirements, such as those requiring proper operation and maintenance (O&M), or may be in violation of State law."

The exact use of language in a NPDES permit disallowing SSOs may vary from one facility to another (often depending on how a State NPDES permit authority contends with SSOs). Some permits explicitly prohibit overflows from the system and in other cases, where the permit may be silent, SSOs are treated as unauthorized discharges.

Systems have been found to be out of compliance because of overflows (even those that do not reach waters of the United States) that are the result of improper operation and maintenance. 40 *CFR* 122.41(e) requires, as a standard NPDES permit condition, that permitted wastewater owners or operators must "properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the conditions of this permit."

Another standard permit condition regarding the duty to mitigate states that "the permittee shall take all reasonable steps to minimize or prevent any discharge... in violation of [the] permit which has a reasonable likelihood of adversely affecting human health or the environment." (40 *CFR* 122.41 (d)). This may be interpreted to include sanitary sewer overflow discharges.

Most permittees are required to report any noncompliance, including overflows that result in a discharge or that are caused by improper operation and maintenance. Most permits also require that any noncompliance, including overflows which may endanger the health or the environment be reported within 24 hours, and in writing within five days.

Since there are minor variations among permits regarding how to deal with overflows (except for the standard permit conditions which appear in all permits), the NPDES inspector should rely on the guidance in Chapter X of the EMS (part of which has been summarized above) and the Publicly Owned Treatment Work (POTW) NPDES permit for standards for evaluating compliance.

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EPA has worked with State NPDES authorities to the extent possible to standardize language in permits regarding SSOs. However, a more uniform approach is being developed through a national rulemaking effort.

EPA has carefully considered the recommendations of the SSO Federal Advisory Subcommittee for regulatory and nonregulatory actions to reduce SSOs nationally and has developed draft proposed regulations regarding SSOs. The SSO Federal Advisory Subcommittee was organized to examine the need for national consistency in permitting and enforcement, effective sewer operation and maintenance principles, public notification for SSOs with potential health or environmental dangers, and other public policy issues. The draft regulations include provisions for the periodic self-auditing of capacity, management, operation, and maintenance (CMOM) programs; SSO prohibition language; recordkeeping, reporting and public notification requirements; criteria for remote treatment facilities; the inclusion of satellite collection systems in the scope of NPDES permitting; and watershed management principals.

At the end of March 2000, the SSO proposed rule package (also known as the CMOM proposed rule) was sent to the U.S. Office of Management and Budget for approval/comments. The Administrator signed the Notice of Proposed Rulemaking on January 4, 2001. In accordance with the memorandum of January 20, 2001, from the Administrator to President Clinton and Chief of Staff, entitled "Regulatory Review Plan," published in the Federal Register on January 24, 2001, 66 FR 7701, EPA has withdrawn this document from the Office of the Federal Register to give the Administrator an opportunity to review it. When the regulation is final, a regulatory scheme for the handling of SSOs will be phased in (over the following NPDES permit cycle) with some requirements taking effect upon publication in the Federal Register.

In the SSO proposed rule, EPA is proposing to clarify and expand NPDES permit requirements for municipal sanitary sewer collection systems and SSOs. The proposal includes standard permit conditions addressing capacity, management, operation and maintenance (CMOM) requirements; a prohibition on discharges (with a framework for a defense for unavoidable discharges); and requirements for reporting, public notification, and recordkeeping for municipal sanitary sewer collection systems and SSOs.

The Agency also is proposing a regulatory framework for applying NPDES permit conditions, including applicable standard permit conditions, to municipal satellite collection systems. Municipal satellite collection systems are sanitary sewers owned or operated by a municipality that convey sewage or industrial wastewater to a POTW that has a treatment plant owned or operated by a different municipality. These types of facilities do not typically have their own NPDES permit. Implementation of this proposal would improve the capacity, management, operation and maintenance of municipal sanitary sewer collection systems and improve public notice for SSO events, which would:

- Reduce health and environmental risks by reducing SSO occurrences and improving treatment facility performance

- Protect the nation's collection system infrastructure by enhancing and maintaining system capacity, reducing equipment and operational failures and extending the life of its components.

Among the significant issues that the proposed rule addresses is establishing a definition of Sanitary Sewer Overflow. The rule proposes that a sanitary sewer overflow is an overflow, spill,

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release, or diversion of wastewater from a sanitary sewer system. SSOs do not include combined sewer overflows (CSOs) or other discharges from the combined portions of a combined sewer system. SSOs include:

- Overflows or releases of wastewater that reach waters of the United States

- Overflows or releases of wastewater that do not reach waters of the United States
- Wastewater backups into buildings that are caused by blockages or flow conditions in a sanitary sewer other than a building lateral. Wastewater backups into buildings caused by a blockage or other malfunction of a building lateral that is privately owned is not an SSO.

In addition, national standards for reporting SSO events will be clarified by the proposed rule. These include immediate notifications and followup reports within five days for SSOs (including overflows that do not reach waters of the United States) that may imminently and substantially endanger human health; and for SSOs that enter waters of the US, reporting on Discharge Monitoring Reports (DMRs). The permittee must also prepare an annual report of all overflows in the sewer system, including overflows that do not discharge to waters of the United States. The annual report must include the date, the location of the overflow, any potentially affected receiving water, and the estimated volume of the overflow.

By defining what is a Sanitary Sewer Overflow and standardizing reporting requirements, EPA hopes to clarify national standards thereby enhancing inspector's ability to evaluate a permittee's program.

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13. B. SSO Inspection Procedures

During an inspection of a sanitary sewer system, the inspector will obtain information indicating whether the sewer authority is properly managing, operating, and maintaining its collection system and taking all feasible steps to stop sanitary sewer overflows. The inspection of one sanitary sewer system my involve visits to more than one municipality, depending upon the configuration and possible shared responsibility for the system. Before conducting the inspection, the inspector should identify the authorities responsible for operation of the system and define the scope of the inspection.

Preparation

In evaluating either a system with a past history of SSOs or a system in which overflows may not necessarily be documented, the compliance inspector will rely primarily on the permit as a starting point. The inspector should refer to standard permit language contained in the NPDES permit. The inspector should also review the permit for any overflow-related requirements specific to the system.

An enforcement order, consent decree, or other enforceable document might also indicate prohibition, notification, or special circumstance language. Often, the establishment of a sanitary sewer discharge control program is the result of an enforcement action against a system. The inspector should refer to the enforcement document (e.g., consent decree, order, or other settlement) for a compliance schedule for sanitary sewer discharge control programs.

The compliance inspector will be faced with obtaining information to determine compliance in the following areas:

NPDES Standard Conditions

- Proper operation and maintenance. Regulatory language at 40 *CFR* 122.41(e) states that: "The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the conditions of this permit." Poor operation and maintenance practices frequently lead to unpermitted discharges.

- Duty to mitigate. "The permittee shall take all reasonable steps to minimize or prevent any discharge... in violation of [the] permit which has a reasonable likelihood of adversely affecting human health or the environment." (40 *CFR* 122.41 (d)) These steps would include activities critical to the operation and maintenance of the system.

Notification Procedures

- In general, permits require that any noncompliance, including overflows that result in a discharge or that are caused by improper operation and maintenance, be reported at the end of each month with the DMR. At a minimum, permits typically require that overflow summaries include the date, time, duration, location, estimated volume, cause, as well as

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any observed environmental impacts, and what actions were taken or are being taken to address the overflow.

- Most permits also require that any noncompliance, including overflows, which may endanger the health or the environment be reported within 24 hours, and in writing within five days. Examples of overflows which may endanger health or the environment include major line breaks, overflow events which result in fish kills or other significant harm, and overflow events which occur in environmentally sensitive areas.

Prohibition of Unpermitted Discharges

- Discharges to waters of the U.S. must be regulated by a NPDES permit. Any discharge from a location other than the effluent discharge point specified in the permit constitutes an unpermitted discharge. This includes dry weather overflows.

Records Review

Prior to the inspection, the inspector should review the permittee's DMRs, SSO notification reports submitted by the permittee, sewer overflow service calls, and other documents that may have relevant information (e.g., annual reports). The permittee may have submitted information in response to EPA Section 308 information requests on SSOs. As required by an enforcement action, the permittee may have submitted plans or a report characterizing its program to eliminate SSOs or a report documenting progress of its sanitary sewer discharge control programs or describing SSO discharge points and overflow problems. Other documents and information that should be reviewed, if available, include:

- citizen complaints
- correspondence
- Notices of Violation
- annual capacity reports
- inspection reports
- maps illustrating the proximity of overflows to drinking water sources
- potential for impact to human health and the environment.

Reviewing these reports in advance of the inspection will help the inspector become knowledgeable about the permittee's specific SSO problems, existing SSO controls, and/or plans to reduce or eliminate their SSO problems. The inspector should make copies of those documents that provide evidence of (1) any SSO occurring at the facility within the previous five years or (2) environmental problems related to SSOs at the facility. The inspector should make sure that EPA has a complete copy of the last five years of noncompliance notification reports, indicating the date, time, duration, flow rate, cause, and actions to correct, prevent, and mitigate each sewage overflow from the facility.

During the onsite records review, the types of records that the inspector should find at the facility include logs, reports, or internal memos describing maintenance and operation activities concerning the sanitary sewer system and SSOs. As in any NPDES evaluation, the inspector should review DMRs as well as monitoring results as reported by the laboratory that analyzed the data.

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However, during inspections concerned with SSOs, the inspector might also request records pertaining to management, budget, and planning for sewer infrastructure improvements. The inspector might also want to review maps of the sanitary sewer system, indicating the locations of manholes, pump stations, etc. Consideration should also be given to the location of SIU connections and the possible effect of such industrial discharges could have when discharged untreated from a SSO. Table 13-1 contains a sample list of documents to review. Items have been arranged under headings for each of the four major components: Capacity, Management, Operations, and Maintenance. There is some overlap between the areas where an inspector would typically use some of the documents listed. For example, POTW flow records would be helpful in the section of the inspection report relating to operations and maintenance as well as capacity. As appropriate, the permittee should have as many of these records readily available as possible.

EPA is developing a CMOM guidance related checklist which will be available on the EPA website. Note, EPA has developed an inspection guide for collection systems which incorporates CMOM concepts, *Guide for Evaluating Capacity, Management, Operations, and Maintenance Programs for Sanitary Sewer Collection Systems*, EPA 300-B-00-014, September 2000.

Interviews

As with all NPDES compliance inspections, interviews with appropriate personnel are essential to understanding the context and meaning of the documents and records. In the case of SSO investigations, appropriate personnel would include people in the highest position of authority at the facility as well as those responsible for day-to-day operations, maintenance and/or oversight of crews such as the collection crew or others involved in inspecting, operating, and maintaining the system. It is particularly important that the inspector obtain written statements (see Chapter Two) where personnel are providing information that is not or cannot be substantiated by the facility's records or the inspector's own observations.

The following are examples of relevant questions that the inspector can use to obtain a general understanding of the facility.

- What is the capacity of the collection system? Is the capacity adequate? What measures have been taken to prevent SSOs?
- What flows does the municipality receive from other municipalities? What kinds of overflow problems have the upstream municipalities reported? What agreements exist to maintain various parts of the sewer systems?•What are the causes of overflows, where do they occur, and how are they documented and reported?
- Where are the potential SSO point discharges located? Are any located at pump stations? What receiving stream does each SSO discharge to?
- How many SSOs have occurred in the past five years? What is the plan to reduce/ eliminate SSOs?
- What are the SSO remediation policies and emergency Standard Operating Procedures (SOPs)?
- How does the authority identify and assess impact from nonmunicipally owned lateral lines?

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- What preventive and response Best Management Practices (BMPs), such as containment, recovery, and minimization of impact to human health and the environment, are in place?
- How are personnel trained to manage and/or prevent SSOs, and what are current staffing levels?
- Are there any alarms or systems monitoring to alert you of an imminent SSO, and what are they?
- What are the goals of the authority's program for managing, operating, and maintaining the sanitary sewer conveyance system?
- What structural deficiencies have been identified in the system?
- What is the O&M schedule for replacement parts/equipment and collection system improvements?
- What studies have been performed of the authority's program for managing, operating, and maintaining the sanitary sewer collection system?

Facility Site Inspection

Previous chapters of this manual provide guidance on general procedures for performing compliance inspections and are a valuable source of information on such topics as entry, legal authority and responsibilities of the inspector. However, there are some issues with entry that are specific to CMOM inspections. The inspector should be aware that some collection system components may be on private property, and they must gain entry properly through the property owner.

After reviewing records of SSO incidents, the inspector should visit previously identified SSO locations. The field inspection of the collection system should be directed by information gathered on prior SSOs, noncompliance notifications, citizen complaints, State reports, municipal studies, etc. Locations where large or representative SSOs have occurred or where SSOs occur more frequently should have higher priority for field inspection. The inspector should review causes (e.g., evidence of illicit connections) and determine whether the situation that led to the spill has been adequately addressed.

Field sampling must be conducted according to approved EPA methodology discussed in other chapters and may include sampling of the discharge and/or the receiving stream. Field sampling may be useful in developing enforcement actions to address chronic or acute violations, and as such, must be conducted with strict adherence to 40 *CFR* Part 136 and chain-of-custody protocol.

The inspector is reminded to take appropriate safety precautions. Collection systems may present physical, biological, chemical, and atmospheric hazards. Safety equipment should include a hard hat, steel-toed boots, safety glasses, gloves and for those with prescription eyeglasses, eyeglass straps are very important. A flashlight is also useful for collection system inspections. Collection system operators typically deal with manhole cover removal and other physical activities. The inspector should refrain from entering confined spaces unless absolutely necessary and then, only with the proper personal protective (safety) equipment. In sewer collection systems, the two most common confined spaces are the underground pumping station and manholes. The underground pumping station is typically entered through a relatively narrow metal or concrete shaft via a fixed ladder.

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Table 13-1. Documents to Review

Capacity	Management	Operations	Maintenance
• Information relating to system capacity • Performance data • POTW Flow Records • Capital improvement projects (CIP) plan (including funding and planned improvements) • Collection system master plan • Infiltration/Inflow studies • I/I studies and evaluations (including programs for eliminating illegal connections).	• Organization chart(s) and chain of communication for reporting SSOs • Program goals • Management Policies and Procedures • Job descriptions • Staffing plans, crew assignments and schedules • Sewer Use Ordinance, Grease Control Ordinance • Legal authority establishing control of system equipment and its maintenance • O&M budget with cost centers for wastewater collection • Recent annual report if available • Procurement process • Information systems • Training plan • Training and certification records • Public education materials • Policy and procedures for trenching, confined space, lockout tagout, PPE • CMOM program audits • Methods to extend good collection systems management to any satellite communities discharging to the central system.	• Detailed maps/schematics of the collection system and pump stations (SIU location) • O&M manuals • Inspection strategy, forms, and records • SSO reports detailing location, receiving water, volume, cause, start and stop date and time, system component, corrective action, and actions to mitigate impacts • Safety manual • Emergency response plan/SOP (awareness, notification, training, and emergency response) • SCADA and other alarm system information • Materials management program • Vehicle management • Overall map of system showing facilities such as pump stations, treatment plants, major gravity • Odor and corrosion control strategy • Root control program • Sampling procedures • Industrial pretreatment oversight of the collection system.	• Routine reports regarding system O&M activities • Work order management system • Maintenance tasks and frequencies • Replacement parts inventory • Performance measures for inspection, cleaning, repair, rehabilitation sewers, and force mains • Preventive maintenance cleaning strategy • Problem diagnosis records • Repair, rehabilitation, replacement strategy for pipes and pump stations • Record of citizen complaints and emergencies (normal hours and after hours) • Notifications to public health agencies, NPDES authority, and other entities.

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13. C. References

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14. POLLUTION PREVENTION

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Related Websites

Pollution Prevention (P2) Homepage: http://www.epa.gov/opptintr/p2home
EnviroSense: http://es.epa.gov/
Pollution Prevention Information Clearinghouse (PPIC):
http://www.epa.gov/opptintr/library/ppicindex.htm

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14. A. Overview of Pollution Prevention

Pollution prevention is a proactive environmental management approach for minimizing material and resource losses during production. Pollution prevention addresses all aspects of production processes from raw material usage and inventory procedures to waste management and utilities conservation. Management techniques that incorporate pollution prevention reduce or eliminate the generation of pollutants, wastes, and adverse ecological impacts through new approaches, material substitutions, and optimizing processes and operating procedures.

Pollution Prevention Goals

The goal of pollution prevention is to reduce pollution by eliminating or reducing waste. Pollution prevention is a multimedia approach that minimizes or eliminates pollutants released to land, air, and/or water without shifting pollutants from one medium to another. The Pollution Prevention Act of 1990 defines source reduction as:

> ...any practice which reduces the amount of a hazardous substance, pollutant, or contaminant entering any wastestream or otherwise released into the environment (including fugitive emissions) prior to recycling, treatment, or disposal; and any practice which reduces the hazards to public health and the environment associated with the release of such substances, pollutants, or contaminants.

Pollution prevention, therefore, represents a fundamental shift in approach away from the conventional reliance on waste treatment/disposal or "end-of-pipe" treatment to the active investigation of prevention techniques. Facilities can implement pollution prevention by:

- Modifying Equipment or technology
- Modifying process or procedure
- Reformulating or redesigning products
- Substituting of raw materials
- Improvements in housekeeping, maintenance, training, and/or inventory control.

Waste Management Hierarchy

A facilities pollution prevention program should eliminate or reduce the generation of pollutants and wastes at the source by carefully considering material usage, production processes, and waste management practices. The facility's pollution prevention program should identify opportunities for reducing the use of hazardous materials and waste generation or releases, as well as opportunities to protect natural resources by conserving and efficiently using energy and water.

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The Pollution Prevention Act of 1990 includes a Waste Management Hierarchy that describes a comprehensive waste management program. The hierarchy assigns the highest priority to source reduction and places a decreasing level of preference on recycling, treatment, and disposal. To be most effective, a facility's pollution prevention program should focus on implementing source reduction. Where source reduction cannot be achieved, reuse and recycling projects should be implemented. If there is no feasible pollution prevention alternative, treatment and disposal should be used as a last resort. Figure 14-1 is a graphic representation of the waste management hierarchy. Each level of the hierarchy is described below.

Source Reduction

Source reduction refers to the use of materials, processes, or practices that reduce or eliminate the quantity and toxicity of wastes at the point of generation. By preventing waste the need for costly treatment and disposal is decreased. Source reduction can be achieved by substituting raw materials improving operating practices and changing processes and equipment.

- **Substituting Raw material:** Replacing hazardous materials with less hazardous (or less toxic) alternatives reduces releases to the environment of hazardous materials and wastes resulting from routine production processes and accidental spills. Examples of material substitutions include, but are not limited to, (1) substituting soy-based or water-based ink to replace solvent-based ink for printing, (2) using recycled paper instead of virgin stock, (3) replacing styrofoam packing materials with re-usable hard-pack plastic materials for shipping products, (4) eliminating trichloroethylene as a cleaning agent by substituting a caustic cleaner such as potassium hydroxide or sodium hydroxide, and (5) eliminating Freon® use.

- **Improving operating practices**: Improved operating practices can reduce waste generated from poorly developed standard operating procedures, inadequate training, and inefficient production scheduling. In the past, facilities developed operating practices that maximized production without taking into account factors such as raw material usage, waste disposal costs, and environmental impacts. Examples of improved operating practices include, but are not limited to, segregating waste, improving housekeeping, and establishing preventive maintenance, training, and outreach programs.

- **Modifying processes and equipment modifications**: In the long run, one of the most effective source reduction techniques may involve process and equipment modifications. Changes to processes and equipment present significant opportunities for source reduction and pollution prevention. Such modifications include using newer or more efficient equipment or redesigning a process so that less raw material is required, yet product quality is maintained.

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Recycling

While source reduction prevents wastes from being generated, recycling turns by-products and wastes into reusable products. Recycling includes such practices as onsite or offsite recycling, materials exchange or reuse, and raw materials recovery.

- **Onsite/offsite recycling:** Both onsite and offsite recycling can help reduce dependence on expensive virgin materials by reusing spent materials.

- **Materials exchange or reuse:** A materials exchange system maximizes the use of a facility's excess raw materials and equipment. A system generally consists of a database for tracking the availability of excess materials by department (or whatever organizational unit is appropriate). In addition, a materials exchange system may include a communication link with the facility's supply system to alert stock clerks that excess items are on hand and should be used prior to purchasing new stock.

- **Materials recovery:** Some of the by-products and wastes generated during production can be recovered and sold as commodities. For example, waste acids that no longer meet the requirements of a final, critical cleaning process can be used in a secondary process that does not require the same level of cleanliness. Other examples of materials recovery as part of waste treatment are discussed below.

Waste Treatment

Unlike source reduction, waste treatment applies to wastes after generation. The goals of waste treatment technologies are to neutralize the waste, to recover energy or material resources, to render the waste nonhazardous, or to reduce the volume. Treatment technologies that enable material to be recovered include ion exchange, reverse osmosis, electrolytic metal recovery, and electrodialysis. Volume reduction through evaporation is an example of treatment. Although volume reduction decreases the amount of wastewater, the absolute quantity of hazardous or toxic waste released to the environment is not reduced. In addition, equipment for volume reduction requires a capital cost and energy costs.

Waste Disposal

Disposal should be considered only when all other options are exhausted. Disposal is considered the least favored waste management method because of the associated costs, liability, and environmental impacts. In addition, a limited number of permitted waste sites are available for disposing hazardous material, and many of these sites are approaching capacity. Also, waste transportation may pose hazards. Finally, recordkeeping and reporting requirements associated with disposing hazardous wastes are an additional burden that can be avoided through preventive measures, such as source reduction.

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Pollution Prevention Benefits

Figure 14-2 summarizes the direct benefits of pollution prevention practices for facilities. Source reduction improves the potential for environmental compliance. Because penalties for environmental compliance are becoming increasingly severe, compliance is a top priority.

Implementing source reduction measures can also reduce costs associated with waste management. Costs reductions may be experienced in expenditures for raw materials, waste disposal, transportation, handling and storage, training, management overhead, and emergency response. By decreasing the amount of hazardous waste shipped offsite for disposal, the facility may also reduce the costs associated with tracking and filing paperwork required for hazardous waste manifests. Future costs, such as remediation activities, can also be avoided with source reduction activities.

In addition, source reduction will produce positive health and environmental benefits. By maintaining fewer hazardous or toxic materials onsite facilities reduce occupational hazards, and, therefore, improve worker health and safety. Creating a safer workplace may reduce the need for expensive health and safety protection devices. Also, insurance cost may be lowered. A safer workplace will also improve employee job satisfaction. Reducing hazardous materials usage also decreases the volume of toxic substances released to the environment from spills, leaks, and air emissions.

The indirect benefits of pollution prevention may be equally significant. One indirect benefit is reduced liability. The Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) "cradle to grave" provisions stipulate that a generator remains responsible for all environmental damage resulting from its waste including damage that occurs after disposal. A pollution prevention program can generate goodwill in the community and workplace, enhance the facility's public image, and foster environmental awareness among employees.

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Figure 14-1

Waste Management Hierarchy

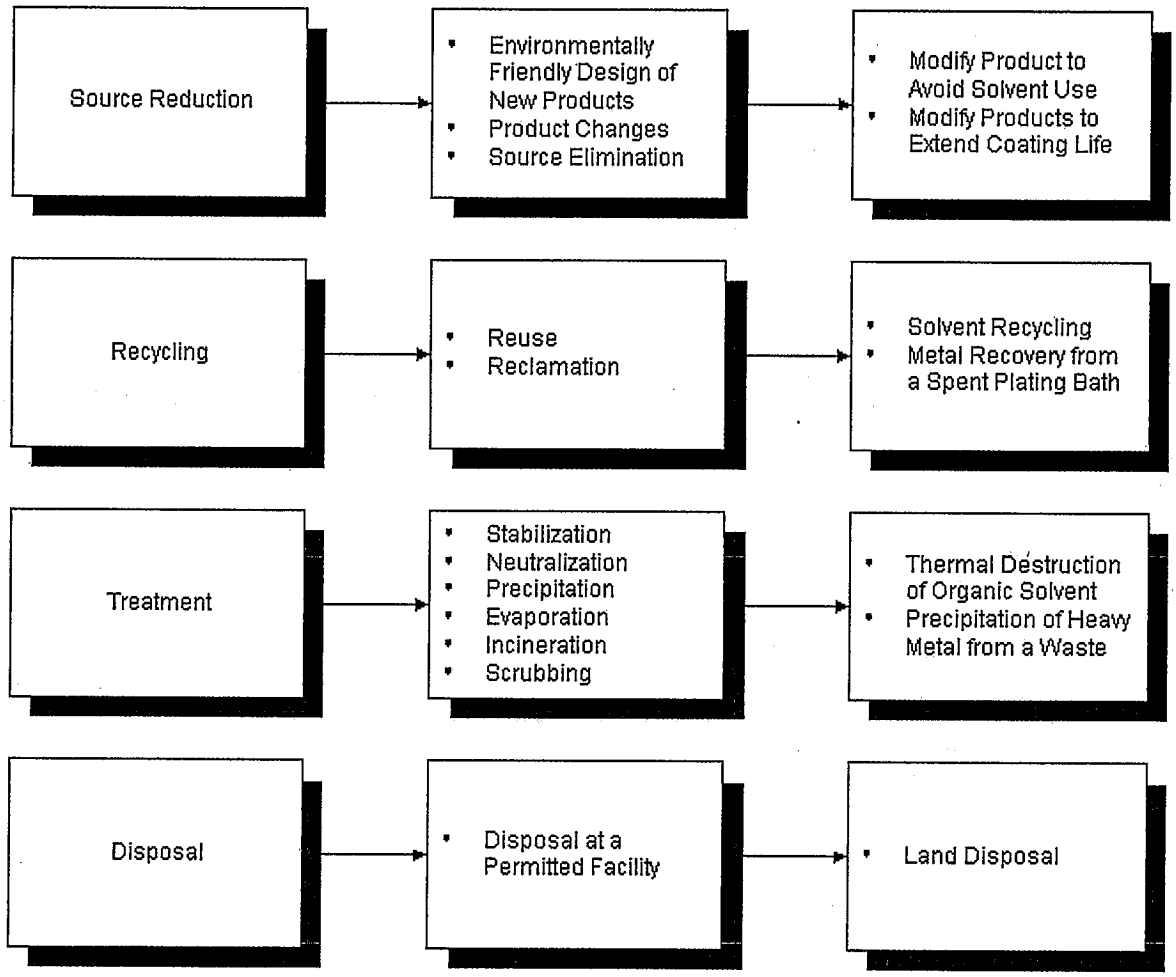

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Figure 14-2

Benefits of Pollution Prevention

- Significantly reduces the amount of pollution released to the environment.
- Improves the potential for environmental and safety compliance.
- Improves worker health and safety by reducing occupational hazards.
- Provides the flexibility to choose cost-effective and environmentally sound solutions that will also result in improved efficiency and increased profit margins.
- Provides public recognition of a facility's efforts.
- Saves capital because of reductions in waste sent for costly treatment and disposal and because of decreased raw materials and energy usage.

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14. B. Pollution Prevention Opportunity Assessment Procedures for Industrial Facilities

Because the primary objective of a routine National Pollutant Discharge Elimination System (NPDES) compliance inspection is to evaluate the facility's compliance with its NPDES permit requirements, a pollution prevention assessment incorporated into a compliance assessment may, by necessity, be limited. Nevertheless, the inspector can use these routine NPDES compliance inspections to identify pollution prevention options, particularly those options that would improve compliance. Alternatively, a facility visit may be conducted solely to evaluate the facility. In this instance, the general procedure for a facility visit is the same as that for any inspection (e.g., preparation, entry, opening conference, facility tour), but the specific focus is on identifying pollution prevention opportunities for the facility to investigate. Two reference documents the inspector may find useful are the *Waste Minimization Opportunity Assessment Manual* (EPA/625/7-88/003) and the *Facility Pollution Prevention Guide* (EPA/600/R-92/088). These documents contain procedures for conducting a pollution prevention opportunity assessment. Pollution prevention opportunity assessments have four phases: (1) planning and organization, (2) assessment, (3) feasibility analysis, and (4) implementation. The four phases are summarized in Figure 14-3.

The inspector cannot perform all the steps in the type of pollution prevention assessment described in the *Waste Minimization Opportunity Assessment Manual* (EPA/625/7-88/003) and in the *Facility Pollution Prevention Guide* (EPA/600/R-92/088). These documents were developed as guides for waste generators who want to implement a pollution prevention program. The feasibility analysis and implementation phases require development of criteria to screen and rank the options, conduct an in-depth technical assessment of options that can be successfully applied at that facility, conduct an economic evaluation, and the develop an implementation plan and schedule, which only the facility can determine. However, the inspector can evaluate whether the facility has conducted such an assessment and whether there are obvious pollution prevention opportunities.

It will be impossible, and unnecessary, for the inspector to have in-depth knowledge and understanding of all production processes and facility activities. However, as part of the entire pollution prevention assessment, whether during the preparation, interview, or facility site visit, the inspector should strive to become familiar with the facility layout, equipment and processes, points of potential waste generation, types of waste generated, and waste handling & disposal practices. If possible, the inspector should collect sufficient detailed information to develop a general flow diagram or material balance for each process step. The inspector should know the source, type, quantity, and concentration of each identified wastestream in order to identify data gaps, problem areas, and data conflicts.

As the assessment is conducted, the inspector should keep the pollution prevention principles in mind:

- Multimedia focus looking at all environmental media as a unified whole to avoid transfers from one medium to another

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- Comprehensive evaluation of the total environmental impacts over the life cycle of the product, from raw materials through manufacturing (including energy use) to use and ultimate disposal.

Preparation

The inspector should prepare for the assessment by examining information about the processes, operations, and waste management practices at the facility. Any background material should be reviewed in the facility's file. If the inspection is planned to focus on pollution prevention assessment, the inspector should contact the facility to inform plant officials of this objective. During this initial contact, the inspector should ask for information that will help identify potential pollution prevention options. Table 14-1 provides a list of useful information for this assessment.

As the inspector reviews facility information, he or she should develop a list of questions specific to the facility. The inspector should be seeking, through the facility-specific questions, information to answer the following general questions:

- What significant wastestreams are generated by the plant? How much waste is generated?
- Why are these considered "waste"?
- From which processes or operations do these wastestreams originate?
- What is the production rate of each wastestream?
- Which wastes are hazardous and which are not? What makes them hazardous?
- How are the wastes managed at present?
- What are the input materials used that generate the wastestreams of a particular process or plant area?
- How efficient is the process? How much input material is:
  - Used in a process?
  - Released to water or air, or disposed of on land?
  - Destroyed or unaccounted for?
- What types of process controls are used to improve process efficiency?
- Are unnecessary wastes generated by mixing otherwise recyclable or recoverable hazardous wastes with other process wastes?

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- What types of housekeeping practices are used to limit the quantity of wastes generated?
- Has the plant developed a Pollution Prevention Plan or strategy?

There are numerous documents that identify pollution prevention techniques for specific types of industry, such as the metal finishing industry, the fabricated metal products industry, and the pharmaceutical industry. These documents and other pollution prevention information can be obtained from:

- Pollution Prevention Information Clearinghouse (PPIC)
  - Guidance and information on Pollution Prevention Opportunities, (202) 566-0799, (202) 566-0794 (fax)
- Technology Transfer and Support Division [formerly Center for Environmental Research Information (CERI)]
  - Guidance and Information on Environmental Protection Programs, Publications Unit, U.S. EPA, 26 West Martin Luther King Drive, Cincinnati, OH 45268, (513) 569-7578, (513) 569-7585 (fax)

Interview

Just as with a routine NPDES compliance inspection, plant personnel should be interviewed when the inspector first arrives at the facility. The inspector should target personnel from the following areas:

- Management
- Environmental waste management
- Process engineering
- Facility maintenance
- Operation and production
- Safety and health
- Research and development
- Quality control
- Purchasing/inventory
- Shipping/receiving
- Storage.

From the interviews, the inspector should develop (or verify) a list of all waste minimization practices already in place. The inspector should also ask plant personnel for the plant's Pollution Prevention Plan or strategy and any suggested pollution prevention opportunities in the operations and processes and discuss with the plant personnel any pollution prevention opportunities that were identified during preparations for the site visit or during the onsite interviews.

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Facility Site Visit

Again, as with a routine compliance inspection, the inspector should conduct a tour of the facility with plant personnel after the interview. The same areas of the manufacturing facility, materials and waste storage, loading and unloading, and treatment system should be reviewed. At each process area, the plant personnel most knowledgeable about the activity should describe the process or should answer any questions the inspector may have.

The inspector should make personal observations, seek confirmation of the interpretation of an activity that is occurring, and investigate any information plant personnel provide that appears to contradict what is being observed. The inspector should focus on:

- Loading and unloading operations
- In-plant transfers (raw materials handling)
- Process operations
- Housekeeping practices
- Maintenance activities
- Waste management operations.

The inspector should also check for signs of spills or leaks and assess overall cleanliness of the site. Throughout all the areas visited, the following wastestreams should be evaluated:

- Wastewater
- Air emissions, including stack and fugitive emissions (e.g., detectable odors and fumes)
- Hazardous wastes
- Nonhazardous solid wastes.

Each wastestream should be reviewed to:

- Determine whether the wastes are hazardous or nonhazardous
- Determine other physical and chemical characteristics of wastes and emissions
- Determine actual points of generation
- Determine quantities including variations
- Identify all handling, treatment, and storage procedures onsite.

Based on activities described above during a facility tour, the inspector should look for pollution prevention opportunities in the following general areas:

- Substituting less hazardous materials such as:
  - Using latex or water-based paints, rather than oil-based
  - Eliminating organic solvent cleaners and replacing with aqueous cleaners.
- Limiting the amount of hazardous materials disposed of by:
  - Buying only the amount of material the facility needs
  - Using all materials before their expiration date
  - Using only the amount of material needed

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  - Sharing materials or donating extra materials to community organizations.

- Using and storing products carefully to prevent:

  - Accidents and spills
  - Mixtures of incompatible materials that can react, ignite, or explode.

- Recycling wastes, such as:

  - Used oil
  - Plastics, glass, paper, and metals
  - Spent solvents.

- Generating less pollution by:

  - Automating and improving process controls to optimize production operations
  - Allowing products to fully drain process chemicals before rinsing
  - Using less toxic materials (e.g., printing inks, dyes)
  - Adjusting production schedules to minimize cleanup operations
  - Sealing floor drains (permanently or temporarily) to prevent spills
  - Segregating wastes to support recycling (e.g., scrap metals, solvents).

- Turning waste products into new materials by:

  - Treating and recycling rinse waters
  - Recovering metals such as silver from waste materials
  - Recycling waste lubricants and coolants.

- Using fewer resources by:

  - Installing flow restrictors on rinse waters
  - Installing high efficiency boilers and furnaces
  - Using heat exchangers to heat process water supplies.

- Educating employees on the:

  - Goals of pollution prevention and waste management
  - Procedures to follow for waste disposal and pollution prevention
  - Accomplishments for the pollution prevention program being implemented.

Before leaving the facility, the inspector should meet with plant personnel. A list of pollution prevention options identified during the site visit should be prepared and discussed with plant personnel. Inspectors can discuss a pollution prevention technology or refer the facility representatives to EPA or State pollution prevention technical assistance offices. However, the inspector should not recommend specific measures to implement. Nor should the inspector suggest particular products or imply that a certain pollution prevention measure will enable the facility to achieve compliance.

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Figure 14-3

Pollution Prevention Opportunity Assessment

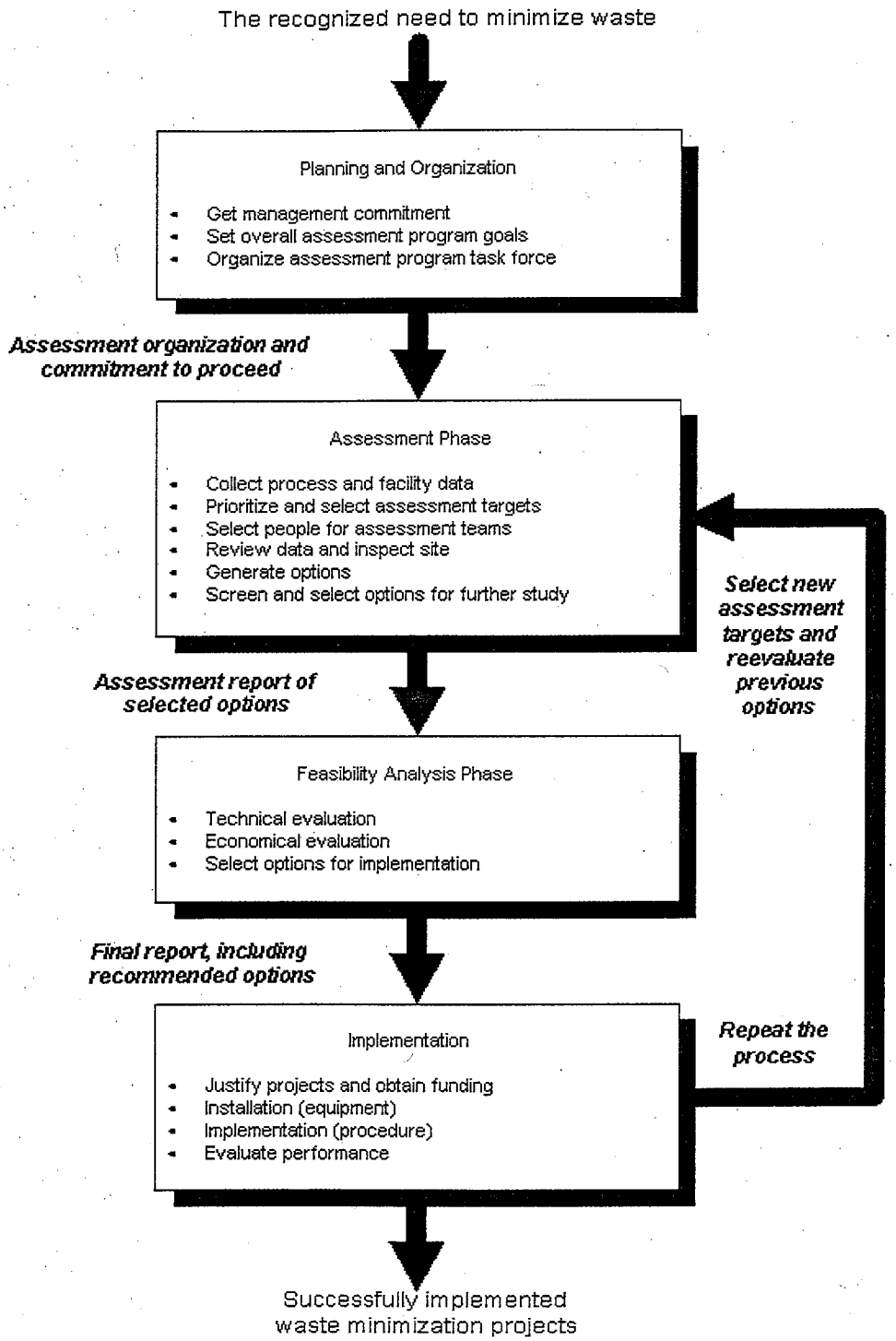

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Table 14-1

Useful Facility Information to Conduct a Pollution Prevention Opportunity Assessment

Raw Materials Information

- Product composition
- Material Safety Data Sheets
- Product and raw material inventory and purchasing records
- Operator data logs
- Production schedules and records

Manufacturing Process Information

- Process flow diagrams
- Material and heat balances for production
- Manufacturing and pollution control processes
- Operating manuals and process descriptions
- Water usage rates
- Equipment and equipment specifications
- Piping and instrument diagrams
- Sewer layout diagrams
- Facility layout and elevation plans
- Equipment layouts and work flow diagrams

Waste Generation and Disposal Information

- Environmental permits—air emissions, solid waste, hazardous waste, NPDES, pretreatment
- RCRA information—manifests, annual reports
- Location of all wastewater, solid and hazardous waste collection, treatment, and storage points
- Diagram of air, wastewater, and/or hazardous waste treatment units
- Operating manuals for treatment units
- Emissions inventories [air, NPDES Discharge Monitoring Reports (DMRs), etc.]
- SARA Title III—Section 313 release reports
- Previous regulatory violations

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14. C. Pollution Prevention Opportunity Assessment Procedures For Municipal Wastewater Treatment Plants

The Municipal Water Pollution Prevention (MWPP) program promotes the application of pollution prevention concepts of the Pollution Prevention Act to Publicly Owned Treatment Works (POTWs). Pollution prevention can reduce the need for substantial capital investment in new infrastructure, enhance worker safety, improve the usability of sludge, and reduce operation and maintenance costs. Practices that stress a preventive approach to water pollution abatement include the following:

- Mechanisms for routine assessments of the compliance status of POTWs. This mechanism should include an early warning system based on periodic self-audits and quantitative techniques for assessing the condition of municipal wastewater treatment systems.
- Reporting processes on the capability of POTWs to sustain compliance.
- Processes for identifying, implementing, and tracking corrective actions to prevent pollution and maintain compliance.
- Program that will encourage POTWs to develop pollution prevention projects.

Pollution prevention practices POTWs can adopt could focus in the areas of:

- Improved operation and maintenance
- Projects that reduce wastewater flows and pollutant loadings
- Energy and water conservation
- Timely planning and financing for future needs and economic growth prior to occurrence of wastewater permit violations
- Toxicity reductions at the source (industrial pretreatment, commercial and residential source reduction programs)
- Recycling
- Proper treatment of wastes
- Beneficial uses of sludge.

Specific opportunities for optimizing each unit operation to maximize removal efficiency may include unit modifications to improve performance. For example:

- Clarifiers — Baffle installations and weir modifications to improve hydraulics and limit short circuiting.

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- Aeration basins — Baffles to limit short circuiting. Fine bubble diffusers to improve aeration. Use of automatic controls to optimize aeration and limit over-aeration.
- Aerobic digester — Recover energy from gas. Insulate digester.

At any time, but especially during upgrading and expansion, the following pollution prevention projects could be considered:

- Install high efficiency pumps, motors and drives.
- Use biological- rather than chemical-based treatment.
- Install equalization basins to improve efficient operation of downstream units and minimize the need for oversize units.
- Design plant layout to minimize the need for intermediate pumping.
- Consider ultraviolet or ozone disinfection instead of chlorine.
- Digest residuals rather than heat or chemical treat.
- Select dewatering equipment not only to maximize solids but to minimize the need for chemical feeds that increase the volume of residuals.
- Evaluate toxicity of all lubricants, solvents, or cleaners, and replace them with less toxic alternatives such as citrus-based cleaners wherever possible.
- Reduce infiltration/inflow, which will result in several benefits:
  - Reduces plant expansion needs
  - Improves performance efficiency
  - Reduces grit (which increases equipment wear and breakage and is a disposal problem).

The Industrial Pretreatment Program is one of the best opportunities to achieve pollution prevention. It represents source control. Pollution prevention programs or projects aimed at residential and commercial users can also reduce loadings. Such pollution prevention programs could:

- Encourage water conservation
- Provide information on compatible or biodegradable cleaners to replace more toxic cleaners (for example, identify an alternative to chlorine-based "hang-in" type toilet bowl cleaners)
- Encourage composting instead of garbage grinders

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- Enforce a commercial oil and grease ordinance requiring installation, operation, and maintenance of grease traps and recovery and recycle of oil and grease
- Discourage oil and grease dumping
- Prohibit disposable diaper flushing.

The POTW could also work with water utilities or agencies involved in establishing plumbing codes to reduce the metals (zinc, copper, and lead) found in drinking water supplies. These metals may be present because the water is corrosive to the pipes and leaches the metals from copper tubing, zinc-coated iron and steel pipes, and lead solder. The water utility may also be using water conditioning chemicals that contain metal salts.

The protocols for conducting a pollution prevention assessment at municipal wastewater treatment plants are similar to those for an industrial facility. The protocols of a Compliance Evaluation Inspection (CEI) are also appropriate, except that the focus during the interview, file review, and site visit is on identifying pollution prevention opportunities.

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14. D. References and Checklist

References

U.S. Environmental Protection Agency. July 1988. *Waste Minimization Opportunity Assessment Manual.* EPA/625/7-88/003.

U.S. Environmental Protection Agency. *Facility Pollution Prevention Guide.* EPA/600/R-92/088.

University of Tennessee. *Waste Reduction Assessment and Technology Transfer (WRATT) Training Manual*, 2nd Edition.

Municipal Water Pollution Prevention Program. March 1991. 21W-7002.

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POLLUTION PREVENTION CHECKLIST FOR INDUSTRY

A. GENERAL

Yes	No	N/A	1. Is there a written facility policy regarding pollution prevention?
Yes	No	N/A	2. Is there a pollution prevention program currently in place?
Yes	No	N/A	3. Is there a specific person assigned to oversee the success of the program?
Yes	No	N/A	4. Are there management/employee initiatives and incentive programs related to pollution prevention?
Yes	No	N/A	Quality circles (free forums between employees and supervisors) to identify pollution prevention options?
Yes	No	N/A	Opportunities for employee suggestions on pollution prevention options?
Yes	No	N/A	5. Has the facility previously conducted a pollution prevention assessment?
Yes	No	N/A	6. Has the facility used better cost accounting and cost allocation to provide incentives to reduce wastes or resource consumption?
Yes	No	N/A	Is cost accounting performed accurately for all process areas and wastestreams?
Yes	No	N/A	Are utility costs (energy, water) and waste treatment and disposal costs allocated to the operations that generate the waste?

B. STORAGE AREAS

Yes	No	N/A	1. Are there designated material storage areas?
Yes	No	N/A	2. Are storage areas clean and organized?
Yes	No	N/A	3. Are containers stored in such a way as to allow for visual inspection for corrosion and/or leaks?
Yes	No	N/A	4. Are containers stacked in a way to minimize the chance of tipping, puncturing, or breaking?
Yes	No	N/A	5. Are there adequate distances from incompatible chemicals and different types of chemicals to prevent cross-contamination?
Yes	No	N/A	6. Is one person responsible for maintaining storage areas?
Yes	No	N/A	7. Does the layout of the facility result in minimizing traffic through material storage areas?
Yes	No	N/A	8. Are stored items protected from damage, contamination, and exposure to weather?
Yes	No	N/A	9. Are all storage tanks routinely monitored for leaks?
Yes	No	N/A	10. Is containment, such as a curb or dike, installed in storage areas to contain leakage and to minimize the area contaminated by a spill?

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POLLUTION PREVENTION CHECKLIST FOR INDUSTRY (Continued)

B. STORAGE AREAS (Continued)

Yes No N/A	11. Are leak detection systems installed for underground storage tanks?
Yes No N/A	12. Are floating-roof tanks used for VOC control?
Yes No N/A	13. Are conservation vents used on fixed roof tanks?
Yes No N/A	14. Does the facility use vapor recovery systems?

C. MATERIALS INVENTORY

Yes No N/A	1. Is there an inventory control system designed to prevent materials from deteriorating in storage (first in, first out to prevent expiration)?
Yes No N/A	2. Is obsolete raw material returned to the supplier?
Yes No N/A	3. Does the facility try to order smaller containers of infrequently used materials to avoid disposing of large quantities of unused obsolete materials?
Yes No N/A	4. Has the facility tried to order larger containers of frequently used materials to reduce the number of small containers that must be cleaned and disposed of?
	5. Does the facility use or maintain:
Yes No N/A	Hazardous chemicals inventory lists?
Yes No N/A	Material safety data sheet files?
	6. Are all in-plant containers of hazardous chemicals labeled, tagged, or marked with:
Yes No N/A	Identity of the hazardous chemical(s)?
Yes No N/A	Appropriate hazard warnings?
Yes No N/A	7. Has the facility reexamined its need for each raw material?
Yes No N/A	8. Does the facility have a way to use off-spec material, where possible?

D. MATERIAL HANDLING

Yes No N/A	1. Are raw materials tested for quality before being accepted from suppliers?
Yes No N/A	2. Does the facility follow proper procedures when transferring materials?
Yes No N/A	3. Are expired materials tested for effectiveness before being disposed of?
Yes No N/A	4. Are drums, packages, and containers inspected for damage before being accepted?
Yes No N/A	5. Are containers properly resealed after use?

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POLLUTION PREVENTION CHECKLIST FOR INDUSTRY (Continued)

D. MATERIAL HANDLING (Continued)

Yes	No	N/A		
			6.	Are containers emptied thoroughly before cleaning or disposal?
			7.	Does the facility segregate its wastes as much as possible?
Yes	No	N/A		Solid wastes from aqueous wastes?
Yes	No	N/A		Nonhazardous from hazardous?
Yes	No	N/A		Segregated according to type of contaminant?
Yes	No	N/A		Different types of solid waste to improve recycling/reuse?
Yes	No	N/A		Different types of solvents, cleaner wastes, and lubricants (e.g., organic solvents from mineral oils)?

E. PROCESS OPERATIONS

Yes	No	N/A		
Yes	No	N/A	1.	Are water conservation measures, recycling, and reuse techniques practiced in processes that use water or generate a wastewater (e.g., cleaning and rinsing operations)?
Yes	No	N/A	2.	Has material substitution been tried for any hazardous materials used in process?
Yes	No	N/A	3.	Have any techniques been used to increase the life of any process baths?
Yes	No	N/A	4.	Are any wastes being recycled, reused, or recovered in some manner?
Yes	No	N/A	5.	Have any equipment or process modifications been made to increase material use efficiency and thus reduce material waste generation?
Yes	No	N/A	6.	Do processes employ any detectors to alert personnel of malfunctions that could produce/generate excessive wastes?

F. SPILLS AND LEAKS

			1.	When a spill occurs, what cleanup methods are employed?
Yes	No	N/A	2.	Would different cleaning methods allow for direct reuse or recycling of the water?
Yes	No	N/A	3.	Are there preventive maintenance procedures designed to reduce incidents of equipment breakdowns, inefficiency, spills, or leaks?

G. MATERIAL SUBSTITUTION

Yes	No	N/A		
Yes	No	N/A	1.	Could the facility modify or completely change a given process to use water-based coolants and fluids instead of oil-based fluids?

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POLLUTION PREVENTION CHECKLIST FOR INDUSTRY (Continued)

H. SOLVENT USE

	1. Can solvent cleaning be replaced with less toxic cleaning, such as:
Yes No N/A	A dry process (e.g., bead or sand blasting or other abrasives)?
Yes No N/A	Steam cleaning?
Yes No N/A	Cryogenic?
Yes No N/A	Caustic cleaning?
Yes No N/A	2. Are non-chlorinated solvents substituted for chlorinated solvents?
Yes No N/A	3. Are parts wiped to remove oil and dirt prior to solvent cleaning?
Yes No N/A	4. Is the loss of cleaning ability of the solvent monitored before the solvent is replaced?
Yes No N/A	5. Are chemicals reused or recycled?
Yes No N/A	6. Is an onsite distillation unit for solvent recovery and reuse installed?
Yes No N/A	7. Is solvent use standardized?

I. RINSE WATERS

Yes No N/A	1. Have excessive rinses been evaluated and eliminated?
Yes No N/A	2. Is rinse water reclaimed, pretreated, and reused?
Yes No N/A	3. Are water softeners used only where necessary?

J. TRAINING

Yes No N/A	1. Are there formal personnel training programs on raw material handling, spill prevention, proper storage techniques, and waste handling procedures?
Yes No N/A	2. Are employees trained in pollution prevention techniques?
	3. How often is training given and by whom?

K. GOOD OPERATING PRACTICES

Yes No N/A	1. Are plant material balances performed routinely?
Yes No N/A	2. Are they performed separately for each material of concern?
Yes No N/A	3. Are records kept for each waste, documenting sources of origin and eventual disposal?
Yes No N/A	4. Are operators provided with detailed operating manuals or instruction sets?
Yes No N/A	5. Are all operator job functions well defined?

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POLLUTION PREVENTION CHECKLIST FOR INDUSTRY (Continued)

K. GOOD OPERATING PRACTICES (Continued)

Yes No N/A	6. Are regularly scheduled training programs offered to operators?
	7. Has the facility integrated pollution prevention into supervision and management by:
Yes No N/A	Closer supervision to improve production efficiency and reduce inadvertent waste generation (increased opportunity for early detection of mistakes)?
Yes No N/A	Management By Objectives (MBO) with defined and achievable goals for waste minimization (better coordination among the various parts of an overall operation)?
Yes No N/A	Scheduling production to minimize cleaning frequency?
	8. Has the facility improved production scheduling and planning to include:
Yes No N/A	Maximizing batch sizes?
Yes No N/A	Dedicating equipment to a single product?
Yes No N/A	Altering batch sequencing to minimize cleaning frequency?
Yes No N/A	9. Is corrective maintenance practiced, such as resetting control valves or adjusting process temperatures, to increase efficiency and to prevent raw material loss through wastestreams?
Yes No N/A	10. Does the facility forbid operators to bypass interlocks and alarms, or to significantly alter set points without authorization?
Yes No N/A	11. Are overflow or malfunction alarms installed on tanks and equipment?

L. HOUSEKEEPING PRACTICES

	1. Good housekeeping is the maintenance of a clean, orderly work environment. Does the facility:
Yes No N/A	Maintain neat and orderly storage of chemicals?
Yes No N/A	Promptly remove spillage?
Yes No N/A	Maintain dry and clean floors by use of brooms and/or vacuum cleaners?
Yes No N/A	Provide proper walkways with no containers protruding into walkways?
Yes No N/A	Minimize the accumulation of liquid and solid chemicals on the ground or floor?
Yes No N/A	Stimulate employee interest in good housekeeping?

Checklist derived from Waste Reduction Assessment and Technology Transfer (WRATT) Training Manual, 2nd Edition, University of Tennessee

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POLLUTION PREVENTION CHECKLIST FOR MUNICIPAL WASTEWATER TREATMENT PLANTS

A. AGE

	1. What year was the wastewater treatment plant constructed or the last major expansion to increase the capacity of the plant completed?
	2. What sewer system improvements does the municipality have under consideration for the next 10 years?
	3. What is the expected community and industrial growth?
Yes No N/A	4. Is there any major development (industrial, commercial, or residential) anticipated in the next 2 to 3 years, such that either the flow or pollutant loadings could significantly increase?

B. TREATMENT EFFICIENCY

	1. Compare influent actual flow to influent design flow. When will actual hydraulic loading exceed design?
Yes No N/A	Has the plant initiated expansion plans and financing sufficiently in advance to avoid overloading?
Yes No N/A	Has the plant investigated measures for reducing flow?
	2. Compare conventional pollutant loadings (BOD, TSS, ammonia, phosphorus) to design loadings. When will actual loadings exceed design?
Yes No N/A	Has the plant initiated expansion plans and financing sufficiently in advance to avoid overloading?
Yes No N/A	Has the plant investigated measures for reducing loadings?
	3. Review operating records. How many months were the effluent concentrations or loadings above 90 percent of the permit limits?
____ Mo.	BOD?
____ Mo.	COD?
____ Mo.	Fecal coliform?
____ Mo.	Other conventional pollutants limited by permit (ammonia, phosphorus)?
____ Mo.	Metals or other toxics?
	4. How many times were permit limits violated (in the last year)?
	5. What types of violations have occurred in the last 5 years?
Yes No N/A	Are any of a recurrent nature?
	What were the causes?
Yes No N/A	Have effective solutions been implemented to prevent future recurrence?

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POLLUTION PREVENTION CHECKLIST FOR MUNICIPAL WASTEWATER TREATMENT PLANTS (Continued)

B. TREATMENT EFFICIENCY (Continued)

Yes No N/A	6. How many bypasses have occurred? What were the causes? Have effective solutions been implemented to prevent future recurrence?
Yes No N/A	7. What are the future regulatory or permit requirements that may require modifications to the plant or its operations? Can the facility currently meet any future anticipated water quality standards or effluent discharge limits?
Yes No N/A	8. Has the plant investigated ways to maximize operating efficiency?
Yes No N/A	9. Has the plant investigated improvements to the chlorination system to decrease chlorine usage?

C. SLUDGE

Yes No N/A	1. Does the plant have sufficient sludge treatment, storage, and disposal capacity?
Yes No N/A	2. What percentage of the methane gas is captured and used? Has the plant investigated ways to increase the amount of gas captured and used?
Yes No N/A	3. Has the plant investigated ways to decrease the amount of dewatering chemicals used?

D. COLLECTION SYSTEM

	1. How many overflows within the collection system have occurred?
Yes No N/A	2. How many backups at any point in the collection system have occurred for any reason? What were the causes? Have effective solutions been implemented to prevent future recurrence?
Yes No N/A	3. Has the plant investigated ways to decrease infiltration/inflow?

E. PREVENTIVE MAINTENANCE PROGRAM

Yes No N/A	1. Does the plant have a written preventive maintenance program on major equipment items and the sewer collection system?
Yes No N/A	2. Does the preventive maintenance program depict frequency of intervals, types of lubrication, types of repair and other preventive maintenance tasks necessary for each piece of equipment or each section of the sewer?

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POLLUTION PREVENTION CHECKLIST FOR MUNICIPAL WASTEWATER TREATMENT PLANTS (Continued)

E. PREVENTIVE MAINTENANCE PROGRAM (Continued)

Yes No N/A	3. Are these preventive maintenance tasks, as well as equipment and sewer collection problems being recorded, filed, and reviewed so future maintenance problems can be assessed properly?

F. MATERIALS USAGE

Yes No N/A	1. Has the plant identified all supplies used in the operation and maintenance of the plant?
Yes No N/A	2. Has the plant identified materials that could be substituted for less toxic materials?
Yes No N/A	3. Does the plant reuse or recycle any materials used?
Yes No N/A	4. Has the plant investigated ways to reduce chemical usage without compromising preventive maintenance or treatment?

G. PERSONNEL RESOURCES

	1. Review personnel resources, training, and certifications.
Yes No N/A	Are there sufficient numbers?
Yes No N/A	Do all have appropriate certifications and periodic training?
Yes No N/A	Do all personnel certifications meet or exceed required levels?
	How many are below the required level?
Yes No N/A	Is staffing level equal to or does it exceed O&M Manual recommendations?
	2 What percentage of the wastewater budget is dedicated for training?

H. FINANCIAL

Yes No N/A	1. Are the funds for the plant separate from other municipal funds?
Yes No N/A	2. Are funds sufficient for adequate operations?
Yes No N/A	3. Are funds sufficient for adequate preventive maintenance?
Yes No N/A	4. Are funds available for necessary improvements, expansion?
Yes No N/A	5. Is there a capital improvement fund?
Yes No N/A	6. Is the equipment replacement fund in a segregated account?
	7. What financial resources are available to pay for improvements/expansion/ reconstruction?

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POLLUTION PREVENTION CHECKLIST FOR MUNICIPAL WASTEWATER TREATMENT PLANTS (Continued)

I. MUNICIPAL POLLUTION PREVENTION PROJECTS

Yes No N/A	1. Does the plant have a pollution prevention program or strategy?
Yes No N/A	2. Has the plant conducted a self-audit on the adequacy of its maintenance, operation, funding, and operator training?
Yes No N/A	3. Does the pretreatment program include a pollution prevention component or specific pollution prevention projects?
	4. Does the municipality have any pollution prevention projects aimed at reducing toxic/hazardous waste discharges, conventional loadings, or flow (e.g., water conservation) from:
Yes No N/A	Households?
Yes No N/A	Commercial businesses?
Yes No N/A	Industries?

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15. MULTIMEDIA CONCERNS

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15. A. Introduction

This chapter is intended as a guide for National Pollutant Discharge Elimination System (NPDES) inspectors who become involved in multimedia environmental compliance inspections. Multimedia compliance investigations are intended to determine a facility's status of compliance with applicable laws, regulations, and permits in more than one media.

This chapter and the Media and Specific Inspection Components contained in Appendix Y include a significant amount of material drawn directly from the National Enforcement Investigations Center's (NEIC's) *Multimedia Investigation Manual* revised March 1992 and *Process-Based Inspections Guide*, March 1997. NPDES inspectors participating in multimedia inspections are referred to these documents for further guidance.

Additional training specific to the conduct of Multimedia Inspections is also available, and is recommended to anyone conducting or participating in multimedia inspections.

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15. B. Overview of the Multimedia Approach to Inspections

Most inspections can generally be grouped into four categories of increasing complexity, moving from Category A (program-specific compliance inspections) to Category D, (complex multimedia investigations), depending upon the complexity of the facility and the objectives of the investigation. The four general categories of investigations are described below:

Category A: Program-specific compliance inspections (e.g., compliance with NPDES permit requirements), conducted by one or more inspectors. The objective is to determine facility compliance status for program-specific regulations.

Category B: Program-specific compliance inspections, which are conducted by one or more inspectors. The inspector(s) screen for and report on obvious key indicators of possible noncompliance in other environmental program areas.

Category C: Several concurrent and coordinated program-specific compliance investigations conducted by a team of investigators representing two or more environmental and/or statutory program offices. The team, which is headed by a team leader, conducts a detailed compliance evaluation for each of the target programs. The objective is to determine compliance for several targeted program-specific areas. Reports on obvious, key indicators of possible noncompliance in other environmental program areas are also made.

Category D: Comprehensive facility multimedia evaluations not only address compliance in targeted program-specific regulations, but also try to identify environmental problems that might otherwise be overlooked. The initial focus is normally on facility processes to identify potentially regulated activities (from raw material management through final manufacturing and processing) and by-products/wastestreams generated, especially those that may not have been accurately reported to the regulators. When potentially regulated activities or wastestreams are identified, a compliance evaluation is made with respect to applicable requirements and subsequent compliance status. Special attention is often given to pollutants that "change media" (such as air pollutants that are scrubbed into wastewaters).

The investigation team, headed by a team leader, comprises staff thoroughly trained in different program areas. The onsite investigation is conducted during one or more site visits and involve intense concurrent program-specific compliance evaluations, often by the same cross-trained personnel.

Category D multimedia investigations are thorough and, consequently, resource intensive. They are appropriate for intermediate to large, complex facilities that are subject to a variety of environmental laws. Compliance determinations are made for several targeted program-specific areas, and reports on possible noncompliance are prepared.

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Generally, all investigations will include pre-inspection planning, use of a project plan, sampling, inspection procedures, and a final report. The major difference will be in the number of different regulations addressed during Categories C and D investigations.

The multimedia approach to investigations has several advantages over program-specific inspections, including:

- A more comprehensive assessment of a facility's compliance status
- Improved enforcement support and better potential for enforcement
- A higher probability to uncover/prevent problems before they occur or before they manifest an environmental or public health risk
- Ability to respond more effectively to non-program-specific complaints, issues, or needs and to develop a better understanding of cross-media problems and issues, such as waste minimization
- When conducted correctly, the multimedia approach to investigations can be less resource intensive and yield more thorough results than numerous single media investigations.
- A higher probability of identifying cross-media issues, such as pollutants that can be "lost" as they change media.
- The opportunity to identify weaknesses in a facility's Environmental Management Systems
- High visibility and possibly enhance deterrent effect on facility Corporate management

The success of a multimedia investigation program is contingent upon a good managerial system and the support of upper management. Since these investigations will often be conducted at larger facilities, adequate resources (time and personnel) must be provided. Good communications during the planning phase are essential to define the scope of the inspection, as well as each team member's role. Communications could also include State officials since State inspectors might also participate as team members. Because of the extent of the State's knowledge of the facility and its problems, State involvement is often critical to the success of the investigation. Similarly, coordination with other Federal or local agencies needs to be addressed, as necessary.

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15. C. Multimedia Concerns at NPDES Facilities and the Multimedia Screening Program

RCRA

Many NPDES-regulated facilities are also subject to requirements of the Resource Conservation and Recovery Act (RCRA). RCRA regulates the generation, transportation, treatment, storage, and disposal of hazardous wastes. However, RCRA defers the control of hazardous wastes to the Clean Water Act (CWA) when those wastes are either directly discharged to surface waters under an NPDES permit (the direct discharge exclusion) or indirectly discharged to a wastewater treatment plant (the domestic sewage exclusion).

The costs of hazardous waste management using "traditional" storage, treatment, and disposal methods are rising significantly as facilities comply with the 1984 RCRA Amendments. Consequently, industrial facilities may use the two previously mentioned exclusions as preferred disposal methods. Since many of the 126 priority pollutants listed in the CWA would be considered hazardous waste constituents under RCRA, the discharge of these pollutants should concern the inspectors and operators of wastewater treatment plants. Hazardous wastes discharged to wastewater treatment plants pass through to surface waters unless incidentally removed in sludge, degraded, or "lost" through volatilization or exfiltration during the wastewater treatment process. Additionally, the RCRA waste may inhibit or reduce the effectiveness of the wastewater treatment processes potentially resulting in lower quality effluent discharges. Sludges resulting from the treatment of a hazardous waste may become a regulated waste under RCRA.

Special attention should be applied to situations where RCRA regulated hazardous wastes may be introduced into wastewater treatment facilities with surface impoundments with potential regulatory and groundwater contamination issues.

NPDES permit writers and inspectors may learn whether the facility conducts RCRA regulated activities, and the nature of those activities, from State and/or Environmental Protection Agency (EPA) RCRA authorities, databases such as EnvironFacts (public) or OTIS (EPA only) or while discussing facility industrial processes during the initial stages of a comprehensive compliance investigation. Industrial facilities can use and/or generate hazardous waste. The hazardous wastes may be in the liquid, gas, or solid form. These wastes may be generated from raw materials, off-specification products, or residuals or emissions from the process operations. In addition, waste oils used by process equipment, solvents used in cleaning operations, or sludges from treatment of process wastewaters can be hazardous wastes.

Publicly Owned Treatment Works (POTWs) receiving hazardous wastes by truck, rail, or dedicated pipeline are subject to RCRA permit by rule requirements. Included among these requirements is the provision that corrective action must be taken to remedy any contamination that may have resulted from a release of hazardous waste or hazardous constituents from solid waste management units, such as surface impoundments, to the environment. For example, if a POTW that is subject to these RCRA requirements contaminates groundwater through

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leaching or exfiltration, the permittee might be required to investigate the nature and extent of those releases and, where appropriate, implement corrective measures. Guidance on the nature of these requirements, and how they might affect POTWs, is now being developed.

RCRA/CERCLA

Another source of contaminated wastewaters is hazardous waste cleanup actions. Under RCRA and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), EPA, States, and private parties are initiating cleanups of contaminated sites. Much of the waste found at these sites is in liquid form, either as leachate or contaminated groundwater. The treatment, and consequent discharge, of contaminated wastewaters from these sources are expected to increase in the future. These wastes will likely be complex mixtures, requiring careful examination of their composition to determine appropriate treatment techniques.

Nonhazardous Sludge

It has long been known that wastewater treatment results in the transfer of residuals from wastewater effluents to sludges. Several statutes and regulations, induding the CWA, are charged with management of these nonhazardous sludges. NPDES and State permits include disposal limitations for municipal sewage sludge as specified in 40 *CFR* Part 503. Many States already impose such requirements. NPDES inspectors will need to become more familiar with the relationship between State sewage sludge requirements and Federal sewage sludge management and disposal requirements under the CWA and those imposed by other statutes and regulations, particularly RCRA and the Clean Air Act (CAA). Municipal sewage sludge that is co-incinerated with other wastes is regulated by the CAA. Municipal sewage sludge that is co-disposed with other waste in a municipal solid waste landfill is regulated by 40 *CFR* Part 258. Industrial sludges are regulated by 40 *CFR* Part 257 if land applied and by 40 *CFR* Part 258 if disposed of in a nonhazardous landfill. (See Chapter Ten for detailed information on the 40 *CFR* Part 503 requirements.)

Air

Air emissions from wastewater treatment units are under increased scrutiny. For many chemical industries (SOCMI facilities, Polymer Facilities, Petroleum Refineries, Vinyl Chloride Plants, etc), EPA has developed CAA regulations that limit the amount of volatile hazardous air pollutants that can be contained in process wastewaters. The purpose of these regulations are to minimize the amount of pollutants transferred from wastewater to the atmosphere. In general, facilities are required to treat wastewater streams that contain volatile hazardous air pollutants before than can be exposed to the atmosphere. It is important to be aware of what chemical constituents are in the wastewater and what impact this may have on a facilities compliance with CAA regulations. In another development, the 1984 RCRA amendments provide for the control of air emissions from authorized RCRA Treatment, Storage, and Disposal Facilities (TSDFs). As a result, wastewater treatment facilities at RCRA TSDFs are now being investigated by RCRA program personnel. It should be noted that remedial actions

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may be required at some of these facilities and the regulatory issue of emissions from wastewater treatment facilities needs to be addressed.

Additionally, it is important to investigate facility activities, such as the use of air pollution control devices or other waste management activities, that remove pollutants from one media (such as air) but generate a wastewater stream. These wastewaters may not have been accurately reported in CWA permit applications and may not be properly managed.

Multimedia Screening

Regions and States are encouraged to incorporate multimedia screening into as many single medium inspections as possible (i.e., conduct Category B inspections in lieu of Category A inspections). Obtaining multimedia screening information earlier in the process will help target inspection resources and ensure that all noncompliance issues are included in any facility-specific enforcement strategy. The compliance inspector will use a multimedia screening checklist as a guide for making and recording observations and pertinent information.

The Environmental Services Division Field Branch Chiefs and NEIC have led the development and implementation of EPA's multimedia inspection program, including screening inspections. The National Multimedia Screening Inspection Worksheet, dated May 12, 1993, was developed as a general guideline by a Regional work group led by Region 3. A copy of this worksheet is included in Appendix Z. Regions and States have adapted and customized checklists such as this for their own use.

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15. D. NPDES Inspectors and Multimedia Inspections

Description of a Multimedia Inspection

The strategy developed for multimedia inspections usually involves prioritizing the processes and waste management activities, followed by systematically moving from the beginning to the end of a process with emphasis on regulated wastestream generation to final wastestream management. The strategy should be somewhat flexible so that "mid-course corrections" can be made.

The compliance evaluations for each media should be coordinated among all of the investigators and scheduled to make most effective use of the inspectors on-site time and facility contact resources. This schedule should loosely identify time for each media investigator to; review documents, interview facility personnel, conduct on-stie observations, and conduct sampling as appropriate. This schedule must be "organic" and modified throughout the on-site investigation to effectively use the limited available time. Daily meetings between team members to discuss progress and needs are recommended to help modify this schedule to meet the team and the facility personnel needs. Personnel training and availability and other logistical factors may result in a combining of compliance evaluations.

The strategy for process and compliance evaluations should be developed by the inspection team coordinator and discussed with inspection team members. This will serve as the basis for explaining inspection activities and scheduling to the company during the opening conference.

The strategy could include checklists that address potential process wastestreams to be examined and media-specific compliance issues. Checklists can be a vital component of a compliance investigation to help ensure that an investigator does not overlook anything important. Checklists serve as a reminder of what needs to be asked or examined and to help an inspector remember the basic regulatory requirements. However, checklists should not be a replacement for curiosity and common sense.

In larger facilities, multiple site visits coordinated by the team leader may be necessary and desirable for completing the inspection and following-up on issues identified during earlier site visits. This approach can lead to a better overall site compliance determination because of the opportunity to review information obtained in the office, then refine the inspection/strategy to "fill in the gaps" during a subsequent site visit.

The NPDES Inspector's Role in a Multimedia Inspection

Each multimedia investigation team member should bring special program expertise and experience and must be well trained in most facets of conducting a field investigation, including sampling. Most of the investigators on the team, including the team leader, should be current field investigators who already possess most of the necessary skills and qualifications. EPA Order 3500.1 sets forth specific training requirements for any EPA investigator who is leading a single media investigation. These training requirements include both general inspection

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procedures and media-specific procedures. While an individual leading a multimedia investigation may not have had the media-specific training for each media covered during that multimedia investigation, the team leader should have the media-specific training for at least two of the media.

The team leader has overall responsibility for the successful completion of the multimedia investigation. In addition, other investigators may be designated as leads for each of the specific media/programs that will be addressed. These individuals may work alone or have one or more inspectors/samplers as assistants, depending on workload and objectives. However, all investigation team members should report directly to, and be accountable to, the team leader.

The following are some of the more important skills and qualifications that are necessary for team members:

- The ability to work effectively as a member of a diverse team
- Knowledge of the Agency's policies and procedures regarding inspection authority, entry procedures/problems, enforcement actions, legal issues, and safety
- Thorough understanding of sampling equipment; quality assurance (QA) requirements for sample collection, identification, and preservation; and chain-of-custody procedures
- Knowledge of manufacturing/waste producing processes, pollution control technology, principles of waste management, flow measurement theory and procedures, and waste monitoring techniques/equipment
- Investigatory skills including the ability to gather evidence through good interviewing techniques and astute observations
- Ability to convey information gathered during the inspection into clear, understandable investigation reports.
- Up-to-date experience in conducting compliance inspections
- Good communication skills
- Basic understanding of the procedures of obtaining administrative warrants, including preparation of affidavits, technical content of the warrant application, and warrant and procedures for serving a warrant
- At least one team member should have considerable knowledge of laboratory (analytical) methods and Quality Assurance (QA) requirements, if a laboratory evaluation is to be conducted
- For each of the areas addressed in the multimedia investigation, at least one team member should be trained.

Investigators should conduct themselves in a professional manner and maintain credibility. A cooperative spirit should be cultivated within the inspection team and with facility

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representatives, when possible. All investigators should maintain a sensitivity to multimedia issues and implications and freely and routinely discuss, with other members of the team, observations/findings relating to one or more programs.

Investigators should restrict their onsite activities to the normal working hours of the facility, as much as possible. Investigators will need to keep abreast of specific program regulations and should also coordinate, as necessary, with other EPA and State inspectors and laboratory staff (if samples will be collected). The investigation team should implement appropriate field note taking methods and proper document control procedures, particularly when the company asserts a "confidential" claim. Investigators must ensure that important documents (e.g., project plan, safety plan, and log books) are not left unattended at the facility. Sensitive discussions do not take place in front of facility personnel or on company telephones.

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15. E. References and Worksheet

References

National Enforcement Investigations Center (NEIC). March 1992. *Multimedia Investigation Manual and March 1997 P*rocess-Based Inspections Guide (EPA-330/9-97-001).

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16. CONCENTRATED ANIMAL FEEDING OPERATIONS

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Associated Appendices

AA. Bio-Security Guidance (Final)
BB. NPDES CAFO Permit and NMP Minimum Practices Review Checklist

Related Web Sites

Office of Wastewater Management (OWM) Homepage: http://www.epa.gov/owm
National Agriculture Compliance Assistance Center: http://www.epa.gov/agriculture/

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16. A. Objectives

In addition to materials in this chapter, inspectors must be familiar with Chapter 1 - "Introduction" & Chapter 2 - "Inspection Procedures".

The purpose of this Concentrated Animal Feeding Operations (CAFOs) chapter is to provide an overview of the National Pollutant Discharge Elimination System (NPDES) CAFO regulations which include the effluent limitations guidelines (ELGs) and standards for CAFOs. The chapter is for use by state and regional inspectors. It is intended to be used together with the *NPDES Permit Writers' Guidance Manual and Example NPDES Permit for Concentrated Animal Feeding Operations* (the Guidance), published in December 2003, which contains information specific to the inspection of CAFOs. The Guidance reflects the revisions to the ELGs and standards for CAFOs (68 *Federal Register* (FR) 7176: February 12, 2003) that became effective on April 14, 2003. It replaces the previous guidance on NPDES CAFO permits, *Guide Manual on NPDES Regulations for Concentrated Animal Feeding Operations*, issued in 1995. States have from 1 to 2 years to revise their programs to reflect the 2003 CAFO regulations. Under the new regulations, states that do not require a statutory change must revise their programs by February 12, 2004; states that require a statutory change have until February 13, 2005.

The remainder of the *National Pollutant Discharge Elimination System (NPDES) Compliance Inspection Manual* should be consulted for general information about NPDES inspections.

Legal Authority for CAFO Inspections

The Federal Water Pollution Control Act of 1972, as amended by the Clean Water Act (CWA) of 1977 and the Water Quality Control Act of 1987, gives EPA the authority to regulate the discharge of pollutants to waters of the United States. The CWA provides broadly defined authority to establish the NPDES Permit Program, define pollution control technologies, establish effluent limitations, obtain information through reporting and compliance inspections, and take enforcement actions (both civil and criminal) when violations of the act occur.

Section 301(a) of the CWA establishes statutory requirements for the discharge of pollutants from point sources to waters of the United States. Under CWA Section 502(14) and its implementing regulations at 40 CFR Part 122, CAFOs are point source discharges and are therefore subject to the NPDES permitting requirements.

Responsibilities of the CAFO Inspector

The primary role of a CAFO inspector is to gather information to evaluate compliance with the NPDES CAFO permit conditions, including the effluent limitations and any other applicable regulations. The CAFO inspector also plays an important role in enforcement case development and support, as well as permit development. To fulfill these roles, an inspector is required to know and abide by applicable regulations, permits, policies, and procedures; legal requirements concerning inspections; procedures for effective inspection and evidence collection; accepted health and safety practices; and quality assurance standards.

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This chapter is primarily for use by EPA inspectors, but it might also be valuable in orienting and training state inspectors and other regional personnel involved in CAFO enforcement work. Procedures are recommended in this manual, but equivalent state procedures may be substituted where appropriate.

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16. B. CAFO Regulation Overview

Overview

This section defines the term *animal feeding operation* (AFO) and explains which AFOs are CAFOs and subject to NPDES permitting requirements.

Regulatory Background

Section 301(a) of the CWA establishes statutory requirements for the discharge of pollutants from point sources to waters of the United States. Under CWA section 502(14) and its implementing regulations at 40 CFR Part 122, CAFOs are point source discharges and are therefore subject to the NPDES permitting requirements. The effluent limitations guidelines (ELGs) and standards for CAFOs are at 40 CFR Part 412.

Animal Feeding Operation

An AFO is an animal facility that meets both of these conditions:

- Animals are confined for at least 45 days during any 12-month period. The 45 days of confinement do not have to be 45 days in a row, and the 12-month period can be any consecutive 12 months.
- Crops, forage growth, and other vegetation are not grown in the area where the animals are confined.

Pasture and rangeland operations are not AFOs because the animals are not confined or concentrated in an area where manure builds up. A pasture or grazing-based operation, however, might also have additional areas such as feedlots, barns, or pens that meet the conditions described above to be defined as an AFO. A winter feedlot can still be an AFO even if the feedlot area is used to grow crops or forage when animals are not confined there. In the case of winter feedlots, the "no vegetation" condition applies to only the time when the animals are confined there. The AFO definition is not limited to the animal types discussed in the regulations. An operation that confines any type of animal and meets both of the conditions in the definition is an AFO. In addition to confinement areas at animal production facilities, confinement areas at auction houses, sale barns, livestock marketing areas, horse show arenas, and stable areas of racetracks may be considered AFOs if they meet both of the conditions in the definition.

Concentrated Animal Feeding Operation

For a facility to be a CAFO, it must first meet the regulatory definition of an AFO. A CAFO is an AFO that meets specific, regulation-defined, characteristics. There are two ways for an AFO to be considered a CAFO:

- An AFO may be defined as a CAFO
- An AFO may be designated as a CAFO

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AFOs Defined as CAFOs

An AFO may be defined as a CAFO if it has a certain number of animals and it meets the other criteria in the regulations. The regulations set thresholds for size categories (Large, Medium, and Small) based on the number of animals confined at the operation for a total of 45 days or more in any 12-month period. Tables provided later in this chapter show the thresholds for Large, Medium, and Small CAFOs for different kinds of animals.

Large CAFOs

An operation is defined as a Large CAFO if it meets the regulatory definition of an AFO and meets the Large CAFO threshold for that animal type (See Tables 16-2 through 16-13).

Medium CAFOs

An operation is defined as a Medium CAFO if it meets the regulatory definition of an AFO, meets the Medium CAFO thresholds for that animal type (See Tables 16-2 through 16-13), and meets at least one of the following two criteria (called "discharge criteria"):

- A man-made ditch, pipe, or similar device carries manure or process wastewater from the operation to surface water or
- The animals come into contact with surface water that runs through the area where they are confined.

The discharge criteria apply to only the parts of the operation that have animals confined, store manure or raw materials, and contain waste. For example, if a ditch is dug or a pipe is installed to drain water from the confinement area into a stream or lake, the operation would meet the first discharge criterion. Open tile drains in the areas where animals are confined, wastes are collected and stored, or raw materials are kept also meet the first criterion if the tile drains carry pollutants from these areas to surface water. The operation meets the second discharge criterion if a stream runs through the confinement area and the animals have direct access to the stream.

Small CAFOs

Small CAFOs are AFOs that confine fewer than the number of animals that defines a Medium CAFO, meet specific discharge criteria, and have been designated as CAFOs (see the designation discussion below).

AFOs Designated as CAFOs

The second mechanism for an AFO to be determined to be a CAFO is through designation. The NPDES regulations for CAFOs set forth the standards and process for the NPDES permitting authority, or in some cases EPA, to designate, on a case-by-case basis, any AFO as a CAFO, upon determining that the facility is a significant contributor of pollutants to waters of the United States. Designation ensures protection of surface water quality while maintaining flexibility for states or other entities to assist small and medium operations in removing risk conditions before they become subject to the NPDES requirements applicable to CAFOs.

Any AFO may be designated as a CAFO, on a case-by-case basis, if it is determined to be a significant contributor of pollutants to waters of the United States as specified in 40 CFR

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122.23(c). Given the structure of the CAFO definition, however, three types of AFO operations are typically considered for designation:

- A medium-sized AFO that does not meet one of the specific discharge criteria and is determined to be a significant contributor of pollutants to waters of the United States.
- A small AFO (one that confines fewer than the number of animals that define a Medium CAFO) if the facility meets one of the method of discharge criteria [40 CFR 122.23(c)(3)(i) and (ii)] and is determined to be a significant contributor of pollutants to waters of the United States.
- An AFO that raises animals other than species identified in the regulatory definition of a CAFO and is determined to be a significant contributor of pollutants to waters of the United States. Examples of such AFOs include operations that raise geese, emus, ostriches, llamas, mink, bison, alligators.

No operation may be designated as a CAFO until an inspector has conducted an on-site inspection of the facility, regardless of the size of the operation or the type of animals confined [40 CFR 122.23(c)(3)].

Factors to Be Considered When Designating an AFO as a CAFO

For an AFO to be designated as a CAFO, it must be determined to be a significant contributor of pollutants to waters of the United States by the permitting authority or, in some cases, the EPA Regional Administrator [40 CFR 122.23(c)]. Once an operation is designated as a CAFO, it must seek coverage under an NPDES permit and, among other requirements, develop and implement a nutrient management plan.

An AFO may not be designated as a CAFO until the NPDES permitting authority or EPA has conducted an on-site inspection of the operation and determined that the operation should and could be regulated under the permit program [40 CFR 122.23(c)(3)]. In addition, a small AFO may not be designated as a CAFO unless it also meets the small AFO method of discharge criteria [122.23(c)(3)(i) and (ii)] and is determined to be a significant contributor of pollutants to waters of the United States.

The on-site inspection serves three primary objectives: (1) to confirm that the facility meets the AFO definition, (2) to collect information related to the CAFO designation factors, and (3) to provide notice to the AFO that it might be designated as a CAFO. The requirement for an on-site inspection helps ensure that a reasoned assessment of the situation has been performed. EPA recommends that the designation process be conducted as soon as possible following the inspection. Regardless of when an inspection takes place, the designation should be based on current information.

In determining whether an AFO is a significant contributor of pollutants to waters of the United States, the permitting authority or EPA Regional Administrator is to consider the factors specified in 40 CFR 122.23(c)(2), which are listed in the left column of Table 16-1. The right column in Table 16-1 gives examples of case-by-case designation factors that might be assessed during the designation inspection. The assessment of regulatory factors may be based on visual observations, as well as water quality monitoring and other sources of relevant information.

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Table 16-1. Example Factors for Case-by-Case CAFO Designation

Designation Factor	Example Factors for Inspection Focus
❑ Size of the Operation and Amount of Waste Reaching Waters of the United States	• Number of animals • Type of feedlot surface • Feedlot design capacity • Waste handling/storage system design capacity
❑ Location of the Operation Relative to Waters of the United States	• Location of water bodies • Location of floodplain • Proximity of production area and land application area to waters of the United States • Depth to ground water, direct hydrologic connection to waters of the United States • Location in an impaired watershed
❑ Means of Conveyance of Animal Waste and Process Wastewater into Waters of the United States	• Existing or potential man-made (including natural and artificial materials) structures that might convey waste • Direct contact between animals and waters of the United States.
❑ Slope, Vegetation, Rainfall, and Other Factors Affecting the Likelihood or Frequency of Discharge of Animal Waste, Manure, and Process Wastewater into Waters of the United States	• Slope of feedlot and surrounding land • Type of feedlot (concrete, soil) • Climate (e.g., arid or wet) • Type and condition of soils (e.g., sand, karst) • Drainage controls • Storage structures • Amount of rainfall • Volume and quantity of runoff • High water table • Buffers
❑ Other Relevant Factors	• History of noncompliance • Use of conservation practices to minimize nutrient transport to waters of the United States • Working with USDA or Soil and Water Conservation District to improve operation

Following the on-site inspection for designation, the inspector should prepare a brief report that (1) identifies findings and any follow-up actions, (2) determines whether the facility should be designated as a CAFO, and (3) documents the reasons for that determination. Regardless of the outcome, a letter should be prepared and sent to inform the facility of the results of the inspection. If the permitting authority has made a decision to designate an AFO as a CAFO, the letter should specify that the operation must obtain an NPDES permit. The letter should indicate whether a general permit is available or whether an individual permit application is to be submitted by a specific date. In those cases where a facility has not been designated as a CAFO but the NPDES permitting authority has identified areas of concern, these areas should be noted in the letter. The letter should state that if these concerns are not corrected, the facility might be designated in the future. It should also include a date for a follow-up inspection to determine whether the concerns have been adequately addressed.

EPA Designation Authority

The NPDES CAFO regulations explicitly authorize the EPA Regional Administrator to designate AFOs as CAFOs in NPDES-authorized states and tribes where the Regional Administrator has determined that one or more pollutants in an AFO's discharge contribute to an impairment in a downstream or adjacent state or Indian Country water that is impaired by that pollutant. Such designation is based on assessment of the factors in 40 CFR 122.23(c)(2) and also requires an

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on-site inspection. Upon designation by EPA, the operation is required to apply to the permitting authority for permit coverage.

CAFO Definition Thresholds for Specific Animal Sectors

In the NPDES CAFO regulations, EPA has set thresholds for determining which AFOs are CAFOs for specific animal sectors. The thresholds define which AFOs are Large CAFOs. In addition, the thresholds, along with regulation-defined discharge criteria, define which AFOs are Medium CAFOs. The thresholds also determine which operations are potentially subject to designation. Tables 16-2 through 16-13 show these thresholds for the various animal sectors.

The thresholds in Table 16-2 apply to operations that confine any kind of cattle other than mature dairy cows, including heifers, steers, bulls, and cow/calf pairs. For example, these thresholds apply to beef cattle operations such as feedlots and backgrounding yards, veal calf operations, and contract dairy heifer operations. Except for cow/calf pairs, each animal is counted as one animal, regardless of its age or weight. In the case of cow/calf pairs; the pair is counted as one animal until the calf is weaned. After the calf is weaned, the cow and calf count as individual animals.

Table 16-2. Thresholds for Cattle (other than mature dairy cows)

An AFO that has ...	is a ...	by ...
at least 1,000 cattle, dairy heifers, cow/calf pairs, or veal calves	Large CAFO	regulatory definition
from 300 to 999 cattle, dairy heifers, cow/calf pairs, or veal calves and meets one of the medium category discharge criteria	Medium CAFO	regulatory definition
from 300 to 999 cattle, dairy heifers, cow/calf pairs, or veal calves **and** has been designated by the permitting authority	Medium CAFO	designation
fewer than 300 cattle, dairy heifers, cow/calf pairs, or veal calves **and** has been designated by the permitting authority	Small CAFO	designation

The thresholds in Table 16-3 apply to operations that confine mature dairy cows. Mature dairy cows include both milked and "dry" cows. Thresholds for AFOs that house any other kind of cattle, including heifers and veal calves, are shown in Table 16-2 ("Thresholds for Cattle (other than mature dairy cows").

Table 16-3. Thresholds for Mature Dairy Cows

An AFO that has ...	is a ...	by ...
at least 700 mature dairy cows	Large CAFO	regulatory definition

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from 200 to 699 mature dairy cows and meets one of the medium category discharge criteria	Medium CAFO	regulatory definition
from 200 to 699 mature dairy cows **and** has been designated by the permitting authority	Medium CAFO	designation
fewer than 200 mature dairy cows **and** has been designated by the permitting authority	Small CAFO	designation

The thresholds in Table 16-4 apply to operations that confine swine that weigh at least 55 pounds. These operations include farrow-finish operations, wean-finish operations, farrowing operations, breeding operations, grow-finish operations, and other specialized AFOs that confine mature swine. AFOs that house immature swine (less than 55 pounds) might also be subject to the thresholds shown in Table 16-5 ("Thresholds for Swine (less than 55 pounds)").

Table 16-4. Thresholds for Swine (55 pounds or more)

An AFO that has...	is a...	by...
at least 2,500 swine weighing 55 pounds or more	Large CAFO	regulatory definition
from 750 to 2,499 swine weighing 55 pounds or more **and** meets one of the medium category discharge criteria	Medium CAFO	regulatory definition
from 750 to 2,499 swine weighing 55 pounds or more **and** has been designated by the permitting authority	Medium CAFO	designation
fewer than 750 swine weighing 55 pounds or more **and** has been designated by the permitting authority	Small CAFO	designation

The thresholds in Table 16-5 apply to operations that confine swine that weigh less than 55 pounds. These thresholds typically apply to swine nurseries, but they may also apply to other facilities that confine swine of all sizes but primarily confine large numbers of immature swine. For example, an operation with 1,000 sows, 50 boars, and 14,000 newborn pigs is a Large CAFO. Remember that AFOs that house "mature" swine (55 pounds or more) are already subject to the thresholds in the sector "swine (55 pounds or more)" (Table 16-4). Therefore, a swine operation could be defined as a CAFO because of the number of swine weighing 55 pounds or more, the number of swine weighing less than 55 pounds, or both.

Table 16-5. Thresholds for Swine (less than 55 pounds)

An AFO that has...	is a...	by...
at least 10,000 swine weighing less than 55 pounds	Large CAFO	regulatory definition

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from 3,000 to 9,999 swine weighing less than 55 pounds **and** meets one of the medium category discharge criteria	Medium CAFO	regulatory definition
from 3,000 to 9,999 swine weighing less than 55 pounds **and** has been designated by the permitting authority	Medium CAFO	designation
fewer than 3,000 swine weighing less than 55 pounds **and** has been designated by the permitting authority	Small CAFO	designation

The thresholds in Table 16-6 apply to operations that confine horses. The confinement area does not include areas like pastures. Most horse operations confine their animals only for short-term stabling or visits to stalls for shoeing, veterinary care, or similar activities. The horses might not be confined for enough days for the operation to meet the criteria for being an AFO. Data from the U.S. Department of Agriculture's (USDA's) National Animal Health Monitoring System suggest that practically all Large horse CAFOs (those with more than 500 horses in confinement) are racetracks.

Table 16-6. Thresholds for Horses

An AFO that has...	is a...	by ...
at least 500 horses	Large CAFO	regulatory definition
from 150 to 499 horses **and** meets one of the medium category discharge criteria	Medium CAFO	regulatory definition
from 150 to 499 horses **and** has been designated by the permitting authority	Medium CAFO	designation
fewer than 150 horses **and** has been designated by the permitting authority	Small CAFO	designation

The thresholds in Table 16-7 apply to operations that confine sheep, lambs, or both. All confined sheep and lambs are counted to determine whether the operation meets these thresholds. Confinement areas do not include grazing pastures. Operations with grazing areas might confine animals only for shearing, veterinary care, and lambing and before sale or processing. The animals might not be confined for enough days for the operation to be considered an AFO. Animals must be confined for 45 days or more in a 12-month period for an operation to be considered an AFO.

Table 16-7. Thresholds for Sheep or Lambs

An AFO that has...	is a...	by ...
at least 10,000 sheep or lambs mature dairy cows	Large CAFO	regulatory definition

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from 3,000 to 9,999 sheep or lambs **and** meets one of the medium category discharge criteria	Medium CAFO	regulatory definition
from 3,000 to 9,999 sheep or lambs **and** has been designated by the permitting authority	Medium CAFO	designation
fewer than 3,000 sheep or lambs **and** has been designated by the permitting authority	Small CAFO	designation

The thresholds in Table 16-8 apply to operations that confine turkeys. Most turkey operations today confine their birds in confinement houses, but turkeys are also raised on lots. All birds, including poults and breeders, are counted to determine whether the operation meets the thresholds.

Table 16-8. Thresholds for Turkeys

An AFO that has ...	is a ...	by ...
at least 55,000 turkeys	Large CAFO	regulatory definition
from 16,500 to 54,999 turkeys **and** meets one of the medium category discharge criteria	Medium CAFO	regulatory definition
from 16,500 to 54,999 turkeys **and** has been designated by the permitting authority	Medium CAFO	designation
fewer than 16,500 turkeys **and** has been designated by the permitting authority	Small CAFO	designation

The thresholds in Table 16-9 apply to operations that confine laying hens or broiler chickens **and** use a liquid manure handling system (such as caged housing where manure is flushed to a lagoon). Liquid manure handling systems are relatively common among layer operations and are rarely used in other chicken operations. Operations that do not use liquid manure handling systems are subject to thresholds for the sector "laying hens (operations with other than a liquid manure handling system)" (Table 16-10) or "chickens other than laying hens (operations with other than a liquid manure handling system)" (Table 16-11). For pullets see "Thresholds for Chickens other than laying hens (operations with other than a liquid manure handling system)" (Table 16-11).

Table 16-9. Thresholds for Chickens (operations with a liquid handling system)

An AFO that has ...	is a ...	by ...
at least 30,000 chickens and uses a liquid manure handling system	Large CAFO	regulatory definition

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from 9,000 to 29,999 chickens, uses a liquid manure handling system, **and** meets one of the medium category discharge criteria	Medium CAFO	regulatory definition
from 9,000 to 29,999 chickens, uses a liquid manure handling system, **and** has been designated by the permitting authority	Medium CAFO	designation
fewer than 9,000 chickens, uses a liquid manure handling system, **and** has been designated by the permitting authority	Small CAFO	designation

The thresholds in Table 16-10 apply to layer operations that do not use a liquid manure handling system. These operations include scrape-out and belt manure handling systems, high-rise cage housing, and litter-based housing. A chicken operation that uses a liquid manure handling system is subject to thresholds for the sector "chickens (operations with a liquid manure handling system)" (Table 16-9). Non-layer operations, including broiler operations, that do not use a liquid manure handling system are subject to thresholds in the sector "chickens other than laying hens (operations with other than a liquid manure handling system)" (Table 16-11).

Table 16-10. Thresholds for Laying Hens (operations with other than a liquid manure handling system)

An AFO that has...	is a...	by...
at least 82,000 laying hens and **does not** use a liquid manure handling system	Large CAFO	regulatory definition
from 25,000 to 81,999 laying hens, **does not** use a liquid manure handling system, **and** meets one of the medium category discharge criteria	Medium CAFO	regulatory definition
from 25,000 to 81,999 laying hens, **does not** use a liquid manure handling system, **and** has been designated by the permitting authority	Medium CAFO	designation
fewer than 25,000 laying hens, **does not** use a liquid manure handling system, **and** has been designated by the permitting authority	Small CAFO	designation

The thresholds in Table 16-11 apply to operations that confine broilers, roasters, pullets, or breeders **and** do not use a liquid manure handling system. These chicken operations typically use enclosed housing and dry litter systems. A chicken operation that uses a liquid manure handling system is subject to thresholds for the sector "chickens (operations with a liquid manure handling system)" (Table 16-9). A layer operation that does not use a liquid manure handling system is subject to thresholds for the sector "laying hens (operations with other than a liquid manure handling system)" (Table 16-10).

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Chicken operations with uncovered litter stockpiles are treated as operations with liquid manure handling systems and are subject to the Large CAFO threshold of 30,000 chickens for operations with a liquid manure handling system. By covering such stockpiles, a chicken operation becomes eligible for the higher thresholds for operations with other than a liquid manure handling system.

Table 16-11. Thresholds for Chickens Other Than Laying Hens (operations with other than a liquid manure handling system)

An AFO that has ...	is a ...	by ...
at least 125,000 chickens other than laying hens and **does not** use a liquid manure handling system	Large CAFO	regulatory definition
from 37,500 to 124,999 chickens other than laying hens, **does not** use a liquid manure handling system, **and** meets one of the medium category discharge criteria.	Medium CAFO	regulatory definition
from 37,500 to 124,999 chickens other than laying hens, **does not** use a liquid manure handling system, **and** has been designated by the permitting authority	Medium CAFO	designation
fewer than 37,500 chickens other than laying hens, **does not** use a liquid manure handling system, **and** has been designated by the permitting authority	Small CAFO	designation

The thresholds in Table 16-12 apply to duck operations that use a liquid manure handling system. These include operations with "wet" lots, lots with storage ponds, lots with swimming areas, and operations that flush manure from confinement buildings to lagoons. All birds confined at the operation are counted to determine whether the operation meets the thresholds. A duck operation that does not use a liquid manure handling system is subject to thresholds for the sector "ducks (operations with other than a liquid manure handling system)" (Table 16-13).

Table 16-12. Thresholds for Ducks (operations with a liquid manure handling system)

An AFO that has ...	is a ...	by ...
at least 5,000 ducks and uses a liquid manure handling system	Large CAFO	regulatory definition
from 1,500 to 4,999 ducks, uses a liquid manure handling system, **and** meets one of the medium category discharge criteria	Medium CAFO	regulatory definition
from 1,500 to 4,999 ducks, uses a liquid manure handling system, **and** has been designated by the permitting authority	Medium CAFO	designation

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fewer than 1,500 ducks, uses a liquid manure handling system, **and** has been designated by the permitting authority	Small CAFO	designation

The thresholds in Table 16-13 apply to any duck operation that does not use a liquid manure handling system. All birds confined at the operation are counted to determine whether the operation meets the thresholds. A duck operation that uses a liquid manure handling system is subject to thresholds for the sector "ducks (operations with a liquid manure handling system)" (Table 16-12).

Table 16-13. Thresholds for Ducks (operations with other than a liquid manure handling system)

An AFO that has ...	is a ...	by ...
at least 30,000 dusks and does not use a liquid manure handling system	Large CAFO	regulatory definition
from 10,000 to 29,999 ducks, **does not** use a liquid manure handling system, **and** meets one of the medium category discharge criteria	Medium CAFO	regulatory definition
from 10,000 to 29,999 ducks, **does not** use a liquid manure handling system, **and** has been designated by the permitting authority	Medium CAFO	designation
fewer than 10,000 ducks, **does not** use a liquid manure handling system, **and** has been designated by the permitting authority	Small CAFO	designation

Practices That Constitute a Liquid Manure Handling System at Chicken Operations

The thresholds for chicken AFOs in the CAFO definition are based on the type of litter or manure handling system being used. The system is either a liquid manure handling system or other than a liquid manure handling system. A liquid manure handling system includes the use of pits, lagoons, flush systems (usually combined with lagoons), and holding ponds. Systems such as continuous overflow watering, where water is added to manure or litter, are also liquid manure handling systems. In addition, an operation that removes waste from confinement areas and stacks or piles it in areas exposed to rainfall is considered to have a liquid manure system. Such operations include those operations that remove litter from the confinement area and stockpile or store it in remote locations. Permitting authorities may authorize a limited period of temporary storage of litter of no more than 15 days that would not result in the facility's meeting the definition of a liquid manure handling system (e.g., where this limited time is needed to allow for contract hauling arrangements). Once litter is stockpiled beyond such a temporary period, the uncovered stockpile constitutes a liquid manure handling system and the lower threshold for chickens at 30,000 birds and ducks at 5,000 birds becomes applicable to the operation.

Distinguishing Wet Lot and Dry Lot Duck Operations

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For ducks, there are two thresholds for defining an operation as a CAFO: (1) where the animals are raised outside with swimming areas or ponds, or with a stream running through an open lot, or (2) in confinement buildings where water is used to flush the manure to a lagoon, pond, or other liquid storage structure. These types of operations are considered to be wet lots with liquid manure handling systems.

A duck operation using confinement buildings and handling manure and bedding exclusively as dry material; an operation using a building with a mesh or slatted floor over a concrete pit, where the manure is scraped into a waste storage facility; or an operation using dry bedding on a solid floor is referred to as a "dry" operation. These operations use other than a liquid manure handling system. In the case of operations that stack litter, however, see the discussion above.

AFOs With More Than One Type of Animal

An AFO is defined as a CAFO if any one animal type in confinement meets the threshold for either a Large or Medium CAFO. An operation that meets the threshold for a Medium CAFO must also meet one of the discharge criteria to be defined as a Medium CAFO. Under the revised NPDES CAFO regulation, multiple types of animals are no longer counted together to determine the type and size of a CAFO. However, once a given operation is defined as a CAFO, regardless of animal type, the regulations apply to all the manure, litter, and wastewater generated by all the animals confined at the operation. In the event that waste streams from multiple livestock species are commingled and the regulatory requirements for the species are not the same, the permit must include the more stringent ELG requirements.

Requirements for NPDES Permit for CAFO

The basic elements of an NPDES permit for a CAFO are the same as those of permits issued to other point sources. These elements consist of a cover page, effluent limitations, monitoring and reporting requirements, record-keeping requirements, special conditions, and standard conditions (see Table 16-14). For additional details on the elements of an NPDES permit, refer to the *U.S. EPA NPDES Permit Writers' Manual* (EPA-833-B-96-003).

Table 16-14. Elements of an NPDES Permit

Element	Description
Cover Page	Serves as the legal notice of the applicability of the permit, provides the authority under which the permit is issued, and contains appropriate dates and signature(s).
Effluent Limitations and Standards	Serves as the primary mechanism for controlling discharges of pollutants to receiving waters (e.g., the specific narrative or numeric limitations applied to the facility and the point of application of these limits).
Monitoring and Reporting Requirements	Identifies all the specific conditions related to the types of monitoring to be performed, the frequencies for collecting samples or data, and how to record, maintain, and transmit the data and information to the permitting authority.
Record-Keeping Requirements	Specifies the types of records to be kept on-site at the permitted facility (e.g., inspection and monitoring records; manure and soil sampling results; time, amount, and duration of land application activities; precipitation records; records of recipients of waste intended for application on land outside the operational control of the CAFO facility).

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Table 16-14. Elements of an NPDES Permit

Element	Description
Special Conditions	In NPDES permits for CAFOs, special conditions must include (1) the requirement to develop and fully implement a nutrient management plan and (2) the requirement that the nutrient management plan address nine minimum practices defined in the regulation. In addition, NPDES permits for CAFOs may include other special conditions as determined necessary by the permitting authority.
Standard Conditions	Conditions that apply to all NPDES permits, such as the requirement to properly operate and maintain all facilities and systems of treatment and control, as specified in 40 CFR 122.41.

Role of the Inspector

The content of a specific permit may vary, but permits will generally address the six elements in Table 16-14. The inspector's role, however, is to determine compliance with the actual permit as written, not what the permit should contain. The permit conditions required by the NPDES CAFO regulations are outlined below to help inspectors understand what provisions they are likely to find in CAFO permits.

CAFOs That Are Not Required to Have an NPDES Permit

Under some limited circumstances, an operation that meets the definition of a Large CAFO might not be required to obtain an NPDES permit. Large CAFOs that do not have the potential to discharge do not need NPDES permits. A Large CAFO is not required to apply for an NPDES permit if (1) the owner/operator has provided evidence to the permitting authority that there is no potential for the operation to discharge manure, litter, or process wastewater to surface waters; (2) the permitting authority agrees; and (3) the permitting authority has provided notice that the CAFO has "no potential to discharge" manure, litter, or process wastewater. "No potential to discharge" means that the CAFO must not discharge manure, litter, or process wastewater from either the production areas or any land application areas to surface waters, even by accident or because of human error. A large CAFO may qualify for a "no potential to discharge" determination if:

- The owner or operator can show that there is no possibility for any CAFO manure, litter, or wastewater to be added to surface waters under any circumstances or conditions and
- The operation has not had a discharge for at least the past 5 years.

The "no potential to discharge" determination is intended to provide relief where there truly is no potential for a Large CAFO's manure or wastewater to reach surface waters under any circumstances or conditions. For example, the operator of a CAFO that meets the following conditions might be able to demonstrate to the permitting authority that the CAFO has no potential to discharge:

- Located in an arid or semiarid environment.
- Stores all its manure or litter in a permanent, covered containment structure that precludes wind dispersal and prevents precipitation from contacting the manure or litter.
- Has sufficient containment to hold all process wastewater and contaminated storm water.

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- Does not land apply CAFO manure or litter because, for example, the CAFO sends all its manure or litter to a regulated, off-site fertilizer plant or composting facility.

The "no potential to discharge" determination is not available to medium AFOs because the existence of a discharge is incorporated into the definition of a Medium CAFO. Small operations may become CAFOs only through designation, so the determination is not applicable.

NPDES Permit Effluent Limitations and Standards for CAFOs

Section 301 of the Clean Water Act prohibits the discharge of pollutants from a point source into waters of the United States except in accordance with an NPDES permit. Effluent limitations are the primary mechanism in NPDES permits for controlling discharges of pollutants to receiving waters. The CAFO ELGs are at 40 CFR Part 412.

Applicable Technology Standards for CAFOs

The CAFO ELGs, published on February 12, 2003, are applicable to only those operations that meet the regulatory definition of a Large CAFO. The CAFO ELGs establish the technology-based effluent limitations and standards for Large CAFOs. Table 16-15 provides the specific regulatory citations of the ELGs applicable to each animal sector. In the case of Medium and Small CAFOs, the permit writer develops effluent limitations (including the technology-based limitations and standards) on a case-by-case basis. The authority to issue case-by-case permit limitations comes from section 402(a)(1) of the CWA and 40 CFR 122.44(a) and 125.3. These case-by-case effluent limits are referred to as best professional judgment (BPJ) permit limitations.

Permit limitations are based on BPJ when national ELGs that apply to the appropriate industrial category, or to the particular process involved, have not been issued. For example, there are no ELGs for Small or Medium CAFOs or for "exotic" animal species, and there are no applicable ELGs for the land application areas at large horse, sheep, or duck CAFOs.

It is important for the compliance inspector to recognize that the CAFO ELGs do not address some discharges that might occur at a CAFO, such as discharges of plate chiller water and filter backwash water; pollutants (such as manure, feathers, and feed) that have fallen to the ground immediately downwind from confinement building exhaust ducts and ventilation fans and are carried by storm water runoff to waters of the United States; and discharges associated with the use of disinfectants in the production area. If these potential discharge sources are present, the inspector should determine whether they have been included in the ELGs specified in the permit (through the use of BPJ by the permit writer) and whether any discharges to waters of the United States have occurred in violation of CWA requirements.

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Table 16-15. Effluent Limitations Summary

Animal Sector	ELG Technology-Based Limits
Large CAFOs	40 CFR Part 412
Subpart A - Horses and sheep	40 CFR 412.13
Subpart B - Ducks	40 CFR 412.22
Subpart C - Dairy cows and cattle other than veal calves	40 CFR 412.33 and 412.37
Subpart D - Swine, poultry, and veal calves	40 CFR 412.45 and 412.47
Medium CAFOs - Horses, sheep, duck, dairy cows, cattle, swine, poultry, and veal calves	BPJ
Small CAFOs - Horses, sheep, duck, dairy cows, cattle, swine, poultry, and veal calves	BPJ
Other CAFOs - Alligators, geese, emus, ostriches, mink, bison, etc.	BPJ

Technology-based ELGs for Large CAFOs

The ELGs address two main areas of Large CAFOs—the production area and the land application areas. The following sections describe the requirements that will be included in permits for CAFOs that are subject to the ELGs. In some cases the permitting authority might include additional effluent limitations in the permit.

Production Area ELG Requirements for Existing Large CAFOs

The production area of the CAFO includes the animal confinement area, the manure storage area, the raw materials storage area, and the waste containment areas. No discharges of manure, litter, or wastewater from the production area of the CAFO may enter waters of the United States. In addition, the CAFO must comply with specific record-keeping requirements.

The ELG requirements for Large CAFOs do allow a discharge caused by rainfall events, but only if the facility meets certain conditions. Dry-weather discharges are never allowed. Discharges from the production areas of a Large horse, sheep, beef, dairy, swine, turkey, or chicken CAFO are allowed if the operation meets all the following conditions:

- The production area must be designed, built, operated, and maintained to handle all the manure, litter, and process wastewater, including the runoff and direct precipitation (rain) from all normal rainfall events up to a *25-year, 24-hour rainfall event*. To meet this requirement, the design volumes of the storage structures need to account for the following:
  - ✓ The maximum length of time before emptying the structures (the storage period).
  - ✓ All waste accumulated during the storage period.
  - ✓ Normal precipitation and evaporation during the storage period.
  - ✓ Normal runoff during the storage period.
  - ✓ The direct precipitation from a 25-year, 24-hour rainfall event.
  - ✓ The runoff from a 25-year, 24-hour rainfall event.
  - ✓ Residual solids after liquid has been removed.
  - ✓ Necessary freeboard to maintain storage integrity.

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  - ✓ For treatment lagoons, a minimum treatment volume and any additional storage needed to meet management goals or other regulatory requirements.
- The discharge may consist of only overflows caused by the rainfall event. Dry-weather discharges are not allowed.
- The operation must comply with all record-keeping requirements specified in the ELGs. (The specific requirements are discussed later in this section.) If the operation is not keeping the required records, no discharges are allowed.

Discharges caused by poor operation or management are never allowed, even if it is raining. The regulation requires that the production area must be properly designed, constructed, operated, and maintained. Proper design and operation includes designing lagoons for the rainy season, draining lagoons before the rainy season begins, and not applying manure to saturated soils or during rain events. Proper operation and maintenance also includes activities such as dewatering when appropriate and in accordance with a nutrient management plan. Occasionally a series of rainfall events that are far above normal rainfall might occur so close together that they prevent dewatering. Under such conditions, even though storage structures have been properly designed, constructed, and managed, a series of small storms could however, cause a permissible overflow. With proper planning and maintenance, however, the operation should usually be able to avoid these situations.

Production Area ELG Requirements for New Source Large CAFOs

Some new CAFOs designed and built after April 14, 2003, are subject to more stringent ELG requirements for the production area. (No additional requirements apply to the land application areas for new source CAFOs.) For additional information concerning the requirements for new sources, refer to the *NPDES Permit Writers' Guidance Manual and Example NPDES Permit for CAFOs.*

Production Area Additional Measures and Record-keeping Requirements for All Large CAFOs

The following is a general summary of additional measures and record-keeping requirements for the production area that are applicable to all Large CAFOs. The specific requirements are listed in 40 CFR 412.37(a) and (b). The NPDES permit for Large CAFOs will include the following additional measures and record-keeping requirements:

- Routine visual inspections of the CAFO production area. At a minimum the following visual inspections must be performed:
  - ✓ Weekly visual inspections of all storm water diversion devices, runoff diversion structures, and devices channeling contaminated storm water to the wastewater and manure storage and containment structure.
  - ✓ Daily visual inspections of all water lines, including drinking water or cooling water lines.
  - ✓ Weekly inspections of the manure, litter, and process wastewater impoundments. The inspection will note the level in liquid impoundments as indicated by the depth markers.
  - ✓ Any deficiencies found as a result of these inspections must be corrected as soon as possible.
- Installation of depth markers in all open-surface liquid impoundments (excluding for example, in under-house pits) that clearly indicate the minimum capacity necessary to contain the runoff and direct precipitation of the 25-year, 24-hour rainfall event or the 100-year, 24-hour rainfall event, whichever is applicable.

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- No disposal of animal mortalities in any liquid manure or process wastewater systems and the handling of animal mortalities so as to prevent discharge of pollutants to waters of the United States, unless alternative technologies pursuant to 40 CFR 412.31(a)(2) and approved by the Director of the permitting authority are designed to handle mortalities.
- Complete on-site records documenting implementation of all required additional measures and any other records specified by the permitting authority. The specific records required by the CAFO ELGs and the NPDES CAFO regulations are discussed later in this section.

Land Application Area Requirements for Large Beef Cattle, Dairy Cattle, Veal Calf, Swine, Turkey, and Chicken CAFOs

The land application area is any land that is under the control of the CAFO owner or operator — regardless of whether it is owned, rented, or leased — and to which manure or process wastewater from the production area is (or might be) applied. For example, if the CAFO applied litter to field "A" last year and does not intend to apply litter there again until next year, that field is still part of the CAFO's land application area for purposes of the nutrient management plan. The land application requirements are the same for existing and new sources. The land application requirements specified in the CAFO ELGs (40 CFR 412.4) are applicable to all Large beef cattle, dairy cattle, veal calf, swine, turkey, and chicken CAFOs (Large CAFOs subject to 40 CFR Part 412, Subparts C and D).

The CAFO ELGs require that all Large beef cattle, dairy cattle, veal calf, swine, turkey, and chicken CAFOs properly apply manure, litter, or wastewater to land application areas under the control of the CAFO operator. This is done by implementing best management practices (BMPs) developed in accordance with a nutrient management plan. The CAFO's nutrient management plan must be designed to achieve realistic production goals, while minimizing nitrogen and phosphorus movement to surface waters.

Even though the CAFO ELGs do not set land application area requirements for horse, sheep, or duck CAFOs, NPDES permits for these operations will require land application BMPs as part of the nutrient management plan. (See NPDES CAFO permit special conditions that are applicable to all CAFOs).

Large beef cattle, dairy cattle, veal calf, swine, turkey, and chicken CAFOs must also implement the following BMPs and any other BMPs required by their permits (as specified in the ELGs):

- Land apply manure, litter, and process wastewater in accordance with a nutrient management plan that specifies application rates for each field. The permitting authority will establish technical standards that must be used to determine land application rates.
- At least once a year, collect representative samples of manure, litter, and other wastewater and analyze them for nutrient content, including nitrogen and phosphorus.
- At least once every 5 years, collect representative soil samples from all fields where manure, litter, and process wastewater are applied and analyze them for phosphorus content.
- Maintain a setback area within 100 feet of any down-gradient surface waters, open tile intake structures, sinkholes, agricultural well heads, or other conduits to surface waters where manure, litter, and other wastewaters are not applied. As a

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compliance alternative, the CAFO may elect to establish a 35-foot vegetated buffer where manure, litter, and other wastewater are not applied. The CAFO owner or operator may demonstrate to the permitting authority that a setback or vegetated buffer is unnecessary because of site-specific conditions or practices.

- Periodically conduct leak inspections of equipment used for land application of manure, litter, or wastewater.

If a CAFO has a permit and is in full compliance with the permit, which includes properly developing and implementing the nutrient management plan, precipitation-related runoff from the land application area is an allowable discharge. On the other hand, if a CAFO does not have a permit or does not have a nutrient management plan, or the CAFO operator does not follow the nutrient management plan when applying manure, litter, and process wastewater, a discharge from the land application area of the CAFO is a violation of the Clean Water Act.

Technical Standard for Nutrient Management

The ELG determination of appropriate application practices for manure, litter, and process wastewater must be done in accordance with the technical standards established by the permitting authority. These technical standards guide the development of the site-specific nutrient management plan and must include a field-specific assessment of the potential for nitrogen and phosphorus transport from the field to waters of the United States. In addition, the standards must address the form, source, amount, timing, and method of application of nutrients on each field to achieve realistic production goals, while minimizing nitrogen and phosphorus movement to waters of the United States. The technical standards for nutrient management are also to include appropriate flexibility for any CAFO to implement nutrient management practices to comply with the standards.

The NPDES compliance inspector should verify that the permittee has used the nutrient management technical standard established by the permitting authority to develop and implement the site-specific nutrient management plan.

NPDES Permits for CAFOs: Special Conditions

The CAFO regulations establish two special conditions that must be included in all NPDES CAFO permits and one additional special condition applicable to only Large CAFOs. In addition, the permitting authority may include other special conditions in the NPDES permit.

Special Condition for All CAFOs: Develop and Implement a Nutrient Management Plan

The NPDES CAFO regulations specify that the NPDES permit for any CAFO must include a special condition requiring the CAFO, regardless of size, to develop and implement a nutrient management plan. The goal of the nutrient management plan is to minimize the CAFO's impact on water quality. The plan must describe the practices and procedures that will be implemented at the operation to meet all the production area and land application area requirements that apply.

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The nutrient management plan must address land application of manure and wastewater on all land under the operational control of the CAFO operator or owner. Operational control of land includes ownership, rental agreements, leases, and access agreements.

Certified Specialists and Nutrient Management Plans

EPA's CAFO regulations do not mandate that the required site-specific nutrient management plan be developed by a certified specialist or technical service provider. However, compliance inspectors should view the use of these professionals favorably when determining whether the plan complies with permit requirements (ELGs and NPDES minimum practices).

A certified specialist is a person who has a demonstrated capability to develop Nutrient Management Plan (NMPs) in accordance with applicable U.S. Department of Agriculture (USDA) or state standards and is certified by USDA or a USDA-sanctioned organization. States have the discretion to require the use of such specialists to prepare or approve plans.

Requirements for Updating Nutrient Management Plans

CAFOs are dynamic operations where changes to the operational practices are made continually. The site-specific nutrient management plan needs to reflect the current operational practices of the CAFO and for that reason will need to be modified and updated. The compliance inspector should verify that the nutrient management plan is being updated in accordance with permit requirements. At a minimum NPDES permits for CAFOs should require that nutrient management plans be reviewed and updated at the time of permit renewal. The *NPDES Permit Writers' Guidance Manual and Example Permit for CAFOs* includes a recommendation that NPDES permits for CAFOs also specify that the nutrient management plan be updated (1) when the CAFO makes a substantive change in how it manages operations, including the location, method, timing, or frequency of land application, and significant changes to crop rotations or yearly cropping patterns, or (2) when a discharge occurs in violation of the CAFO's NPDES permit.

Special Condition for All CAFOs: Address Minimum Practices

The nutrient management plan must include BMPs and procedures necessary to implement the applicable ELGs for CAFOs. The nutrient management plan must also include, to the extent applicable, a set of minimum practices (see 40 CFR 122.42(e)(1)(i–ix). These NPDES nutrient management plan minimum practices are as follows:

- Ensure adequate storage of manure, litter, and process wastewater, including procedures to ensure proper operation and maintenance of the storage facilities.
- Ensure proper management of mortalities (dead animals) to ensure that they are not disposed of in a liquid manure, storm water, or process wastewater storage or treatment system that is not specifically designed to treat animal mortalities.
- Ensure that clean water is diverted, as appropriate, from the production area.
- Prevent the direct contact of confined animals with waters of the United States.
- Ensure that chemicals and other contaminants handled on-site are not disposed of in any manure, litter, process wastewater, or storm water storage or treatment system unless the system is specifically designed to treat such chemicals or contaminants.

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- Identify appropriate site-specific conservation practices to be implemented, including as appropriate buffers or equivalent practices, to control runoff of pollutants to waters of the United States.
- Identify protocols for appropriate testing of manure, litter, process wastewater, and soil.
- Establish protocols to land apply manure, litter, or process wastewater in accordance with site-specific nutrient management practices that ensure appropriate agricultural utilization of the nutrients in the manure, litter, or process wastewater.
- Identify specific records that will be maintained to document the implementation and management of the minimum elements described above.

The *NPDES Permit Writers' Guidance Manual and Example Permit for CAFOs* states that permitting authorities are to include these nine minimum practices in NPDES permits as stand-alone, enforceable special conditions to help ensure these requirements are ultimately met [see also CWA§402(a)(1) and (2)]. The NPDES CAFO regulations require that these practices be fully implemented by the date specified in the permit, but no later than December 31, 2006.

Table 16-16 provides recommended permit conditions to achieve each of the minimum practices as specified in the *NPDES Permit Writers' Guidance Manual and Example Permit for CAFOs*. The specific minimum practices incorporated into a permit as special conditions by the permit authority may differ from those in Table 16-16, but in all cases the special conditions must be in accordance with the minimum practices specified at 40 CFR 122.42(e)(1)(i–ix).

Table 16-16. NPDES CAFO Permit Minimum Practices

ENSURE ADEQUATE STORAGE[1] CAPACITY Develop and implement specific practices and associated structures to ensure adequate storage capacity to achieve permit limitations including: - Maintain sufficient capacity in liquid manure, wastewater, or storm water storage structures to ensure compliance with all permit requirements. - Store dry manure in production buildings or in storage facilities or otherwise store it in such a way as to prevent polluted runoff. - Provide adequate storage capacity to ensure compliance with the nutrient management technical standard approved by the permitting authority. - Ensure proper operation and maintenance of all manure, wastewater, and storm water storage facilities.
ENSURE PROPER MANAGEMENT OF MORTALITIES Handle and dispose of dead animals in a manner that prevents contamination of waters of the United States.
DIVERSION OF CLEAN WATER Develop and implement management practices to divert clean water from the production area. Clean water includes rain falling on the roofs of facilities, runoff from adjacent land, and other sources. If clean water is not diverted from coming into contact with manure or process wastewater, it must be collected in accordance with permit requirements.
PREVENTION OF DIRECT CONTACT OF ANIMALS WITH WATERS OF THE UNITED STATES Develop and implement appropriate controls to prevent access of animals to waters of the United States in the production area.
CHEMICAL HANDLING Develop and implement controls to prevent the inappropriate introduction of chemicals into the manure, wastewater, and storm water storage and handling system. Examples include pesticides, hazardous and toxic chemicals, and petroleum products and by-products.
CONSERVATION PRACTICES TO CONTROL NUTRIENT LOSS For land application areas under the control of the CAFO operator, develop and implement practices that are sufficient to minimize the discharge of pollutants to waters of the United States. These practices may include, but are not limited to, residue management, conservation crop rotation, grassed waterways, strip cropping, vegetated buffers, riparian buffers, setbacks, terracing, and diversions.

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Table 16-16. NPDES CAFO Permit Minimum Practices
PROTOCOLS FOR MANURE AND SOIL TESTING Identify and implement specific manure, wastewater, and soil sample collection and analysis protocols to be used in developing and implementing the nutrient management plan. At a minimum the protocol is to specify the collection and analysis of manure, litter, and other process wastewaters annually for nutrient content, including nitrogen and phosphorus. The protocol is to specify the collection and analysis of soil samples for phosphorus content at least once every 5 years for all fields under the control of the CAFO operator where manure and wastewater might be applied. In all cases the sampling frequency for both manure, litter, and wastewater and soil is to be consistent with the technical standard for nutrient management established by the Director.
PROTOCOLS FOR THE LAND APPLICATION OF MANURE AND PROCESS WASTEWATER Develop and implement protocols to apply manure, litter, and process wastewater in accordance with the technical standard for nutrient management established by the Director.
RECORD KEEPING Maintain all records necessary to document the development and implementation of the nutrient management plan and compliance with the minimum practices defined in the permit. In addition, records that document compliance with the effluent limitations specified in the permit must be maintained .

Source: *NPDES Permit Writers' Guidance Manual and Example Permit for CAFOs,* December 2003.

[1] Storage includes waste ponds and lagoons and other structures such as tanks (above and below ground) and staking facilities (concrete pad, walls, and a roof).

Duty to Maintain Permit Coverage Until the CAFO Is Properly Closed

NPDES permit coverage must be maintained until the facility has ceased operation or is no longer a CAFO and the permittee has demonstrated to the satisfaction of the permitting authority that there is no remaining potential for a discharge of the manure, litter, or process wastewater that was generated while the operation was a CAFO, other than agricultural storm water from land application areas.

Once an operation is issued an NPDES permit, that permit remains in place for the entire permit term independent of the specific number of animals confined at any one time until the permit is modified or terminated in accordance with applicable NPDES regulations.

Special Condition for Large CAFOs: Meet Manure Transfer Requirements

NPDES permits for Large CAFOs must include specific requirements concerning the transfer of manure, litter, or process wastewater to other persons. The permit must require the operator to provide all recipients of manure and wastewater generated by the CAFO with the most current manure nutrient analysis. These records are to be maintained for a period of 5 years from the date the manure, litter, or process wastewater is transferred.

NPDES Permit for CAFOs: Monitoring, Reporting, and Record-Keeping Requirements

This section includes all the record-keeping, monitoring, and reporting requirements for Large CAFOs. Table 16-17 is an integrated list of the records required by the NPDES CAFO regulation and ELGs for Large CAFOs. In addition, the permitting authority may include record-keeping requirements beyond those specified in Table 16-17. For Medium and Small CAFOs, the regulations require only that the records include the site-specific nutrient management plan and any records necessary to document compliance with each NPDES nutrient management

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plan minimum practice. Records associated with the ELGs for these operations would be defined in the permit because the ELGs for these operations are established by the permit writer using BPJ.

Table 16-17. NPDES Large CAFO Permit Record-Keeping Requirements

Parameter	Units	Frequency
Nutrient Management Plan ***(Note: Required by the NPDES CAFO Regulation – applicable to all CAFOs)***		
The CAFO must maintain on-site a current site-specific nutrient management plan that reflects existing operational characteristics. The operation must also maintain on-site all necessary records to document that the plan is being properly implemented with respect to manure and wastewater generation, storage and handling, and land application. In addition, records are to be maintained to show that the development and implementation of the nutrient management plan are in accordance with the minimum practices defined in 40 CFR 122.42(e).	N/A	Maintain at all times
Soil and Manure/Wastewater Nutrient Analysis ***(Note: Required by the CAFO ELGs – applicable to Large CAFOs)***		
Analysis of manure, litter, and process wastewater to determine nitrogen and phosphorus content.[1]	Parts per million (ppm) Pounds/ton	Conduct initial sampling, then at least annually
Analysis of soil in all fields where land application activities are conducted to determine phosphorus content.[1]	ppm	Conduct initial sampling, then at least once every 5 years
Operation and Maintenance ***(Note: Required by the CAFO ELGs – applicable to Large CAFOs except as noted)***		
Visual inspection of all water lines.	N/A	Daily[2]
Documentation of depth of manure and process wastewater in all liquid impoundments.	Feet	Weekly
Documentation of all corrective actions taken.	N/A	As necessary
Documentation of animal mortality handling practices.	N/A	As necessary
Design documentation for all manure, litter, and wastewater storage structures, including the following information: - Volume for solids accumulation - Design treatment volume - Total design storage volume[3] - Days of storage capacity	 Cubic yards/ gallons Cubic yards/ gallons Cubic yards/ gallons Days	 Once in the permit term unless revised
Documentation of all overflows from all manure and wastewater storage structures, including the following: ***(Note: Required by the NPDES Regulation – applicable to all CAFOs)*** - Date and time of overflow - Estimated volume of overflow - Analysis of overflow (as required by the permitting authority)	 Month/day/year Total gallons TBD	 Per event Per event Per event
Documentation of manure application equipment inspection.	N/A	Seasonally
Land Application ***(Note: Required by the CAFO ELG – applicable to Large CAFOs)***		

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Table 16-17. NPDES Large CAFO Permit Record-Keeping Requirements

Parameter	Units	Frequency
For each application event where manure, litter, or process wastewater is applied, documentation of the following by field:		
- Date of application	Month/day/year	Daily
- Method of application	N/A	Daily
- Weather conditions at the time of application and for 24 hours prior to and following application	N/A	Daily
- Total amount of nitrogen and phosphorus applied[4]	Pounds/acre	Daily
Documentation of the crop and expected yield for each field.	Bushel/acre	Seasonally
Documentation of test methods and sampling protocols used to sample and analyze manure, litter, wastewater, and soil.	N/A	Once in the permit term unless revised
Documentation of the basis for the application rates used for each field where manure, litter, or wastewater is applied.	N/A	Once in the permit term unless revised
Documentation showing the total nitrogen and phosphorus to be applied to each field, including nutrients from the application of manure, litter, and wastewater and other sources.	Pounds/acre	Once in the permit term unless revised

Manure Transfer ***(Note: Required by the NPDES CAFO Regulation –applicable to Large CAFOs)***

For all manure transfers the CAFO must maintain the following records:		
- Date of transfer	N/A	As necessary
- Name and address of recipient	N/A	As necessary
- Approximate amount of manure, litter, or wastewater transferred	Tons/gallons	As necessary

[1]
[2] Refer to the state nutrient management technical standard for the specific analyses to be used.
Visual inspections should take place daily during the course of normal operations. The completion of such inspection should be documented in a manner appropriate to the operation. Some operations might wish to maintain a daily log. Other operations might choose to make a weekly entry, when they update other weekly records, that required daily inspections have been completed.

[3] Total design volume includes normal precipitation less evaporation on the surface of the structure for the storage period; normal runoff from the production area for the storage period; 25-year, 24-hour precipitation on the surface of the structure; 25-year, 24-hour runoff from the production area; and residual solids.

[4] Including quantity/volume of manure, litter, or process wastewater applied and the basis for the rate of phosphorus application.

Monitoring and Reporting

NPDES permits for CAFOs incorporate monitoring and reporting requirements consistent with the minimum reporting requirements at 40 CFR Part 122.41(l). The permit may also include monitoring and reporting requirements that address nonroutine activities. For example, discharges at a CAFO can occur because of an overflow during a catastrophic storm event (which can be an allowable discharge under the terms of the permit) or a leak, breach, overflow, or other structural failure of a storage facility due to improper operation, design, or maintenance (which would be an unauthorized discharge). Unauthorized discharges can also occur due to manure releases related to the improper storage or handling of liquid or solid manure, or improper land application. NPDES CAFO permits will require notification (within specific time frames) of the permitting authority, specific data collection activities, and a follow-up report describing such discharges. The monitoring and reporting requirements must ensure that the permittee provides a description; identifies the time and duration of the event, as well as the cause(s); and presents an analysis (if required to determine compliance by the permitting authority) of the discharge. The NPDES CAFO permit guidance recommends the analysis include, at a minimum, total nitrogen, ammonia nitrogen, phosphorus, pH, temperature,

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Escherichia coli or fecal coliform bacteria, 5-day biochemical oxygen demand (BOD_5), and total suspended solids. The analysis is to be performed in accordance with approved EPA methods for wastewater analysis listed in 40 CFR Part 136. The permitting authority may specify additional parameters at its discretion.

Annual Report

All NPDES permits for CAFOs will include a requirement for the permittee to submit an annual report to the permitting authority with specific information defined in the regulation [40 CFR 122.42(e)(4)]. The annual reports submitted by permitted operations will yield valuable information for the compliance inspectors and should be reviewed before conducting an inspection.

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16. C. CAFO Inspection Overview

This section provides a general overview of the purpose of AFO/CAFO inspections, the authority for EPA to conduct these inspections, and how facilities are selected for inspection. A brief summary of the implementation plan for the revised CAFO regulations is also included. In addition, this section provides a general overview of the process of a CAFO inspection and the safety and bio-security issues that might be encountered.

Purpose of AFO/CAFO Inspections

An inspection at an animal feeding operation is typically a compliance evaluation inspection, in which the facility is being inspected to determine whether it is complying with the requirements of the CWA. Another purpose of an AFO/CAFO inspection is to evaluate whether the requirements of any other federal environmental laws are applicable to the facility and, if so, whether the facility is in compliance with such requirements. An inspection of an AFO or CAFO may be conducted for the following reasons:

- Compliance inspection at a permitted facility to evaluate the facility's compliance with the requirements of its NPDES permit.
- Inspection at a nonpermitted AFO to determine whether the facility meets the basic definition of a CAFO, whether the facility has caused or is likely to cause water pollution, and whether the facility should have an NPDES permit.
- Routine inspection.
- To follow up on a citizen tip or complaint.
- For case development support after a violation has been identified.
- To determine whether a facility should be designated as a CAFO.
- For a follow-up inspection to ensure that the permittee has implemented required controls or BMPs.
- Compliance inspection to ensure compliance with settlement requirements.

EPA Authority for AFO/CAFO Inspections

EPA has the authority to regulate and inspect CAFOs through statutory requirements established in the CWA:

- 40 CFR 122.23 defines CAFOs as point sources subject to the NPDES permitting program.
- 40 CFR 123.26 establishes procedures and objectives for routine inspections of NPDES-permitted facilities by state programs.
- Section 402 of the CWA states that permittees issued permits for point source discharges of pollutants must meet specific discharge limits and operating conditions.
- Section 308 of the CWA authorizes inspections and monitoring to determine whether NPDES permit conditions are being met.
- Under the CWA, EPA may conduct an inspection wherever there is an existing NPDES permit, where a discharge exists or might exist, and where no permit has been issued. The CWA established enforcement authorities. EPA retains independent authority to take enforcement actions in both authorized and unauthorized states.

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- Section 309(a) allows EPA to administer administrative compliance orders for persons violating the CWA and to set a reasonable schedule for compliance (violation notice).
- Section 309(g) allows EPA to assess administrative penalties of two classes. Administrative actions may preclude other civil action penalties or citizen suits.
  - –Class I, with an informal hearing process, can carry penalties of up to $25,000.
  - –Class II involves formal administrative procedure hearings with penalties of up to $125,000.
- Sections 309(b) and (d) and 404 provide for injunctive relief and civil penalties of up to $25,000 per day for each violation of the act.
- Section 309(c) provides for criminal penalties of a fine of $2,500 to $25,000 per day, or up to 1 year of imprisonment, or both, for negligent violations of the act (for subsequent convictions, fines of up to $50,000 per day or 2 years of imprisonment, or both, may be called for).

Selection of Facilities for Inspection

Although, specific procedures will vary by EPA Region and by authorized state, the basic approach is similar. Some facilities are selected for inspection based on "probable cause," which means that the regulatory agency has obtained specific evidence of a possible existing violation at a facility. Inspections are conducted in response to citizen complaints about a specific facility, emergency situations such as reports of ongoing spills, information about specific water quality problems or fish kills, or as a follow-up to prior inspections indicating violations at the same facility or at other facilities owned or operated by the same person. Facilities are also selected through the Neutral Administrative Inspection Scheme, in which the regulatory agency does not have any prior information indicating that there are existing violations. These are routine inspections to evaluate compliance. Facilities are selected using the Neutral Administrative Inspection Scheme, and priority should be given to facilities that meet one or more of the following criteria:

- Are Large CAFOs
- Are in priority watersheds impaired by runoff from AFOs
- Are subject of citizen or government tips and complaints
- Are in watersheds with high AFO or CAFO density
- Are near surface waters
- Have the potential for large amounts of animal waste to reach surface water

CAFO Permitting and Compliance Strategy

The EPA CAFO Permitting and Compliance Strategy was developed in the summer of 2003 to address the permitting, compliance, and enforcement efforts by EPA (headquarters and regions) and states to ensure that the following actions occur:

- Permit authorities revise their regulations
- CAFOs are provided with effective compliance assistance support
- CAFOs are issued NPDES permits and develop nutrient management plans by December 2006
- Inspections and enforcement actions occur when necessary

The strategy covers the 5-year period beginning with the publication of the final CAFO regulations in February 2003. The CAFO Implementation Plan provides for the following:

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- The use of tailored approaches at the state level that reflect the specific status of their existing CAFO program. Encouraging interagency cooperation and coordination by partnering with USDA where appropriate.
- Regions taking leadership in working with their states to develop regional implementation plans that reflect both state and federal priorities to ensure a consistent national approach.
- Taking the necessary steps to improve the quality of information in the Permit Compliance System concerning CAFO permits.
- The development of a system that is focused on program progress and addresses emerging problems. This part of the strategy will focus on the identification and tracking of specific deadlines for permitting authorities to complete necessary program revisions, issue permits, and develop compliance assistance programs.
- Outreach and coordination with stakeholders to provide timely compliance assistance information on regulatory requirements.
- Issuance of guidance to facilitate permit issuance, development and implementation of nutrient management plans, and the approval of alternative technologies by permitting authorities.
- The development of measures of success and targeted evaluation tools.

General Process of an Inspection

Pre-Inspection Activities

The primary role of the inspector is to gather information that can be used to evaluate compliance with permit conditions, applicable regulations, and other requirements. Inspectors should be familiar with the conditions of the specific permit and with all applicable statutes and regulations. Prior to conducting a CAFO inspection, the inspector should complete the following specific pre-inspection preparation activities:

- Become familiar with the facility location and its geographic features.
- Review the conditions of the permit.
- Review prior inspection notes and issues, along with any previous site entry problems.
- Review prior compliance problems, enforcement actions, and correspondence.
- Answer these questions: Does the facility require extra safety requirements? Will biohazards be an issue?
- Determine whether there any potential bio-security issues at the facility.

To facilitate the CAFO inspection process, a detailed checklist based on the NPDES CAFO regulations and CAFO ELGs requirements has been developed. The checklist is useful in collecting information associated with the nutrient management plan and the minimum practices. It is included in Appendix AA.

Onsite Activities

Upon arrival at the facility, the inspector must show credentials as a form of identification to gain access. To conduct the inspection, the inspector uses an inspection checklist, a notebook for field notes, and a camera to take photographs. The inspectors should ask to see the CAFO owner or operator, or the designated representative for the facility. The typical sequence of events that occur during the inspection is as follows:

- Entry interview

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- Record and document review
- Facility tour
- Exit interview

Some portions of the inspection can be completed without the assistance or accompaniment of the facility representative. Although most inspections are unannounced, CAFO inspectors should be aware that they might have to call the facility prior to the time of inspection to announce their arrival because small farm operators might not be able to stop production and assist the inspector with the inspection process. In addition, the inspector might need to know the facility's bio-security procedures before the time of inspection. The inspector should be able to determine compliance with a permit or the CAFO status of a facility with an unannounced inspection.

Entry Interview

The purpose of the entry interview is for the inspector to

- Present credentials authorizing the inspection.
- Seek consent for an on-site inspection.
- Inform the facility owner or operator of the scope and purpose of the inspection.
- Provide a copy of the NPDES regulations or other fact sheets concerning the regulation of CAFOs.
- Ask basic information about the facility. Information and documents that the inspector should request include the following:
  - Verification of the name, address, and telephone number of the facility.
  - A determination of who is the authorized representative for the facility.
  - A determination of whether the facility is being leased, along with the names, addresses, and telephone numbers of the lessor and lessee.
  - Copies of specific records that might be required by the permit.
  - Questions concerning the history of the facility, including any discharges that might have occurred.
  - A determination of conditions as they exist at the time of the inspection.
- If desired, inform the operator what information, if any, will be available at the conclusion of the inspection.

The inspector should ask the facility owner or operator questions about the management and control of wastes from maintenance facilities, releases of chemicals to the environment, bulk fuel storage, pesticide usage, and other issues specified in the permit.

Record and Document Review

The inspector should also ask to see the records required to be kept by the facility's permit, the specific management plans, and the records to verify that the facility is complying with the terms and conditions of its permit. The inspector may ask to see all records or may ask for just a random sample to evaluate.

Typical records that the inspector may ask the facility to produce include the following:

- Animal inventory records.
- Records of waste levels in the retention structure.
- Manure and wastewater application records such as the following:
  - –Date(s) of application
  - –Location(s) of applications

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  - –Crop rotations
  - –Soil, manure, and wastewater nutrient testing results
- NPDES permit for the facility.
- Lease(s) or rental agreements.
- "Spreading agreements" if wastes are applied on land not owned or leased by the facility.
- Construction plans or as-built drawings of the facility.
- Nutrient management plan.

As needed, the inspector should ask to photocopy documents that will assist in preparing the inspection report. These documents may include a site map of the facility, drainage information, discharge reports, or other facility documentation.

Facility Tour

After reviewing the records and documents, the inspector asks the facility representative to accompany him or her on a tour of the facility. The purpose of the site tour is to assess existing conditions and confirm that the facility conforms to the description in the permit. During this phase of the inspection, the inspector might want to observe the following portions of the facility to assess structural integrity, maintenance condition, and storage availability:

- Solids sedimentation basins
- Manure and wastewater handling equipment
- Waste retention structures
- Catch basins
- Floor drains
- Fuel storage areas
- Depth markers and required liquid levels
- Maintenance facilities
- Runoff storage structures

To document the findings of the inspection, the inspector should photograph or videotape aspects of the operation. If the facility is discharging during the course of the inspection or there is evidence that the facility has recently discharged, the inspector might also take samples. During the course of the facility tour, the inspector might determine that additional records or documents need review. The inspector should ask the facility representative as soon as this has been determined to facilitate the retrieval of the needed information.

Exit Interview

Following the facility tour, the inspector conducts a debriefing or exit interview with the facility representative. This phase of the inspection allows both parties to follow up on the inspection or to clarify issues that arose during the inspection. If any records or documents were obtained during the inspection, the inspector prepares a Receipt for Documents and Samples. The inspector also gives the facility the opportunity to claim that some or all of the information provided during the inspection is confidential business information (CBI).

The inspector may relay basic findings of the inspection. If the inspector needs additional information from the facility or if another entity will complete the evaluation, the inspector might not be able to provide a list of the findings during the inspection. The inspector does not make the determinations of compliance or noncompliance of the facility; that determination is made by

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other enforcement personnel of the regulatory agency. Once the inspector has reviewed all the information obtained during the inspection, an inspection report is prepared. The inspection report includes the inspection checklist, documentation copied during the inspection, an explanation of findings, and supporting photographs. In some cases, the inspector might need to contact the facility if additional information is needed or issues require clarification.

Compliance personnel for the regulatory authority review the inspection report and evaluate whether the facility is in noncompliance and what type of follow-up action, if any, is appropriate. Copies of the report are sent to the inspected facility. EPA responds to noncompliance in a number of different ways, depending on the nature and circumstances of the violation:

- No follow-up needed
- Letter notifying the facility of violations or compliance assistance
- Administrative compliance order
- Administrative compliance order plus administrative penalty
- Civil judicial enforcement action (penalties and/or injunctive relief)
- Criminal enforcement

CAFO Operational Overview

This section presents a brief synopsis of several operations that might take place at a CAFO and some of the elements to note when conducting an inspection. Additional site-specific processes that are beyond the scope of this document might be encountered. When inspecting a facility, the following areas are of concern: animal housing, feeding, and maintenance areas; manure and process wastewater collection and transport; manure and process wastewater storage and treatment; and manure and process wastewater land application.

Animal Housing, Feeding, and Maintenance Areas

Housing areas can be indoor facilities with concrete, metal grate, gravel, clay, or packed earth flooring; outdoor areas with dirt surfaces; or pastureland or rangeland. Pasture areas are not subject to regulation as part of a CAFO except with respect to their use as manure application sites. Livestock housing areas are particularly susceptible to runoff and erosion because of the concentrated populations of manure-producing animals. Soil compaction in soil-based yards (also called dry cow lots, loafing areas, or exercise yards) prevents water infiltration and causes ponding and runoff. Runon and runoff controls, such as grading and berms, are important components of pollution control and prevention in livestock housing areas. An inspector should note whether the animals are treated chemically for pests or if the bedding areas are cleaned chemically because of the potential for manure contamination by the pesticides. Bedding material, if provided, can consist of peat moss, sawdust, shredded newspaper, straw, or other materials.

Swine housing areas are often enclosed buildings, dirt lots, or outdoor concrete pads. Poultry housing areas are usually enclosed buildings.

Feeding areas inside buildings are often troughs; outside areas typically have a concrete, gravel, or packed-earth surface with troughs or a feed bunker. Although a water trough increases animal traffic in the immediate area, it is advantageous because it allows the operator to restrict access to (fence off) any streams previously used for livestock watering. Poultry houses use feeding bins or trays; water is provided continuously or through on-demand

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systems such as nipple or cup drinkers.

Animals may spend time in non-pasture areas that are for neither housing nor feeding purposes. These areas may be for such activities as milking, shearing, birthing, breeding, or sales display. If these areas are not pasture, they are part of the CAFO. The inspector will need to observe manure management practices in these areas as well.

Manure and Process Wastewater Management Systems

Manure Collection

Dry manure is usually collected by being pushed, scraped, or scooped up. Slurry manure is generally collected by scraper or pumped after the addition of small amounts of water. Liquid manure is generally collected by flushing with large amounts of water. For indoor facilities, manure may be removed by an automated spraying system, a scraping system, a flushing system beneath the metal grates, or manual removal.

In poultry houses with dry manure systems, the manure that builds up adjacent to the feed and water devices forms a cake (crust). The collection and removal of that cake is called cake removal or crust-out. Poultry houses usually crust out the manure following each flock. A machine called a cruster is often used for this process in poultry houses. Poultry operations with liquid manure systems collect the manure in long pits underneath the birds' cages. Large earthmoving equipment is used to collect manure at large cattle feedlots. Beef cattle pens are usually cleaned after each set of cattle is marketed. Many enclosed swine operations house the hogs on a slotted floor that allows the manure and waste feed to drop through for removal. Manure pits capture the manure as it falls from the animals' containment area. Swine manure removal methods include under-floor flush, open-gutter flush, pit recharge, and hosing. Dairy facilities remove manure through slotted floors, use gutter cleaners or alley scrapers, or flush the alleys with water. Many dairies that remove manure by flushing also recycle this water for multiple flushes. Milking areas usually produce manure and process wastewater, which are generally channeled into the manure and process wastewater handling and storage system.

Manure Transport

The transport of manure is related to the solids content. Dry manure cannot be pumped; liquid manure cannot be scraped. Dry manure is usually transported directly to the land application site in a box-type manure spreader. Manure spreaders are commonly loaded by tractor bucket loaders or elevated conveyor units. Slurried and liquid manure can be pumped or flushed through pipes and concrete channels to storage or treatment processes. The pipes can be above or below the ground.

Slurry and liquid manure are often loaded into tank trucks or tractor-drawn tanks. Tankers are often loaded by stationary pumps, pumps located on a floating barge, and moveable pumps operated by a tractor PTO drive. Liquid manure is often transported by pumping through permanent and temporary piping to irrigation devices.

Manure Storage and Treatment

In most cases, manure is stored for some period between manure production and manure disposal. This storage can be long-term (180 days or more) or short-term. Manure storage is necessary where disposal or application immediately after collection and removal is impossible

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or impractical. One such situation is avoiding the application of manure during poor meteorological conditions. For example, if manure is applied during the winter months, it is more likely that the melting snow and spring rains will wash away most of the nutrients before the ground thaws enough to absorb them. Manure is stored in three forms: solid, semisolid, and liquid.

Long-term storage usually consists of liquid or semisolid manure, and the storage vessels typically consist of lagoons or tanks made from glass-lined steel, concrete staves, poured concrete, or earthen waste storage pits. Manure is typically stored for a period of time, then applied to the land. The liquid or semisolid waste may be treated in a lagoon; the methane gas produced is reclaimed, and the remaining waste is applied to fields. Manure in lagoons is biodegraded by bacteria using aerobic or anaerobic processes. To provide an oxygen supply, aerobic lagoons must have aeration equipment or larger surface areas than anaerobic lagoons.

During an inspection the inspector may encounter manure that is stored in piles in fields or pastures, piles on feedlots and in livestock pens, or a watertight manure pit with a concrete- or clay-lined bottom. Short-term-storage manure is usually in solid form. Solid-manure storage areas sometimes have a grass filter strip to absorb any nutrients from leachate. In some cases, solid manure might be composted. Operations that store manure in piles exposed to rainfall in fields or pastures are considered to have a liquid manure handling system. Permitting authorities may authorize a limited period of temporary field storage of manure of no more than 15 days that would not result in the facility's meeting the definition of a liquid manure handling system (e.g., where this limited time is needed to allow for contract hauling arrangements). Once the manure is stockpiled beyond this temporary period, the uncovered stockpile constitutes a liquid manure handling system. The presence of such a liquid manure handling system affects the regulatory thresholds for chicken and duck operations.

Liquid and semisolid dairy wastes are stored using the slurry method or the lagoon method. Slurry storage is usually in a pit, slurry storage tank, or earth basin. Waste in lagoons is usually diluted with water from flush systems or milking parlor washdown. Solid waste storage facilities, both indoor and outdoor, are common at dairies. Swine operations often use manure storage basins or single- or multi-stage lagoons.

Runoff control systems, storage area integrity, and management practices are important to note. Proper siting of storage areas helps prevent contamination of drinking water supplies and other risks to human and animal health.

Land Application Activities

Land application is the most common form of manure use at CAFOs. Solid manure is usually spread using a mechanical manure spreader. Liquid manure can be applied by an irrigation system or surface applied by truck or tanker. It is sprayed on the surface (and, in some cases, later incorporated into the soil) or injected into the soil. Swine operations commonly use manure spreaders for solids or traveling irrigators, permanent irrigation systems, or portable sprinklers for liquids.

The CAFO is to conduct land application of manure and process wastewater in accordance with the applicable CAFO effluent limitations land application BMPs, the site-specific Nutrient Management Plan, the nutrient management technical standard established by the permitting authority, and the NPDES CAFO permit minimum practices.

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CAFO Inspection Sampling Procedures

Rather than determining compliance with permit limitations for specific pollution parameters, CAFO sampling is focused on documenting evidence of a nonauthorized discharge to waters of the United States. Inspectors might not know whether they will be able to collect samples prior to arriving at the site but should be prepared to do so. In addition, if there is no discharge at the time of the inspection, inspectors might wish to identify and document likely pathways that a discharge would follow and the name and location of the receiving waters if such a discharge event should occur in the future.

Preparation for sampling is often based on a sampling plan. The plan is usually developed by the inspector, with input from laboratory personnel and legal counsel as appropriate. A sampling plan includes the objectives of the sample, data needs, parameters to be sampled, methods, volumes and holding times of samples, documentation and transport, and quality control procedures. The remainder of this section covers the various elements typical of sampling plans.

Parameters and Types of Samples at CAFOs

Inspectors must know before arriving at a CAFO what parameters they intend to sample to support a determination that an illegal discharge has occurred. This decision is generally made with the input of the EPA legal counsel who would be responsible for managing any enforcement action against the facility. Typical parameters sampled at CAFOs are those which readily show an effect on water quality by the discharge. These might include Biochemical Oxygen Demand (BOD), fecal or total coliform bacteria, specific conductance, and ammonia nitrogen. Many other parameters, however, may appropriately be sampled to document such discharges. Sampling of any one or a combination of these parameters can aid the inspector in documenting an illegal discharge.

Because discharges from CAFOs are likely to be nonroutine and transitory, grab sampling is usually the most appropriate sampling technique. Grab samples are individual samples collected over a period of time (not exceeding 15 minutes). They represent conditions at the time the sample is collected, and they provide information about instantaneous concentrations of pollutants at that specific time. The sample volume needed depends on the types and number of analyses to be performed.

Some parameters may be sampled only by grab sampling, but others may be sampled by either grab or composite sampling. Parameters not amenable to compositing include pH, temperature, dissolved oxygen, chlorine, purgeable organics, oil and grease, coliform bacteria, and others specified in 40 CFR Part 136. Volatile organics, sulfides, phenols, and phosphorus samples can be composited but require special handling procedures. BOD and ammonia nitrogen can be sampled by using either grab or composite techniques; if composite sampling is used, appropriate preservation must be provided during and after the sampling period.

Sample Volume

The volume of samples collected depends on the types and number of analyses needed, as reflected in the parameters to be measured. The volume of the sample obtained should be sufficient for all the required analyses plus an additional amount to provide for any split samples or repeat analyses. The laboratory receiving the sample should be consulted for any specific volume

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required. Specific recommended minimum sample volumes for different pollutant parameters are provided in EPA's *Methods for Chemical Analysis of Water and Wastes* (USEPA 1979) and *Handbook for Sampling and Sample Preservation of Water and Wastewater* (USEPA 1982), and in the current EPA approved edition of *Standard Methods for the Examination of Water and Wastewater* (American Public Health Association), American Water Works Association, and Water Environment Federation.

Data Handling and Reporting

Verified analytical results are normally entered into a laboratory data management system of some type. The system should contain the sampling data, including sampling time and exact location, dates and times, names of analysts, analytical methods or techniques used, and analytical results. Data are then reported to the inspector for inclusion in the compliance report. Detailed information on laboratory procedures and quality assurance can be found in Chapter Seven of this manual.

Safety Issues and Bio-Security at CAFOs

Inspector Heath and Safety

Very few diseases in animals are of concern to humans. However, persons with low immunity can contract a specific respiratory illness from poultry called histoplasmosia. In addition, CAFOs might store pesticides in both concentrated and dilute form. Inspectors should never enter an area where pesticides are being applied. Before entering an area where pesticides have been applied, the inspector should be familiar with the pesticide signs, and should know the type of pesticide applied, the time and date of application, and whether the area is safe to enter.

The other major hazards at CAFOs include toxic gases, drowning, electrocution, and hazards associated with the equipment used for handling, transporting, and applying manure from CAFOs. During an inspection, inspectors must be aware of these potential hazards and seek to avoid the dangers they pose.

Confined spaces at CAFOs, as at other types of facilities, present a safety risk to inspectors. Gases such as hydrogen sulfide, carbon dioxide, ammonia, and methane are present in every manure pile, and if not properly ventilated, can reach concentrations dangerous to humans. Covered or enclosed tank facilities present the greatest danger, especially when manure is being agitated or pumped out of the structures. Silos and silage bunkers also represent a confined-space hazard. CAFO inspectors should ensure that facilities are properly ventilated before entering to conduct an inspection.

Drowning is a possibility where semisolid, slurry, and liquid manures are stored. Manure usually forms a surface crust. The thickness of the crust depends on the moisture content and consistency of the manure. However, under no conditions is the crust solid enough to support a human being. Inspectors should never venture out onto any crusted surfaces during an inspection.

Some owners or operators use tractors to power pumps when transferring waste out of storage lagoons. The power sources (takeoffs) present both electrical hazards and physical hazards for inspectors wearing loose-fitting clothing.

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Facilities being washed present an electrocution hazard to the inspector. Wash water might conduct electricity from wiring, connections, or equipment to persons in contact with that water. Inspectors are advised to stay out of facilities during washdown.

Equipment used for handling, transporting, and applying manure can be hazardous to the operator and to others close by. The operator's manual for the equipment should document the potential hazards for that equipment. Common hazards include getting clothing or limbs caught in moving equipment parts; injury from escaping hydraulic fluid; and slippage of tractors, loaders, and spreaders. Inspectors should exercise appropriate caution (e.g., but not wearing loose-fitting clothing) around any machinery encountered during an inspection. Occupational Safety and Health Administration (OSHA) regulations make the private employer responsible for the safety of its employees, so the regulatory agency (EPA or the state) might be responsible for the inspector's safety during a CAFO inspection.

Animal Safety and Bio-Security Issues

The CAFO inspector should be familiar with all safety obligations and practices regarding basic inspections, including regional and state policies or requirements. In addition to the basic health and safety risks associated with inspecting facilities, CAFO inspectors have the added responsibility to avoid transporting livestock diseases between facilities. Many large livestock facilities give the animals medication to prevent diseases and might also disperse hormones. Livestock animals are susceptible to diseases from other facilities, and human carriers are a risk to livestock operations. Many facilities are concerned about bio-security because of the recent outbreaks of foot-and-mouth disease and mad cow disease. Without the proper precautions, inspectors might transport diseases between facilities by wearing contaminated clothing or using contaminated equipment. The current EPA bio-security policy is provided as Appendix BB.

Most swine facilities do not allow any person who has been to another swine operation within the past 72 hours to access their facility. In addition, many swine operations do not allow access to anyone who has visited another livestock operation within the past 24 hours. Inspectors must be aware of the specific facility's bio-security requirements and plan multiple inspections accordingly. The inspector might need to call in advance so that the bio-security measures are known before the inspection and the information is accessible along with other pre-inspection information.

To minimize the risk that visitors will carry diseases or infections into livestock facilities, livestock owners or operators might ask visitors to abide by their specific bio-security measures. USDA's Animal and Plant Health Inspection Service and the University of Wisconsin recommend the following bio-security precautions when visiting farms:

- Stay off farms if you have been in a foot-and-mouth disease-infected nation within 1 week. If this is not possible, wear clothing that has been laundered or dry-cleaned since leaving the infected nation.
- For visitors who have been in contact with livestock or have been on animal farms within the past 48 hours, wear clothing and outer garments that were not worn at that time or have been laundered since the previous contact.
- Wear disposable plastic boots or clean rubber boots. Rubber boots must be thoroughly cleaned and disinfected before entering and upon leaving the facility. Disposable boots must be new before entering the facility and thrown away upon leaving the facility.
- Carry disposable boots or a disinfectant in your vehicle, as well as a supply of disposable face masks. Before you enter areas where animals are kept, remove manure and soil from your shoes or boots and disinfect them, or put on disposable boots.

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- Wash clothing and footwear using approved disinfectant after contact with livestock or poultry.
- Keep a supply of clean or disposable protective clothing in your vehicle. Do not wear this clothing at more than one farm without laundering. If you use disposables, throw them away after wearing them at one farm.
- Park away from areas where your vehicle might come in contact with animal waste or runoff.
- Meet the livestock owner or operator away from production areas.
- Stay away from farm animals or wear a face mask when you are near them.
- Heed warning signs asking visitors to stay out of buildings where animals are housed.
- Leave all food in your vehicle.
- Clean your nostrils and fingernails and wash your hair thoroughly.
- Dispose of clothing, shoes, equipment, cameras, and other items that are difficult or impossible to disinfect.
- Do not wear items, such as jewelry, watches, glasses, or hairpieces, that cannot be disinfected when working around animals.

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16. D. Multimedia Concerns

Multimedia Concerns

This section is intended as a cursory guide for CAFO inspectors who become involved in multimedia environmental compliance inspections.

Multimedia Inspections and Multimedia Screening

Multimedia compliance investigations are intended to determine a facility's status of compliance with applicable laws, regulations, and permits in more than one medium. CAFO inspectors participating in multimedia inspections may refer to the National Enforcement Investigations Center's *Multimedia Investigation Manual* (NEIC's____) for further guidance.

Multimedia Concerns at CAFOs

CAFOs regulated under the NPDES program might be also subject to the requirements of other regulatory programs. The direct relationship of these requirements to CAFOs is hard to determine without understanding the other common areas of concern. Multimedia concerns related to CAFOs fall into the following areas.

Pesticides

If a CAFO grows crops, improper application of pesticides to agricultural fields could be in violation of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). The facility should have in its records the registration numbers of the pesticides and any information relating to their application. Pesticide applicators must also hold appropriate licenses for application.

Sources of Drinking Water

A CAFO that has a discharge could be contaminating the drinking water of the surrounding area if the drinking water source is a well. The facility should have its water sampled and analyzed for contaminants, and the results should be reported to the state or EPA. This is discussed more thoroughly in the following section, Other Regulatory Requirements.

Other Regulatory Requirements

Coastal Zone Act Reauthorization Amendments (CZARA) of 1990

In reauthorizating the Coastal Zone Management Act in 1990, Congress identified nonpoint source pollution as a major factor in the continuing degradation of coastal waters. Congress also recognized that effective solutions to nonpoint source pollution could be implemented at the state and local levels. Therefore, in the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA), Congress added Section 6217, which calls on states with federally approved coastal zone management programs to develop and implement coastal nonpoint source pollution control programs. The Section 6217 program is administered at the federal level jointly by EPA and the National Oceanic and Atmospheric Administration (NOAA).

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Section 6217 (g) of CZARA called for EPA, in consultation with other agencies, to develop guidance on "management measures" for sources of nonpoint source pollution in coastal waters. Under Section 6217 of CZARA, EPA is responsible for developing technical guidance to assist states in designing coastal nonpoint source pollution control programs. On January 10, 1993, EPA issued its *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters,* which addresses five major source categories of nonpoint pollution:

- Urban runoff
- Agriculture runoff
- Forestry runoff
- Marinas and recreational boating
- Hydromodification

The guidelines for the agriculture nonpoint source category specifically include management measures for "confined animal facilities." The guidance also specifies management measures for erosion and sediment control, nutrient management on cropland, and grazing. These three management measures apply to facilities with livestock even if they are not confined animal facilities as defined by CZARA. However, they do not apply to CAFOs under the NPDES program. This section explains which feedlots are subject to the confined animal facility requirements of CZARA and discusses these requirements in more detail. It also briefly explains the nutrient management measures, which may be implemented by confined animal facilities.

CZARA Requirements versus CWA Requirements with Respect to Confined Animal Facilities

The CZARA guidance document has thresholds for identifying large and small confined animal facilities that are lower than those established in the NPDES CAFO regulations. Thus, in coastal states the CZARA management measures potentially apply to a greater number of small facilities than the NPDES regulations. Despite the fact that both the CZARA management measures for confined animal facilities and the NPDES regulations for CAFOs address similar operations, these programs do not overlap or conflict with each other. EPA's CZARA guidance states that any facility with an NPDES permit for CAFOs is exempt from CZARA management measures. CZARA applies to nonpoint source dischargers. Any CAFO, as defined by 40 CFR Part 122, that has an NPDES permit is a point source discharger and thus not subject to CZARA. Similarly, if an AFO subject to CZARA management measures later becomes a CAFO (by definition or designation), that facility is no longer subject to the CZARA management measures. This means that an AFO will never be subject to an NPDES permit and CZARA at the same time.

The Safe Drinking Water Act

The following four programs established by the Safe Drinking Water Act (SDWA) might apply to select feedlots. The *Underground Injection Control Program* (UIC) helps protect underground sources of drinking water by controlling the pollutants disposed of in injection wells. Injection wells that accept feedlot drainage are classified as agricultural drainage wells, one of the many types of Class V wells. Currently, all Class V wells are authorized by rule and are subject to the inventory requirements at 40 CFR Part 144, but not to the technical requirements. Class V wells, however, are subject to a performance standard that prohibits movement of contaminants into an underground source of drinking water if the contaminants could cause a violation of a drinking water standard or otherwise adversely affect human health. Because well injection of feedlot waste and runoff is very uncommon, the UIC program requirements apply to very few feedlots.

The *Sole Source Aquifer Program* includes development of a comprehensive management plan requiring identification of existing and potential point and nonpoint sources of groundwater degradation, an assessment of the relationship between activities on the land surface and

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groundwater quality, and development of management practices to be implemented in the critical protection area. If identified as a source of groundwater degradation, a feedlot located above a sole source aquifer could be subject to additional management practice requirements. In a sole source aquifer area, no federal financial assistance may be used for projects that could contaminate the aquifer and create a significant public health hazard. For feedlots above a sole source aquifer, permitting authorities should work with USDA-NRCS (Natural Resources Conservation Service) and USDA-CFSA (Conservation Farm Service Agency) to determine applicable waste retention requirements for facilities that use federal cost-share funds.

The *State Wellhead Protection Areas Program* requires each state to adopt a program to protect wellhead areas from contaminants that might adversely affect human health. States determine the boundaries of their wellhead protection area. A feedlot within a designated wellhead protection area identified as a source of contaminants adversely affecting human health could be subject to additional discharge limitations or management practices.

The *Surface Water Treatment Rule* establishes criteria that public water systems must meet to avoid filtration. These criteria include identification of activities that might have an adverse effect on the quality of water sources and demonstration, through ownership or written agreements with landowners, that all sources of human activities with the potential for such adverse impacts can be controlled. Feedlots near public water systems may be asked to enter into such a written agreement.

SDWA also provides EPA with *emergency powers* to take action when a contaminant enters or is likely to enter a public water system or an underground source of drinking water and could present an imminent and substantial endangerment to the public health. An action in this case may be either an order issued to or a civil action taken against those responsible for the contamination.

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16. E. References

Guidance

National Enforcement Investigations Center (NEIC). March 1992. *Mulitmedia Investigation Manual.*

U.S. Department of Agriculture - Natural Resources Conservation Service. December 2000. *Comprehensive Nutrient Management Planning Technical Guidance.*

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U. S. Department of Agriculture - Natural Resources Conservation Service. *Field Office Technical Guide* (State Specific)

U.S. Department of Agriculture - U.S. Environmental Protection Agency. March 1999. *Unified National Strategy for Animal Feeding Operations.*

U.S. Environmental Protection Agency - Office of Water. December 2003. *NPDES Permit Writers' Guidance Manual and Example NPDES Permit for Concentrated Animal Feeding Operations.* EPA 833-B-04-001.

U.S. Environmental Protection Agency - Office of Water. November 2003. *Producers' Compliance Guide for CAFOs.* EPA 821-R-03-010.

U.S. Environmental Protection Agency - Office of Enforcement and Compliance. August 2003. Clean Water Act Enforcement Strategy Update for Concentrated Animal Feeding Operations.

University of Wisconsin-Madison. 2001. *Biosecurity guidelines for UW-Madison Dairy and Livestock Facilities.* Available at: www.wisc.edu/animalsci/facilities/biosecurity.pdf. Accessed May 2001.

Statutes and Regulations

Clean Water Act. Section 301. Effluent Limitations (33 USC 1311)
Clean Water Act. Section 304. Information and Guidelines (33 USC 1314)
Clean Water Act. Section 306. National Standards of Performance (33 USC 1316)
Clean Water Act. Section 307. Toxic and Pretreatment Standards (33 USC 1317)
Clean Water Act. Section 402. National Pollutant Discharge Elimination System (33 USC 1342)

40 CFR Part 122. EPA Administered Permit Programs: The National Pollutant Discharge Elimination System
40 CRF Part 123. State Program Requirements
40 CFR Part 412. Concentrated Animal Feeding Operations (CAFO) Point Source Category

Federal Register Notice. FR 7176. February 12, 2003. National Pollutant Discharge Elimination System Permit Regulation and Effluent Limitation Guidelines and Standards for Concentrated Animal Feeding Operations (CAFOs); Final Rule.

Training

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Livestock and Poultry Environmental Stewardship Curriculum, CAFO Fact Sheets, and Educational Materials. (http://lpes.org/)

State Nutrient Management Courses

U.S. Department of Agriculture - Natural Resources Conservation Service. February 2001. *Nutrient Management Version 1.1.* (Self-Study CD-ROM course on nutrient management)

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Appendix BB

NPDES CAFO Permit and NMP Review Checklist

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17. APPEARING AS A WITNESS

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17. A. INTRODUCTION

Introduction

Inspectors perform a vital role throughout the regulatory enforcement process. An enforcement action begins with the inspector collecting and documenting on-site evidence. This chapter deals with the inspector's responsibility to present evidence in formal legal proceedings.

Due in large part to the high quality work that inspectors produce, the EPA files strong cases. Nearly all of the cases that the EPA files result in out of court settlements that will not usually require the inspector's testimony. Of the cases that do not settle, a substantial majority of the legal action takes place in the EPA administrative law system rather than the federal courts. Major differences distinguish administrative from federal courts, such as rapid processing and the absence of a jury. Despite the differences between these two legal proceedings, the inspector's role as a witness will remain predominantly the same.

Under most circumstances an inspector will be called as a "fact witness." A fact witness describes personal knowledge obtained through one of the five senses. Throughout the enforcement process, everything an inspector hears, sees, samples, or records may become evidence about which he or she may be questioned. Many cases are tried years after the field and laboratory activities have been conducted. Thus, the inspection report and field notebook should be sufficiently detailed and legible to allow the inspector to reconstruct the inspection "on the record."

17. B. PRE-TESTIMONY MATTERS

Preparation

Preparation is the key to giving accurate and effective testimony. Successful preparation requires a substantial time commitment. Attorneys and witnesses work together in two types of preparation: factual and procedural.

The inspector will complete most of the factual preparation by writing the inspection report as described in this manual. The witness and the attorney will meet to discuss details from this report. Other items should also be discussed, including the field notebook, photographs, and the inspector's qualifications. Qualifications include the inspector's educational degree, professional accreditations, inspector training as required by Executive Order 3500.1, and on the job experience. The inspector's qualifications must never be exaggerated. Even a small exaggeration may cause the inspector's testimony to lack credibility.

The inspector should inform the EPA attorney of any problems, questions, or concerns in the case as early as possible. An example of one such concern are the confidential business information (CBI) procedures to which the inspectors must adhere. CBI procedures that bind the inspector during an inspection also have implications for the legal proceeding.

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The attorney has the primary responsibility over procedural preparation, which is assembling the facts for presentation in a formal legal setting. In addition to one-on-one preparation, the inspector and attorney may consider whether the inspector should participate in a mock trial or visit a hearing to observe other witnesses testifying. During one-on-one preparation, the attorney and the inspector should discuss:

- Times and dates that require the inspector's attendance.
- Legal etiquette and procedure.
- General legal framework of the case.
- Significance of the inspector's testimony in this framework.
- Probable areas of questioning, including direct and cross-examination.
- What documents, if any, will be used by the inspector during testimony.

Before giving testimony, the witness should again review inspection documents, his or her professional qualifications, and information provided by the attorney. This review should be repeated until the witness has become thoroughly familiar with the details of the testimony and how it will be presented.

An inspector may be subpoenaed to give testimony by the opposing attorney or even by the EPA attorney. A subpoena is a Court Order to appear, and it is a mandatory legal process that does not suggest dishonesty or bias, an inspector should not be offended if he or she receives a subpoena. If an inspector is subpoenaed, the appropriate EPA attorney should be contacted immediately. Time will be short to prepare to give testimony or to fight the subpoena.

Legal Etiquette, Appearance, and Demeanor

A witness's conduct should reflect the solemn nature of the administrative or judicial proceeding. To act in accordance with required legal etiquette, a witness should:

- Dress conservatively following the advice of the EPA attorney.
- Arrive early and be available immediately when called to testify.
- Address the judge as "your honor."
- Treat an administrative proceeding as seriously as a federal court trial.

A witness should not:

- Whisper, talk, or make jokes in the hearing room. If necessary, a note may be passed.
- Bring magazines or newspapers into the hearing room.
- Discuss the case within the hearing of anyone but the EPA attorney.

Posture, speech, and appearance influence a witness's credibility. An inspector is a professional who collects, preserves, and presents evidence. In order to convey a professional demeanor, an inspector should:

- Firmly but politely speak to the opposing attorney.

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- Appear natural and animated, but not impatient or overly anxious to testify.
- Minimize nervous tendencies.
- Remain calm.
- Refrain from showing hostility toward the opposing counsel, the specific defendant, or the regulated community as a whole.

17. C. GIVING TESTIMONY

General Considerations

A witness gives testimony to create a legal record of the facts. Before giving testimony, a witness will take an oath that he or she will tell the truth. Failure to tell the truth is actionable as perjury. A witness may give pre-trial testimony in a deposition or trial testimony under direct examination or cross-examination.

To give effective testimony, a witness should 1) listen, 2) pause, and then 3) answer if possible. Listening carefully to the wording and implications of an attorney's questions requires significant effort. If the witness does not understand the question, he or she should stop to think, have the question repeated, or have it explained.

A witness should pause before answering. Pausing provides time to think, makes the response more considered and deliberate, and gives the attorney time to object if necessary. When pausing, the witness should not use words such as "um." As the court reporter documents everything spoken, these words may incorrectly indicate hesitation when later read from the written record.

When answering, a witness should:

- Reply with a "Yes" or "No" when appropriate.
- Speak in complete sentences when answering more fully.
- Be as descriptive as possible in referring to exhibits or photographs. For example, "In the upper right hand corner, we see" rather than "Here, we see."
- Stop immediately if the judge or either of the lawyers begins to speak.
- Avoid memorizing answers to potential questions.
- Never manipulate an answer to benefit one side.

A witness's credibility is defined as the degree of confidence that the judge or jury gives to the witness's testimony. The opposing attorney will try to "impeach" a witness's credibility by suggesting the following: bias, inaccuracy, inability to recollect, false testimony, or even corruption. To lessen the opposing attorney's ability to discredit the witness's testimony, the witness should:

- Always tell the truth.
- Answer only the question asked, without volunteering information.

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- Explain answers fully. If the opposing attorney does not allow a full explanation, the EPA attorney can choose to bring this out later in the trial during a redirect examination.
- Answer within the limits of his or her knowledge of the facts.
- Willingly say, "I don't know," or "I don't remember," if that is the case.
- Correct any mistakes in his or her previous testimony as soon as a mistake is recognized.
- Carefully identify estimates.
- Never exaggerate.
- Never guess.
- Avoid absolutes, like "I always..." or "I never...".

Pre-Trail Testimony: Depositions

In a federal court trial, an inspector may be subpoenaed to give a deposition, which is pre-trial questioning under oath by the opposing attorney. Depositions are not often conducted in administrative hearings. Participants include the attorneys for each side, a court reporter, and the witness. Most importantly, a judge will have no role in deposition testimony unless one side abuses the process and the other side seeks relief.

The attorney may use a deposition to "discover" information or to contradict a witness's testimony at trial. In most cases, deposition testimony cannot be used as a substitute for live testimony. To properly prepare for and give deposition testimony, an inspector should:

- Read the notice of deposition.
- Consult with the EPA attorney to determine what documentation will be necessary.
- Realize that he or she is not "off the record" until completely away from the deposition setting.
- Request a break whenever needed.

After the deposition is transcribed, the witness can read it to make any appropriate corrections. Small errors always exist, but some transcripts contain absolute disasters. Errors in technical details, such as numbers and units, can have a large impact. A witness should never waive the right to read and sign the finished deposition.

Trial Testimony: Direct Examination

The EPA attorney will question the inspector during direct examination in order to put the facts known by the inspector on the record in a well-organized and logical manner.

A good direct examination leads the inspector through his or her entire testimony using a dialogue of short questions and answers. The attorney is responsible for asking appropriate questions in the correct order and ensuring that nothing important is omitted. The witness is only responsible for answering the attorney's questions completely and truthfully.

In order to avoid legally objectionable or tactically unwise remarks, the witness should trust the EPA attorney's final decision concerning what questions to ask at the hearing. If the inspector has forgotten a fact, the attorney may refresh the inspector's recollection with documents, such

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as the inspection report. The EPA attorney might also ask, "Is there anything else?" to signal to the inspector that something has been left out.

Redirect examination is a round of questioning only concerning issues raised during cross-examination. Redirect will give the EPA attorney an opportunity to reduce any damage done to the credibility of the inspector's testimony during cross-examination.

Trial Testimony: Cross-Examination

Cross-examination, questioning by the opposing attorney, will subject the witness to a more difficult interrogation than direct examination. The opposing attorney will try to cast doubt on the credibility of the witness's testimony. Many witnesses fear counsel techniques such as leading questioning and twisting interpretation. The EPA attorney will try to protect the witness from abusive uses of these techniques.

The witness can also protect the credibility of his or her testimony by 1) answering briefly, 2) answering accurately, and 3) remaining calm. Answering briefly consists of being responsive to the question, but not volunteering extra information. Avoid rambling, even if the opposing counsel remains silent.

In addition to the recommendations in the section "Giving Testimony," answering accurately requires listening carefully for the following types of questions:

- Questions that inaccurately paraphrase the witness's previous testimony. The error should be corrected or the previous answer restated in full.

- Hypothetical questions or questions requiring a "Yes" or "No" answer. If these questions may compel a misleading or incomplete answer, the witness should explain the answer fully at that time or later during redirect if cut short by the opposing attorney.

- Two-part questions. The inspector should ask the attorney to restate the question or carefully answer each part separately.

Even when a witness's truthfulness, occupational competence, or professional conclusions are challenged, he or she should remain calm. An angry, sarcastic, or argumentative answer is inconsistent with the inspector's role as a neutral government witness. Remaining calm will add credibility to the inspector's testimony. Becoming familiar with the process, including participation in a mock trial can help reduce the stress of cross-examination.

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17. D. SPECIAL CONSIDERATIONS

Technical Testimony

An inspector frequently presents technical facts. The inspector must balance the need to be technically accurate with the need to reduce scientific issues to simple terms and concepts.

The first barrier to communicating technical information is the use of jargon. The inspector should prepare carefully in order to simplify his or her language without over-simplifying the scientific concepts. The inspector should:

- Speak as clearly as possible. The court reporter may have difficulty recognizing numbers and unfamiliar technical terms.
- Provide a glossary of technical terms, including acronyms, to the reporter.
- Review the meaning of frequently used acronyms, such as OECA meaning the Office of Enforcement and Compliance Assurance.

Even after the witness explains the definitions of the technical language, the underlying concepts may still be difficult to understand. To teach the necessary technical concepts, the inspector and attorney should consider using:

- Short answers in a logical progression of questions.
- Slow enough questioning to avoid information overload.
- Diagrams and pictures.
- Appropriate analogies.

Finally, the inspector should not try to outdo the opposing attorney on technical issues. Not only may the inspector confuse the judge or jury in the process, but also a well-prepared attorney will have thoroughly studied the subject before trial and will have a large advantage in legal debate. To successfully answer questions regarding technical information, an inspector should:

- Examine questions and answers for assumptions and exceptions.
- Look for inaccurate paraphrasing of the inspector's previous testimony.
- Always identify estimates.
- Use references in cases of complicated details. For example, the inspection report could be consulted before testifying about the characteristics of a specific sample.

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Expert Witness

Expert witnesses give opinions on the record. An expert witness has technical or other specialized knowledge that helps the judge or jury better understand the case. In order to prove a witness's expertise, his or her qualifications are introduced by one side and cross-examined by the other side. Only those opinions that the witness is qualified to express by virtue of special training or expertise will be admissible.

An expert is not necessarily someone from outside the agency with particular academic or research credentials. Due to the inspector's professional expertise, he or she might be asked specific questions that require an opinion or might even be called as an expert witness. The EPA attorney will object if the opposing counsel asks inappropriate questions and will decide whether to use the inspector as an expert witness. The inspector should stay carefully within his or her limits of expertise and knowledge whenever asked a question requiring an opinion.

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18. GLOSSARY

24-hour composite sample: Either a flow or time-proportioned mixture of a certain number of discreet aliquots over a period of 24 hours.

Activated Sludge: A process for removing organic matter from sewage by saturating it with air and adding biologically active sludge.

Acute: A stimulus severe enough to rapidly induce an effect; in aquatic toxicity tests, an effect observed in 96 hours or less is typically considered acute. When referring to aquatic toxicology or human health, an acute effect is not always measured in terms of lethality.

Adsorption: An advanced way of treating wastes in which activated carbon removes organic matter from wastewater.

Aeration Tank: A chamber for injecting air into water.

Aerobic: A life or process that occurs in the presence of oxygen.

Algae: Plants which grow in sunlit waters and release oxygen into the water. They are a food for fish and small aquatic animals.

Aliquot: A discrete sample used for analysis.

Alternative Systems: A system utilized in lieu of a conventional system.

Anaerobic: A life or process that occurs in the absence of oxygen.

Antidegradation: Policies which ensure protection of water quality for a particular water body where the water quality exceeds levels necessary to protect fish and wildlife propagation and recreation on and in the water. This also includes special protection of waters designated as outstanding natural resource waters. Antidegradation plans are adopted by each State to minimize adverse effects on water.

Authorized Program or Authorized State: A State, Territorial, Tribal, or interstate NPDES program which has been approved or authorized by EPA under 40 CFR Part 123.

Average monthly discharge limitation: The highest allowable average of daily discharges over a calendar month, calculated as the sum of all daily discharges measured during that month divided by the number of days on which monitoring was performed (except in the case of fecal coliform).

Average weekly discharge limitation: The highest allowable average of daily discharges over a calendar week, calculated as the sum of all daily discharges measured during a calendar week divided by the number of daily discharges measured during that week.

Bacteria: Small living organisms which often consume the organic constituents of sewage.

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Beneficial Uses: The uses of water necessary for the survival or well being of man, plants, and wildlife. These uses of water serve to promote the tangible and intangible economic, social, and environmental goals. "Beneficial Uses" that may be protected against include, but are not limited to: domestic, municipal, agricultural and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves.

Best Available Technology Economically Achievable (BAT): Technology-based standard established by the Clean Water Act (CWA) as the most appropriate means available on a national basis for controlling the direct discharge of toxic and nonconventional pollutants to navigable waters. BAT effluent limitations guidelines, in general, represent the best existing performance of treatment technologies that are economically achievable within an industrial point source category or subcategory.

Best Conventional Pollutant Control Technology (BCT): Technology-based standard for the discharge from existing industrial point sources of conventional pollutants including BOD, TSS, fecal coliform, pH, oil and grease. The BCT is established in light of a two-part "cost reasonableness" test which compares the cost for an industry to reduce its pollutant discharge with the cost to a POTW for similar levels of reduction of a pollutant loading. The second test examines the cost-effectiveness of additional industrial treatment beyond BPT. EPA must find limits which are reasonable under both tests before establishing them as BCT.

Best Management Practice (BMP): Permit condition used in place of or in conjunction with effluent limitations to prevent or control the discharge of pollutants. May include schedule of activities, prohibition of practices, maintenance procedure, or other management practice. BMPs may include, but are not limited to, treatment requirements, operating procedures, or practices to control plant site runoff, spillage, leaks, sludge or waste disposal, or drainage from raw material storage.

Best Practicable Control Technology Currently Available (BPT): The first level of technology-based standards established by the CWA to control pollutants discharged to waters of the U.S. BPT effluent limitations guidelines are generally based on the average of the best existing performance by plants within an industrial category or subcategory.

Best Professional Judgment (BPJ): The method used by permit writers to develop technology-based NPDES permit conditions on a case-by-case basis using all reasonably available and relevant data.

Bioaccumulation: The progressive accumulation of contaminants in the tissues of organisms through any route including respiration, ingestion, or direct contact with contaminated water, sediment, pore water, or dredged material to a higher concentration than in the surrounding environment. Bioaccumulation occurs with exposure and is independent of the tropic level.

Bioassay: A test used to evaluate the relative potency of a chemical or a mixture of chemicals by comparing its effect on a living organism with the effect of a standard preparation on the same type of organism.

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Biochemical Oxygen Demand (BOD): A measurement of the amount of oxygen utilized by the decomposition of organic material, over a specified time period (usually 5 days) in a wastewater sample; it is used as a measurement of the readily decomposable organic content of a wastewater.

Biosolids: Nutrient-rich organic materials resulting from the treatment of domestic sewage in a treatment facility. When treated and processed, these residuals can be recycled and applied as a fertilizer to improve and maintain productive soils and stimulate plant growth. Uses include, but are not limited to, land application to agricultural land, forest land, a reclamation site or sale or give away to the public for home lawn and garden use.

Black Water: The term given to any water that carries animal, human or food wastes.

Bypass: The intentional diversion of wastestreams from any portion of a treatment (or pretreatment) facility.

Categorical Industrial User (CIU): An industrial user subject to National categorical pretreatment standards.

Categorical Pretreatment Standards: Limitations on pollutant discharges to publicly owned treatment works promulgated by EPA in accordance with Section 307 of the Clean Water Act that apply to specified process wastewaters of particular industrial categories [40 CFR §403.6 and Parts 405-471].

Chain-of-Custody: Procedures used to protect samples from tampering and to document such protection.

Chemical Oxygen Demand (COD): A measure of the oxygen-consuming capacity of inorganic and organic matter present in wastewater. COD is expressed as the amount of oxygen consumed in mg/l. Results do not necessarily correlate to the biochemical oxygen demand (BOD) because the chemical oxidant may react with substances that bacteria do not stabilize.

Chlorinator: A device for adding chlorine gas to sewage to kill infectious germs.

Chronic: A stimulus that lingers or continues for a relatively long period of time, often one-tenth of the life span or more. Chronic should be considered a relative term depending on the life span of an organism. The measurement of a chronic effect can be reduced growth, reduced reproduction, etc., in addition to lethality.

Clean Water Act (CWA): An act passed by the U.S. Congress to control water pollution. It was formerly referred to as the Federal Water Pollution Control Act of 1972 or Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500), 33 U.S.C. 1251 et. seq., as amended by: Public Law 96-483; Public Law 97-117; Public Laws 95-217, 97-117, 97-440, and 100-04.

Clean Water Act Section 402(p) [33 USC 1342(p)]: The federal statute requiring municipal and industrial dischargers to obtain NPDES permits for their discharges of storm water.

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Clean Water Act Section 303(d) Listed Water Body : An impaired water body in which water quality does not meet applicable water quality standards and/or is not expected to meet water quality standards, even after the application of technology-based pollution controls required by the CWA.

Coagulation: The clumping together of solids to make them settle out of the sewage faster. Coagulation of solids is brought about with the use of certain chemicals such as lime, alum and iron salts.

Code of Federal Regulations (CFR): A codification of the final rules published daily in the Federal Register. Title 40 of the CFR contains the environmental regulations.

Combined sewage: Domestic and industrial wastewater and storm drainage carried in the same pipe.

Combined Sewer Overflow (CSO): A discharge of untreated wastewater from a combined sewer system at a point prior to the headworks of a publicly owned treatment works. CSOs generally occur during wet weather (rainfall or snowmelt) when the systems become overloaded, bypass treatment works, and discharge directly to receiving waters.

Combined Sewer System (CSS): A wastewater collection system which conveys sanitary wastewaters (domestic, commercial and industrial wastewaters) and storm water through a single pipe to a publicly owned treatment works for treatment prior to discharge to surface waters.

Comminutor: A device for the catching and shredding of heavy solid matter in the primary stage of waste treatment.

Compliance Schedule: A schedule of remedial measures included in a permit or an enforcement order, including a sequence of interim requirements (for example, actions, operations, or milestone events) that lead to compliance with the CWA and regulations.

Composite Sample: Sample composed of two or more discrete samples. The aggregate sample will reflect the average water quality covering the compositing or sample period.

Composting: The natural biological decomposition of organic material in the presence of air to form a humus-like material.

Concentrated Animal Feeding Operation (CAFO): A facility that confines a specific number of animals and meets certain other conditions in the regulations. Wastewater discharge permits for these operations are based upon the requirements of the CAFO Effluent Guidelines.

Confined Space: An enclosed space that an employee can bodily enter and perform assigned work, that has limited means of exit and entry.

Control Authority: The POTW, if it has an approved pretreatment program; in the absence of such a program, the NPDES State, if it has an approved pretreatment program or EPA, if the State does not have an approved pretreatment program.

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Conventional Pollutants: Pollutants typical of municipal sewage, and for which municipal secondary treatment plants are typically designed; defined by Federal Regulation [40 CFR §401.16] as BOD, TSS, fecal coliform bacteria, oil and grease, and pH.

Conventional Systems: Systems that have been traditionally used to collect municipal wastewater in gravity sewers and convey it to a central primary or secondary treatment plant prior to discharge to surface waters.

Conveyance: A channel or passage that conducts or carries water including any pipe, ditch, channel, tunnel, conduit, well, or container.

Criteria: The numeric values and the narrative standards that represent contaminant concentrations that are not to be exceeded in the receiving environmental media (surface water, ground water, sediment) to protect beneficial uses.

Daily Discharge: The discharge of a pollutant measured during a calendar day or any 24-hour period that reasonably represents the calendar day for purposes of sampling. For pollutants with limitations expressed in units of mass, the "daily discharge" is calculated as the total mass of the pollutant discharged over the day. For pollutants with limitations expressed in other units of measurement, the "daily discharge" is calculated as the average measurement of the pollutant over the day.

Daily Maximum Limit: The maximum allowable discharge of pollutant during a calendar day. Where daily maximum limitations are expressed in units of mass, the daily discharge is the total mass discharged over the course of the day. Where daily maximum limitations are expressed in
terms of a concentration, the daily discharge is the arithmetic average measurement of the pollutant concentration derived from all measurements taken that day.

Debris: The remains of anything destroyed or broken, or accumulated loose fragments of rock.

Designated uses: Those uses specified in water quality standards for each water body or segment whether or not they are being attained.

Diffused Air: A technique by which air under pressure is forced into sewage in an aeration tank. The air is pumped down into the sewage through a perforated pipe and bubbled through the sewage.

Digestion: The decomposition of sludge that takes place in tanks and results in the partial gasification, liquefaction, and mineralization of pollutants.

Director: The Regional Administrator or State Director, as the context requires, or an authorized representative. When there is no approved State program, and there is an EPA administered program, Director means the Regional Administrator. When there is an approved State program, "Director" normally means the State Director.

Discharge: Any addition of any pollutant to waters of the U.S. from any conveyance.

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Discharge Monitoring Report (DMR): The form used (including any subsequent additions, revisions, or modifications) to report self-monitoring results by NPDES permittees. DMRs must be used by approved States as well as by EPA.

Distillation: The heating the effluent and removing of the vapor or steam.

Effluent: The liquid that comes out of a treatment plant after completion of the treatment process.

Effluent Limitation: Any restriction established by the Administrator on quantities, rates, and concentrations of chemical, physical, biological and other constituents which are discharged from point sources, other than new sources, into navigable waters, the water of the contiguous zone or the ocean.

Erosion: When land is diminished or wanes away due to the effects of wind, water, or glacial ice. Often the eroded debris (silt or sediment) becomes a pollutant via storm water runoff. Erosion occurs naturally but can be intensified by land clearing activities such as farming, development, road building, and timber harvesting.

Existing uses: Those uses actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards.

Floc: A clump of solids formed in sewage by biological or chemical action.

Flocculation: The process by which clumps of solids in sewage are made to increase in size by chemical, physical, or biological action.

Flume: A specially shaped open channel flow section providing a change in the channel area and/or slope which results in an increased velocity and change in the level of the liquid flowing through the flume. A flume normally consists of three sections: (1) a converging section; (2) a throat section; and (3) a diverging section. The flow rate through the flume is a function of the liquid level at some point in the flume.

Flow-Weighted Composite Sample: A composite sample consisting of a mixture of aliquots collected at a constant time interval, where the volume of each aliquot is proportional to the flow rate of the discharge.

Flow-Proportional Composite Sample: A composite sample that combines discrete aliquots of a sample collected over time, based on the flow of the wastestream being sampled. There are two methods used to collect this type of sample. One collects a constant sample volume at time intervals which vary based on stream flow. The other collects varying sample volumes based on stream flow, at constant time intervals.

First Flush: Individual sample taken during the first 30 minutes of a storm event. The pollutants in this sample can often be used as a screen for non-storm water discharges since such pollutants are flushed out of the system during the initial portion of the discharge.

Fungi: Small, non-chlorophyll bearing plants which may play a useful role in trickling filter treatment operations.

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General Permit: An NPDES permit issued under 40 CFR §122.28 that authorizes a category of discharges under the CWA within a geographical area. A general permit is not specifically tailored for an individual discharger.

Grab sample: A sample which is taken from a wastestream on a one-time basis without consideration of the flow rate of the wastestream and without consideration of time.

Grading: The cutting and/or filling of the land surface to a desired slope or elevation.

Gray Water: Domestic wastewater composed of washwater from sinks, kitchen sinks, bathroom sinks and tubs and laundry tubs.

Grinder Pump: A mechanical device which shreds solids and raises the fluid to a higher elevation through pressure sewers.

Groundwater: The body of water beneath the surface of the ground that is made up primarily of the water that has seeped down from the surface.

Hazardous Substance: Any substance, other than oil, which, when discharged in any quantities into waters of the U.S., presents an imminent and substantial danger to the public health or welfare, including but not limited to fish, shellfish, wildlife, shorelines and beaches (Section 311 of the CWA); identified by EPA as the pollutants listed under 40 CFR Part 116.

Head of Liquid: Depth of flow.

Illicit Discharge: Any discharge to a municipal separate storm sewer that is not composed entirely of storm water except discharges pursuant to an NPDES permit and discharges from fire fighting activities.

Incineration: The burning of sludge or other material to remove the water and reduce the remaining residues to ash.

Infiltration: water other than wastewater that enters a wastewater system and building sewers from the ground through such means as defective pipes, pipe joints, connections, and manholes. (Infiltration does not include inflow.)

Infiltration and inflow (I&I): The total quantity of water from both infiltration and inflow.

Infiltration/Percolation: A land application technique where large volumes of wastewater are applied to land, allowed to penetrate the surface and percolate through the underlying soil.

Inflow: Water other than wastewater that enters a wastewater system and building sewers from sources such as roof leaders, cellar drains, yard drains, area drains, foundation drains, drains from springs and swampy areas, manhole covers, cross connections between storm drains and sanitary sewers, catch basins, cooling towers, storm waters, surface runoff, street wash waters, and drainage. (Inflow does not indude infiltration.)

Influent: Water, wastewater, or other liquid flowing into a reservoir, basin or treatment plant, or any unit thereof.

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Indirect Discharge: The introduction of pollutants into a municipal sewage treatment system from any nondomestic source (i.e., any industrial or commercial facility) regulated under Section 307(b), (c), or (d) of the CWA.

Instantaneous Maximum Limit: The maximum allowable concentration of a pollutant determined from the analysis of any discrete or composite sample collected, independent of the flow rate and the duration of the sampling event.

Interceptor Sewer: A sewer without building sewer connections that is used to collect and carry flows from main and trunk sewers to a central point for treatment and discharge.

Irrigation: A land application technique wherein wastewater is applied to the land to supply the water and nutrient needs of plants.

Land Application: The discharge of wastewater onto the ground for treatment or reuse.

Landfill: An area of land or an excavation in which wastes are placed for permanent disposal, and which is not a land application unit, surface impoundment, injection well, or waste pile.

Lateral Sewers: The pipes that run under the streets of a city and receive the sewers from homes or businesses.

Local Limits: Conditional discharge limits imposed by municipalities upon industrial or commercial facilities that discharge to the municipal sewage treatment system.

Major Facility: Any NPDES facility or activity classified as such by the Regional Administrator, or in the case of approved State programs, the Regional Administrator in conjunction with the State Director. Major municipal dischargers include all facilities with design flows of greater than
one million gallons per day and facilities with EPA/State approved industrial pretreatment programs. Major industrial facilities are determined based on specific ratings criteria developed by EPA/State.

Mass-Based Standard: A discharge limit that is measured in a mass unit such as pounds per day.

Materials Management Practices: Practices used to limit the contact between significant materials and precipitation. These may include structural or nonstructural controls such as dikes, berms, sedimentation ponds, vegetation strips, spill response plans, etc.

Maximum daily discharge limitation: The highest allowable daily discharge.

Mechanical Aeration: The injection of air into water via mechanical energy that causes the waste stream to absorb oxygen from the atmosphere.

Maximum Extent Practicable (MEP): There is no regulatory definition for MEP. The CWA section 402(p)(3)(B)(iii) requires that municipal permits "shall require controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques and system, design and engineering methods, and such other provisions as the Administrator or the State determines appropriate for the control of such pollutants.

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Method Detection Limit (MDL): Defined as the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte.

Microbes: Minute plant or animal life. Some microbes that may cause disease exist in sewage.

Million Gallons per Day (mgd): A unit of flow commonly used for wastewater discharges. One mgd is equivalent to 1.547 cubic feet per second.

Mixed Liquor: A mixture of activated sludge and waters, containing organic matter undergoing activated sludge treatment in the aeration tank.

Mixing Zone: An area where an effluent discharge undergoes initial dilution and is extended to cover the secondary mixing in the ambient water body. A mixing zone is an allocated impact zone where water quality criteria can be exceeded as long as acutely toxic conditions are prevented.

Municipality: A city, town, borough, county, parish, district, association, or other public body created by or under state law and having jurisdiction over disposal of sewage, industrial wastes, or other wastes, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of CWA.

Municipal Separate Storm Sewer Systems (MS4): A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels, or storm drains) owned by a State, city, town or other public body, that is designed or used for collecting or conveying storm water, which is not a combined sewer, and which is not part of a publicly owned treatment works. [40 CFR §122.26(b)(8)].

National Pollutant Discharge Elimination System (NPDES): The national program for issuing, modifying, revoking and reissuing, terminating, monitoring and enforcing permits, and imposing and enforcing pretreatment requirements, under Sections 307, 318, 402, and 405 of CWA.

National Pretreatment Standard or Pretreatment Standard: Any regulation promulgated by the EPA in accordance with Sections 307(b) and (c) of the CWA that applies to a specific category of industrial users and provides limitations on the introduction of pollutants into publicly owned treatment works. This term includes the prohibited discharge standards under 40 CFR §403.5, induding local limits [40 CFR §403.3(j)].

New Source Performance Standards (NSPS): Technology-based standards for facilities that qualify as new sources under 40 CFR §122.2 and 40 CFR §122.29. Standards consider that the new source facility has an opportunity to design operations to more effectively control pollutant discharges.

Nitrogenous Wastes: Wastes of animal or plant origin that contain a significant concentration of nitrogen.

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Nonconventional Pollutants: All pollutants that are not included in the list of conventional or toxic pollutants in 40 CFR Part 401. Includes pollutants such as chemical oxygen demand (COD), total organic carbon (TOC), nitrogen, and phosphorus.

Nonpoint Source Pollution (NPS): Nonpoint source refers to diffuse, widespread sources of pollution. Nonpoint Sources include but are not limited to urban, agricultural, or industrial areas, roads, highways, construction sites, communities served by septic systems, recreational boating activities, timber harvesting, mining, livestock grazing, as well as physical changes to stream channels, and habitat degradation.

Non-Storm Water: Non-storm water consists of all discharges to and from a storm water conveyance system that do not originate from precipitation events (i.e., all discharges from a conveyance system other than storm water).

Non-structural BMPs: In general, activities or programs to educate the public or provide low cost non-physical solutions. Examples include: activity schedules, prohibitions of practices, street sweeping, facility maintenance, detection and elimination of illicit connections and illegal dumping, and other low-cost measures.

Nuisance: As defined in the Porter-Cologne Water Quality Control Act a nuisance is "anything which meets all of the following requirements: 1) Is injurious to health, or is indecent, or offensive to the senses, or an obstruction to the free use of property, so as to interfere with the comfortable enjoyment of life or property. 2) Affects at the same time an entire community or neighborhood, or any considerable number of persons, although the extent of the annoyance or damage inflicted upon individuals may be unequal. 3) Occurs during, or as a result of, the treatment or disposal of wastes."

Numeric Effluent Limitations: The typical method by which effluent limits are prescribed for pollutants in waste discharge requirements implementing the federal NPDES regulations. When numeric effluent limits are met at the "end-of-pipe," the effluent discharge generally will not cause water quality standards to be exceeded in the receiving waters.

Nutrients: Elements or compounds essential as raw materials for organism growth and development (e.g., carbon, oxygen, nitrogen and phosphorous).

Organic Matter: The carbonaceous waste contained in plant or animal matter and originating from domestic or industrial sources.

Outfall: Point source where an effluent is discharged into receiving waters.

Overland Flow: A land application technique that cleanses wastewater by allowing it to flow over a sloped surface. As the water flows over the surface, the contaminants are removed and the water is collected at the bottom of the slope for reuse.

Oxidation: The addition of oxygen which breaks down organic wastes or chemicals in sewage by bacterial and chemical means.

Oxidation Pond: A man-made lake or body of water in which wastes are consumed by bacteria. It is used most frequently with other waste treatment processes. An oxidation pond is basically the same as a sewage lagoon.

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Pathogen: An organism that is capable of producing an infection or disease in a susceptible host.

Peak flow: The maximum flow that occurs over a specific length of time (e.g. daily, hourly, instantaneous).

Percolation: The movement of water through sub-surface soil layers, usually continuing downward to the groundwater.

Permittee: Any "person," as defined at 40 CFR §122.2, authorized by an NPDES Permit to discharge to Waters of the United States.

pH: A measure of the hydrogen ion concentration of water or wastewater; expressed as the negative log of the hydrogen ion concentration in mg/l. A pH of 7 is neutral. A pH less than 7 is acidic, and a pH greater than 7 is basic.

Phosphorous: An element that while essential to life, contributes to the eutrophication of lakes and other bodies of water.

pin floc: Small floc particle.

Point Source: Any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fixture, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel, or other floating craft from which pollutants are or may be discharged.

Pollutant: Dredged spoil, solid waste, incinerator residue, filter backwash, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials (except those regulated under the Atomic Energy Act of 1954, as amended (42 U.S.C. 2011 et seq.)), heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water.

Pollution Prevention: Practices and processes that reduce or eliminate the generation of pollutants, in contrast to source control, treatment, or disposal.

Polyelectrolytes: Synthetic chemicals used to speed the removal of solids from sewage. The chemicals cause the solids to flocculate or clump together more rapidly than chemicals like alum or lime.

Post-Construction BMPs: A subset of BMPs including structural and non-structural controls which detain, retain, filter, or educate to prevent the release of pollutants to surface waters during the final functional life of development.

Practical Quantification Limit (PQL): The lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions.

Pressure Sewer: A system of pipes in which the water, wastewater or other liquid is transported to a higher elevation by applying a pumping force behind it.

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Pretreatment: The reduction of the amount of pollutants, the elimination of pollutants, or the alteration of the nature of pollutant properties in wastewater prior to or in lieu of discharging or otherwise introducing such pollutants into a publicly owned treatment works [40 CFR §403.3(q)].cultural waste discharged into water.

Primary Treatment: The practice of removing some portion of the suspended solids and organic matter in a wastewater through sedimentation. Common usage of this term also includes preliminary treatment to remove wastewater constituents that may cause maintenance or operational problems in the system (i.e., grit removal, screening for rags and debris, oil and grease removal, etc.).

Priority Pollutants: Those pollutants considered to be of principal importance for control under the CWA based on the NRDC consent decree settlement [(NRDC et al. v. Train, 8 E.R.C. 2120 (D.D.C. 1976), modified 12 E.R.C. 1833 (D.D.C. 1979)]; a list of these pollutants is provided as Appendix A to 40 CFR Part 423.

Process Wastewater: Any water which, during manufacturing or processing, comes into direct contact with, or results from the production or use of any raw material, intermediate product, finished product, byproduct, or waste product.

Publicly Owned Treatment Works (POTW): A treatment works, as defined by Section 212 of the CWA, that is owned by the State or municipality, including any devices and systems used in the storage, treatment, recycling, and reclamation of municipal sewage or industrial wastes of a liquid nature and sewers, pipes, and other conveyances only if they convey wastewater to a POTW treatment plant [40 CFR §403.3].

Pump: A mechanical device for causing flow, raising or lifting water or other fluid, or applying pressure to fluids.

Receiving Water: The Waters of the U.S. which includes both surface and groundwaters.

Runoff Coefficient: The fraction of total rainfall that will appear at the conveyance as runoff.

Salts: The minerals that water picks up as it passes through the air over and under the ground, and as the water is used by households and industry.

Sand Filters: Filters that physically remove some suspended solids from sewage. Air and bacteria decompose additional wastes filtering through the sand. Cleaner water drains from the bed. The sludge accumulating at the surface must be removed from the bed periodically.

Sanitary Sewer: A pipe or conduit (sewer) intended to carry wastewater or water-borne wastes from homes, businesses, and industries to the POTW.

Sanitary Sewer Overflows (SSOs): Untreated or partially treated sewage overflows from a sanitary sewer collection system.

Secondary Industry Category: Any industry category which is not a primary industry category.

Secondary Treatment: Technology-based requirements for direct discharging municipal sewage treatment facilities. Standard is based on a combination of physical and biological

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processes typical for the treatment of pollutants in municipal sewage. Standards are expressed as a minimum level of effluent quality in terms of: BOD 5 , suspended solids (SS), and pH (except as provided for special considerations and treatment equivalent to secondary treatment).

Sedimentation Tanks: Tanks that help to remove solids from sewage. The wastewater is pumped to the tanks where the solids settle to the bottom or float on the top as scum. The scum is skimmed off the top, and solids on the bottom are pumped to incineration, digestion, filtration or other means of final disposal.

Seepage: The slow movement of water through small cracks or pores of a material, through the soil, or into or out of a body of surface or subsurface water.

Self-Monitoring: Sampling and analyses performed by a facility to determine compliance with a permit or other regulatory requirements.

Septic Tanks: Underground tanks where domestic wastes are piped to directly from a home or homes when a sewer line is not available to carry them to a treatment plant. The bacteria in the wastes decompose the organic waste and the sludge settles on the bottom of the tank. The effluent flows out of the tank into the ground through drains. The sludge is pumped out of the tanks, usually by commercial firms, at regular intervals.

Sewage Sludge: Solid, semi-solid, or liquid residue generated during the treatment of domestic sewage in a treatment works [40 CFR §503.9(w)]. Sewage sludge includes, but is not limited to, domestic septage; scum or solids removed in primary, secondary, or advanced wastewater treatment processes; and a material derived from sewage sludge. Sewage sludge does not include ash generated during the firing of sewage sludge in a sewage sludge incinerator or grit and screenings generated during preliminary treatment of domestic sewage in a treatment works.

Sewer: A system of pipes that collects and delivers wastewater to treatment plants or receiving streams.

Significant Industrial User (SIU): An indirect discharger that is the focus of control efforts under the national pretreatment program; includes all indirect dischargers subject to national categorical pretreatment standards, and all other indirect dischargers that contribute 25,000 gpd or more of process wastewater, or which make up five percent or more of the hydraulic or organic loading to the municipal treatment plant, subject to certain exceptions [40 CFR §403.3(t)].

Sludge: The solid matter that settles to the bottom, floats, or becomes suspended in sedimentation tanks and must be disposed of by filtration and incineration or by transport to appropriate disposal sites.

Spill Prevention Control and Countermeasure Plan (SPCC): A plan prepared by a facility to minimize the likelihood of a spill and to expedite control and cleanup activities should a spill occur.

Standard Industrial Classification (SIC) Code: A code number system used to identify various types of industries. The code numbers are published by the Superintendent of

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Documents, U.S. Government Printing Office, Washington, D.C. 20402. A particular industry may have more than one SIC code if it conducts several types of commercial or manufacturing activities onsite.

Sterilization: The destruction of all living organisms. In contrast, disinfection is the destruction of most of the living organisms.

Storm Sewer: A separate system of pipes that carries only runoffs from buildings and land during a storm.

Storm Water: Discharges generated by runoff from land and impervious areas such as paved streets, parking lots, and building rooftops during rainfall and snow events that often contain pollutants in quantities that could adversely affect water quality. Most storm water discharges are considered point sources and require coverage by an NPDES permit.

Structural Controls: Physical facilities or controls which may include secondary containment, treatment measures, (e.g. first flush diversion, detention/retention basins, and oil/grease separators), run-off controls (e.g., grass swales, infiltration trenches/basins, etc.), and engineering and design modification of existing structures.

Sump Pump: A mechanism used for removing water or wastewater from a sump or wet well.

Suspended Solids: The small particles of solid pollutants which are present in sewage and which resist separation from the water by conventional means.

Technology-Based Effluent Limit: A permit limit for a pollutant that is based on the capability of a treatment method to reduce the pollutant to a certain concentration.

Time Composite Sample: A composite sample prepared by collecting fixed volume aliquots at specified time intervals, which are combined into a single sample for analysis.

Total Dissolved Solids: The total dissolved (filterable) solids as determined by use of the method specified in 40 CFR part 136.

Total Maximum Daily Load (TMDL): The maximum amount of a pollutant that can be discharged into a water body from all sources (point and non-point) and still maintain water quality standards. Under Clean Water Act Section 303(d), TMDLs must be developed for all water bodies that do not meet water quality standards after application of technology-based controls.

Total Organic Carbon (TOC): The amount of organic carbon in water.

Total Suspended Solids (TSS): A measure of the filterable solids present in a sample, as determined by the method specified in 40 CFR Part 136.

Toxic Pollutants: Pollutants or combinations of pollutants, including disease-causing agents, which after discharge and upon exposure, ingestion, inhalation or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, will, on the basis of information available to the Administrator of EPA, cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions, (including

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malfunctions in reproduction) or physical deformations, in such organisms or their offspring. Toxic pollutants include those pollutants listed by the Administrator under CWA Section 307(a)(1) or any pollutant listed under Section 405(d) which relates to sludge management.

Toxicity: Adverse responses of organisms to chemicals or physical agents ranging from mortality to physiological responses such as impaired reproduction or growth anomalies.

Toxicity Reduction Evaluation (TRE): A site-specific study conducted in a stepwise process designed to identify the causative agent(s) of effluent toxicity, isolate the sources of toxicity, evaluate the effectiveness of toxicity control options, and then confirm the reduction in effluent toxicity.

Toxicity Test: A procedure to determine the toxicity of a chemical or an effluent using living organisms. A toxicity test measures the degree of effect on exposed test organisms of a specific chemical or effluent.

Trickling Filter: A support media for bacterial growth, usually a bed of rocks or stones. The sewage is trickled over the bed so the bacteria can break down the organic wastes.

Turbidity: The capability of light to pass through water.

Upset: An exceptional incident in which there is unintentional and temporary noncompliance with the permit limit because of factors beyond the reasonable control of the permittee. An upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventive maintenance, or careless or improper operation.

Urban Runoff: All flows in a storm water conveyance system, including storm water (wet weather flows) and non-storm water illicit discharges (dry weather flows).

Use Attainability Analysis (UAA): A structured scientific assessment of the factors affecting the attainment of a designated use, such as physical, chemical, biological, and economic factors as described in §131.10(g).

Variance: Any mechanism or provision under Sections 301 or 316 of the CWA or under 40 CFR Part 125, or in the applicable "effluent limitations guidelines" which allows modification to or waiver of the generally applicable effluent limitations requirements or time deadlines of the CWA. This includes provisions which allow the establishment of alternative limitations based on fundamentally different factors.

Waste Treatment Plant: A series of tanks, screens, filters, and other processes by which pollutants are removed from water.

Wastesload Allocation (WLA): The proportion of a receiving water's total maximum daily load that is allocated to one of its existing or future point sources of pollution.

Water Quality-Based Effluent Limit (WQBEL): A value determined by selecting the most stringent of the effluent limits calculated using all applicable water quality criteria (e.g., aquatic life, human health, and wildlife) for a specific point source to a specific receiving water for a given pollutant.

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Water Quality Criteria: Comprised of numeric and narrative criteria. Numeric criteria are scientifically derived ambient concentrations developed by EPA or States for various pollutants of concern to protect human health and aquatic life. Narrative criteria are statements that describe the desired water quality goal.

Water Quality Standards (WQS): A law or regulation that consists of the beneficial use or uses of a water body, the numeric and narrative water quality criteria that are necessary to protect the use or uses of that particular water body, and an antidegradation statement.

Waters of the United States: All waters that are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters subject to the ebb and flow of the tide. Waters of the United States include but are not limited to all interstate waters and intrastate lakes, rivers, streams (including intermittent streams), mudflats, sand flats, wetlands, sloughs, prairie potholes, wet meadows, play lakes, or natural ponds. [See 40 CFR §122.2 for the complete definition.]

Watershed: That geographical area which drains to a specified point on a watercourse, usually a confluence of streams or rivers (also known as drainage area, catchments, or river basin).

Weir: A device used to gauge the flow rate of liquid through a channel; is essentially a dam built across an open channel over which the liquid flows, usually through some type of notch.

Wet Weather Flow: Dry weather flow combined with storm water introduced into a combined sewer, and dry weather flow combined with inflow in a separate sewer.

Whole Effluent Toxicity (WET): The total toxic effect of an effluent measured directly with a toxicity test.

Virus: The smallest form of microorganism capable of causing disease.

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APPENDIX A

EPA ORDER 3500.1
TRAINING AND DEVELOPMENT FOR COMPLIANCE INSPECTORS/ FIELD INVESTIGATORS

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** Note: This is copy of text of EPA Order 3500.1 **

EPA ORDER
Classification No.: 3500.1
Approval Date: June 29, 1988

TRAINING AND DEVELOPMENT FOR COMPLIANCE INSPECTORS/FIELD INVESTIGATORS

1. PURPOSE. This Order establishes a consistent Agency-wide training and development program for employees leading environmental compliance inspections/field investigations.

2. APPLICABILITY. This Order applies to all Environmental Protection Agency (EPA) personnel who lead or oversee the conduct of compliance inspections/field on a full- or part-time basis under any of EPA's statutes. This order is advisory to State and local agencies.

3. POLICY. It is the policy of the Environmental Protection Agency to ensure that those who lead environmental compliance inspections/field investigations are properly trained to perform these functions in a legally and technically sound manner.

4. REFERENCES.

a. EPA 1440. Occupational Health and Safety Manual: Chapter 7, Occupational Health and Safety Training.

b. EPA Order 1440.2, Health and Safety Requirements for Employees Engaged in Field Activities.

c. EPA order 1440.3, Respiratory Protection.

d. Agency-wide Program to Train, Develop and Recognize Compliance Inspectors/Field Investigators: A Program Description, June 1988.

5. DEFINITIONS.

a. Compliance Inspections/Field Investigation Function. The function includes leading, or overseeing State/local, contractor or other personnel conducting any of the following activities for the purpose of establishing the compliance status of facilities or sites with applicable laws, standards, regulations, permits and/or of supporting appropriate enforcement action (administrative, civil judicial or criminal), including:

(1) planning and carrying out inspections of pollution abatement equipment, relevant facility operations and maintenance practices, self-monitoring practices and records, and laboratory equipment;

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(2) gathering and developing evidence, including but not limited to emission monitoring measurements, other analytical field procedures such as sampling and the associated quality assurance procedures, and in-depth engineering evaluations; and

(3) maintaining field logs, recording field observations photographically, analyzing sampling and emissions data, and preparing reports of observations along with any supporting documentation.

Any EPA employee performing these activities regardless of job title or program shall be considered a compliance inspector/field investigator for the purposes of this Order. The terms compliance inspector/field investigator will be used throughout this Order. This function does not include field activities or investigations for purposes such as research and development, which are unrelated to compliance monitoring or enforcement.

Not all individuals performing work as On-Scene Coordinators (OSCs) and Remedial Project Managers (RPMs) under the CERCLA program are covered by the definition of the compliance inspection/field investigation function. Additional program guidance will be developed to assist Regions in distinguishing these functions from other programmatic responsibilities.

b. New Compliance Inspector/Field Investigators. Including:

(1) Individuals newly employed by EPA subsequent to the issuance date of this Order regardless of previous training in and experience leading environmental compliance inspections/field investigations, or

(2) Individuals rehired by EPA or transferred within EPA, subsequent to the issuance date of this Order, with no previous training in and experience leading environmental compliance inspections/field investigations.

c. Experienced Compliance Inspectors/Field Investigators. Including: Individuals who were employed by EPA on the issuance date of this policy, and/or who have previous training in and experience leading environmental compliance inspections/field investigations in any one of EPA's compliance and enforcement programs.

d. First-line Supervisors of Inspectors. A first-line supervisor is the immediate supervisor of the day-to-day work of an individual who leads or oversees compliance inspections/field investigations. The first-line supervisor, who is responsible for the official performance appraisal, may be "new" or "experienced" as defined above in Items 5(b) or 5(c).

e. Contract Inspectors and Others. This category includes contract personnel and employees of a grantee organization under the Senior Environmental Employment Program, performing compliance inspections/field investigations under EPA's statutes.

f. Leading an Inspection. Leading an inspection means independently

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conducting a compliance inspection/field investigation or directing an inspection/investigation with others as support staff.

g. Curriculum. Curriculum refers to defined content presented in a sequence of supervised self-study, formal on-the-job and/or classroom training:

(1) Supervised Self-Study. Self-study means any knowledge gained through independent, personal study, and overseen by a first-line supervisor or an experienced inspector/investigator.

(2) On-the-Job Training. On-the-job training (OJT) means structured training that relates principles or theories to work-related skills which are demonstrated and applied in the field environment during an actual compliance inspection/field investigation.

(3) Classroom/classes.. This refers broadly to any form of instruction, flexible in format and size, to include seminars, workshops, lecture-type or video-assisted classes, or question-and-answer sessions following prior independent self-study, that fosters group interaction with an instructor or an experienced inspector.

h. Completing Required Training. Completion of required training means completing self-study, OJT and participation in classes covering the content described in applicable training curricula.

6. TRAINING PROGRAM. EPA's training program consists of three parts - Occupational Health and Safety Curriculum, Basic Curriculum, and Program-Specific Curricula - as follows.

a. Occupational Health and Safety Curricula. EPA Order 1440.2 establishes basic, intermediate, advanced and refresher requirements for occupational health and safety training for all EPA employees before engaging in any field activities. In addition, EPA compliance inspectors/field investigators must meet requirements, where these apply, of EPA Order 1440.3 for Respiratory Protection. A summary of the curriculum is found in Appendix B of Reference 4(d) above. Contractor personnel must meet training requirements of applicable regulations of the Occupational Safety and Health Administration (OSHA).

b. Basic Inspector Curriculum. This Curriculum establishes required training to provide a comprehensive overview of knowledge and skills needed for compliance inspections/field investigations under any EPA statute. It consists of a course, that integrates legal, technical and administrative subjects, with communication skills. It also includes the Occupational Health and Safety Curriculum cited in 6(a) above. The Basic Curriculum is summarized in Appendix C of Reference 4(d) above. Related supplemental Training is recommended to further develop some of these skills, as summarized in Appendix F of Reference 4(d) above.

c. Program-Specific Curricula. The Program-Specific Minimum Curriculum for each major environmental program establishes required training in legal, programmatic

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and technical subjects. Any EPA compliance inspector conducting inspections in more than one program is required to have completed the relevant Program-Specific Minimum Curricula in each such program. Program-Specific Specialized Training is recommended to further develop inspection skills. Summaries of these curricula are available in Appendix D, of Reference 4(d) above. A summary of multi-media (multi-program) training recommendations is available in Appendix E of Reference 4(d) above.

d. Refresher Training.

(1) Occupational Health and Safety: EPA Orders 1440.2 and 1440.3 require refresher training annually.

(2) Basic and Program-Specific Minimum Curricula: Refresher training in both the Basic Curriculum and Program-Specific Minimum Curricula is strongly recommended, but at the discretion of the first-line supervisor. At a minimum, refresher training should occur every three years, or more frequently, depending on the needs of the individual, and changing emphases or needs in the compliance and enforcement program.

7. REQUIREMENTS AND EXCEPTIONS.

a. Before Any Field Activities. All compliance inspectors and first-line supervisors of inspectors are required to complete applicable occupational health and safety training before any field activities as defined in EPA Orders 1400.2 and 1400.3.

b. Before Leading Inspections/Investigations. All compliance inspectors/field investigators must complete the Basic Curriculum and the Program-Specific Minimum Curriculum in the assigned program area(s) before leading an inspection. Experienced inspectors may be excepted from the Basic Curriculum, but new inspectors may not. There may be limited exceptions to program-specific requirements for new and experienced inspectors.

c. Within One Year When Supervising. The requirements to complete the Basic and Program-Specific Minimum Curriculum apply to first-line supervisors of compliance inspectors. First-line supervisors shall meet these requirements within one year of appointment to the supervisory position, if they have not already done so. If the first-line supervisor directs inspectors/investigators in two or more programs, the supervisor may need additional time to complete all of the applicable Program-Specific Minimum Curricula, and should do so as soon as practicable. Experienced first-line supervisors may be excepted from the Basic Curriculum, but new ones may not. There may be limited exceptions to program-specific requirements for new and experienced first-line supervisors.

d. Procedures for Exceptions.

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(1) Health and Safety Training. Any exceptions to the occupational health and safety training requirements must be in accordance with Paragraph 9(d), EPA Order 1440.2, or the provisions of 1440.3.

(2) Basic and Program-Specific Minimum Curricula. In the Regions, exceptions must be approved by the Regional Administrator. Delegation below this level may be made to the Deputy Regional Administrator or a cross-regional panel of managers established for this purpose, but excluding the immediate first- or second-line supervisor of the individual for whom the exception is being requested. For Program Offices with inspectors based in Headquarters, the Assistant Administrator shall approve exceptions for those inspectors. Delegation below this level may be made to the Deputy Assistant Administrator, or Office Director, or in the case of OECM, to the Director of the National Enforcement Investigations Center (NEIC). The first-line supervisor shall prepare a written request based upon guides for evaluating the previous knowledge, experience and/or training of the inspector, and shall submit this to the approving official, according to procedures adopted in the Region or Headquarters, whichever apply. A copy of the approved written request shall be placed in the employee's official personnel file along with other training records.

8. EFFECTIVE DATE.

a. Occupational Health and Safety Training. The requirements of EPA Orders 1440.2 and 1440.3 are in effect and will remain in effect.

b. Basic and Program-Specific Minimum Curricula. This Order is effective on the date of issuance; however, requirements are phased in as follows:

(1) New Inspectors. Beginning October 1, 1989, new inspectors shall not lead inspections unless they have completed the Basic Curricula, and have completed, or have been formally excepted, from the Program-Specific Minimum Curricula.

(2) Experienced Inspectors. Beginning October 1, 1991, experienced inspectors shall not lead inspections unless they have completed or have been formally excepted from the Basic and Program-Specific Minimum Curricula.

(3) First-line Supervisors. Beginning October 1, 1989, all first-line supervisors shall meet the requirements of this Order or have been formally excepted within one year of appointment to the supervisory position, or as soon as practicable, for those with two or more programs.

(4) Contract Inspectors and Others. Training requirements for EPA contract inspectors shall be appropriately-phased into future contracts or solicitations involving compliance inspection work. These requirements shall be incorporated into future assistance agreements awarded under the Senior Environmental Employment Program involving compliance inspections.

9. RESPONSIBILITIES. This section lists the primary responsibilities for

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implementing this Order. Appendix G of Reference 4(d) above contains a more detailed list of responsibilities.

a. Assistant Administrator for Enforcement and Compliance Monitoring (OECM,). The Assistant Administrator for Enforcement and Compliance Monitoring is responsible for:

(1) Updating this Order, and overseeing and evaluating implementation of the overall program requirements every 3 years;

(2) Developing, updating and disseminating student manuals and instructor's guides for the Basic Curriculum to the Regions, coordinating the selection of and maintaining a list of instructors from the Regions and Headquarters; and

(3) Organizing a board of Senior Agency Managers from Headquarters and Regions, and inspectors/investigators to advise him/her in carrying out the responsibilities listed above.

b. Assistant Administrator for Administration and Resources Management. The Assistant Administrator for Administration and Resources Management is responsible for:

(1) Updating and providing sufficient materials for occupational health and safety training, or approving non-EPA courses to meet the requirements of EPA Orders 1440.2 and 1440.3, and reviewing program-specific health and safety training.

(2) Training and evaluating EPA personnel designated as instructors for delivering the Inspector Health and Safety Curriculum; and

(3) Coordinating and disseminating a timely schedule of classes of the Health and Safety, Basic, and Program-Specific Curricula, in consultation with OECM, Program Offices and the Regions.

c. Assistant Administrators. The Assistant Administrators are responsible for:

(1) Implementing the requirements of this Order and Agency program [Reference 4(d)] within their areas of jurisdiction, including periodically evaluating implementation;

(2) Developing, updating, and disseminating materials and schedules for classes under the Program-Specific Curricula, in consultation with Regions and States, and providing a plan by October 30, 1988, for implementing the Basic Curriculum for inspectors based in Headquarters;

(3) Establishing guides for first-line supervisors of inspectors to evaluate the training and development needs of compliance inspectors/field investigators and approving requests for exceptions;

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(4) Determining who among those inspectors/investigators based in Headquarters are subject to this Order, and reviewing and approving exceptions to the training requirements requested for these personnel.

(5) Ensuring in future contracts and assistance agreements awarded under the Senior Environmental Employment Program involving compliance inspections that training is required by means of statements of work or other appropriate vehicles; and

(6) Establishing standing work groups including Regions, and States where appropriate, to help carry out these responsibilities and to improve the quality of the compliance monitoring function.

d. Regional Administrators. The Regional Administrators are responsible for:

(1) Implementing the requirements of this Order and Agency program (Reference 4(d)) within their areas of jurisdictions, including periodically evaluating implementation;

(2) Determining who in the Region is subject to this Order, and reviewing and approving any exceptions to the training requirements;

(3) Ensuring in future contracts involving compliance inspections that training is required by means of statements of work or other appropriate vehicles;

(4) Supporting in-house instruction for the Basic Curriculum, by working with OECM to identify Regional personnel to serve as classroom instructors and providing a Regional implementation plan by October-30, 1988; and

(5) Ensuring each program identifies States' inspector training needs annually through the State/EPA Enforcement Agreements process; assisting States in identifying ways to meet their training needs; and coordinating training opportunities.

e. Line Supervisors. Line supervisors in Program or Environmental Service Divisions, are responsible for:

(1) Ensuring quality compliance inspections/field investigations using performance standards, periodic appraisals, appropriate assignments to ensure development, and recognition of personnel engaged in the compliance monitoring function; and

(2) Identifying employees who require training, ensuring that employees comply with the requirements of this Order, preparing requests for exceptions, and maintaining records of actions.

f. Compliance Inspectors/Field Investigators. Compliance inspectors/field investigators are responsible for.

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(1) Advising their supervisor about the history and extent of relevant training and experience, and assisting in the preparation of an Individual Development Plan to meet the requirements of this Order; and

(2) Applying and maintaining the knowledge, skills, and techniques acquired through training to ensure that inspections/investigations are accomplished in a technically and legally sound manner.

/s/
James Barnes
Deputy Administrator
Dated: June 29, 1988

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APPENDIX B

EPA ORDER 1440.2
HEALTH AND SAFETY REQUIREMENTS FOR EMPLOYEES ENGAGED IN FIELD ACTIVITIES

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PROTECTIVE SERVICES - SAFETY

HEALTH AND SAFETY REQUIREMENTS FOR EMPLOYEES ENGAGED IN FIELD ACTIVITIES

1. PURPOSE. This Order establishes policy, responsibilities, and mandatory requirements for occupational health and safety training and certification, and occupational medical monitoring of Agency employees engaged in field activities.

2. DEFINITIONS.

a. The term "field activities" as used in this Order means EPA program activities that are conducted by EPA employees outside of EPA administered facilities. These activities include environmental and pesticides sampling, inspection of water and wastewater treatment plants, and hazardous material spills and waste site investigations, inspections, and sampling.

b. The term "health and safety training" means scheduled, formal or informal training courses, approved and sponsored by EPA and conducted by EPA or its contracted agents which is designed to develop, improve and upgrade the health and safety knowledge of EPA employees involved in field activities.

c. The term "occupational medical monitoring" means surveillance over the health status of employees by means of periodic medical examinations or screening in accordance with the Agency's Occupational Medical Monitoring guidelines.

d. The term "certification" as used in this Order means that the employee has successfully completed the minimum classroom and field training requirements for the specified level of training and the Agency has issued a certificate attesting that the employee met these requirements.

3. REFERENCES.

a. 29 CFR 1910, Parts 16, 94, 96, 106, 109, 111, 134, 151, 1000, Occupational Health and Safety Standards.

b. Executive Order 12196, Section 1-201, Sec. (k), Occupational Health and Safety Programs for Federal Employees.

c. 29 CFR 1960.59(a), Occupational Safety and Health for the Federal Employee.

d. EPA Occupational Health and Safety Manual, Chapter 7(1).

e. EPA Training and Development Manual, Chapter 3, Par 7(b).

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f. Occupational Health and Safety Act of 1971, P.L. 91-596, Sec.6.

g. EPA Order on Respiratory Protection (Proposed).

h. 49 CFR, Parts 100-177, Transportation of Hazardous Materials.

i. EPA Order 1000.18, Transportation of Hazardous Materials.

j. EPA Order 3100.1, Change 1, Uniforms, Protective Clothing, and Protective Equipment.

4. BACKGROUND. Field activities are a critical part of most EPA programs. These activities range from routine environmental reconnaissance sampling, inspections, and monitoring, to entering and working in environments with known and unknown hazards. Since protection can not be engineered into the field working situation, the protection of personnel engaged in field activities involves training employees in safe operational procedures and the proper use of appropriate personal protective clothing and equipment.

5. APPLICABILITY. This Order applies to all EPA organizational units which have employees engaged in field activities.

6. POLICY. It is the policy of the Environmental Protection Agency to carry out its field activities in a manner that assures the protection of its employees.

7. RESPONSIBILITIES.

a. Assistant Administrators, Regional Administrators, Deputy Assistant Administrators, Laboratory Directors, and Division Directors. These officials are responsible within their jurisdictions for implementing the provisions of this Order and for budgeting the necessary funds for employee training and certification, personal protective clothing and equipment, and occupational medical monitoring programs.

b. Supervisors. Supervisors are responsible for complying with the requirements of this Order for employee training and certification, and occupational medical monitoring programs. They will identify those employees who require training and certification, and occupational medical monitoring, and assure they receive it to comply with the provisions of this Order and will insure these requirements are properly contained in position descriptions and job postings.

c. Employees. Employees are responsible for making known upon request from their supervisors the extent of their individual occupational health and safety training and the history of their occupational medical monitoring participation. Employees should notify their supervisor of any hazardous work situation and make suggestions for corrective measures. Employees are responsible for applying the knowledge, skills, and techniques acquired through training in a manner that will help assure their health and safety and that of fellow workers.

d. Occupational Health and Safety Designees. The Occupational Health and Safety Designees are responsible for identifying program areas that require training and certification, and occupational medical monitoring; recommending or providing training and certification resources to meet the requirements of this Order; and maintaining records of persons receiving training and certification.

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e. Office of Occupational Health and Safety. The Director, Office of Occupational Health and Safety is responsible for establishing policy and requirements for adequate training and certification programs for field activities, developing and maintaining an occupational medical monitoring program, approving health and safety training and certification programs for employees involved in field activities, and for evaluating the results of these training and certification programs.

8. OBJECTIVES.

a. Training and Certification. The objective of the health and safety training and certification programs for employees involved in field activities are:

(1) To assure that EPA employees are aware of the potential hazards they may encounter during the performance of field activities;

(2) To provide the knowledge and skills necessary to perform the work with the least possible risk to personal health and safety;

(3) To assure that Agency program goals are accomplished in as safe and healthful manner as feasible; and

(4) To assure that EPA employees can safely disengage themselves from an actual hazardous situation which may occur during a field activity.

b. Occupational Medical Monitoring. The objectives of the occupational Medical Monitoring program are:

(1) To detect any adverse effects of occupational exposure on the employees health and to initiate prompt corrective actions when indicated; and

(2) To assure that employees assigned arduous or physically taxing jobs or jobs requiring unique skills are able to perform those jobs without impairing their health and safety or the health and safety of others.

9. TRAINING AND CERTIFICATION REQUIREMENTS. Employees shall not be permitted to engage in routine field activities until they have been trained and certified to a level commensurate with the degree of anticipated hazards.

a. Basic Level. All employees shall be provided a minimum of 24 hours of health and safety training prior to their becoming involved in normal, routine field activities. The training shall include but not be limited to classroom instruction in all the following subject areas:

(1) Employee Rights and Responsibilities;
(2) Nature of Anticipated Hazards;
(3) Emergency Help and Self-Rescue;
(4) Vehicles - Mandatory Rules and Regulations;
(5) Safe Use of Field Equipment;
(6) Use, Handling, Storage, and Transportation of Hazardous Materials;
(7) Personal Protective Equipment and Clothing, Use and Care; and
(8) Safe Sampling Techniques.

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In addition to classroom instruction, the employee shall accompany an employee experienced in field activities and perform actual field tasks for a minimum of three days within a period of three months after classroom instruction. Employees satisfactorily completing these requirements will receive certification at the Basic Level of training from the Occupational Health and Safety Designee at the Reporting Unit.

b. Intermediate Level. All inexperienced employees who are to work with experienced employees in uncontrolled hazardous waste and hazardous spills sites investigators or employees engaged in other activities which at a later data are determined by the Director, Office of Occupational Health and Safety, to present unique hazards requiring additional training, shall be provided a minimum of 8 hours of additional health and safety training. This training shall include (in addition to the Basic Level requirements) but not be limited to the following subject matter:

(1) Site surveillance, observation, and safety plan development;
(2) Use and decontamination of totally enclosed protective clothing and equipment;
(3) Use of field test equipment for radioactivity, explosivity, and other measurements; and
(4) Topics specific to other identified activities.

In addition to classroom instruction, the employee shall accompany another employee experienced in hazardous waste and spill site investigations and/or cleanup operations and perform actual field tasks for a minimum of three days within a three month period, following classroom instruction. The employee should also be able to provide on-the-job training and instructions to inexperienced employees during normal routine field activities (as required above). Employees satisfactorily completing these requirements will be certified at the Intermediate Level by the Occupational Health and Safety Designee at the Reporting Unit.

c. Advanced Level. All employees who manage uncontrolled hazardous waste site and spill site monitoring, sampling, investigations, and cleanup operations shall be provided a minimum of 8 hours additional health and safety training. The classroom training shall include but not be limited to (in addition to the Basic and Intermediate Level requirements), instruction in the following subject areas:

(1) Management of restricted and safe zones;
(2) Rules of Handling the Press and VIP's; and
(3) Safe Use of Specialized Sampling Equipment.

In addition to classroom instruction, the employee shall accompany another employee with experience in managing hazardous waste and spill site investigations or cleanup operations and perform actual field tasks for a minimum of three days within a period of three months after classroom instruction. After satisfactorily completing these requirements, employees will receive Advanced Level certification from the Occupational Health and Safety Designee at the Reporting Unit.

d. General.

(1) An employee may receive certification at the next higher level by completing only the additional training requirements if certified at the next lower level within the previous one-year period.

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(2) The Director, Office of Occupational Health and Safety, may certify employees based on an evaluation of previous training, education, and experience. Recommendations for this type certification should be made to the Director by the Occupational Health and Safety Designee at the Reporting Unit.

10. FREQUENCY OF TRAINING. Employees at the Basic, Intermediate, and Advanced Levels shall complete a minimum of 8 hours of refresher classroom instruction annually consisting of a review of all subject areas to maintain their certification. In addition to the classroom instruction, employees shall have demonstrated by having performed actual field tasks that they have sufficient practical experience to perform their assigned duties in a safe and healthful manner.

11. RECORD OF TRAINING.

a. A record of the level of training and certification shall be maintained in the employee's official personnel file.

b. The Occupational Health and Safety Designee shall maintain a roster of employee training and certification so that a schedule of annual training can be established.

c. The Occupational Health and Safety Designee shall issue a certificate to the employee showing the level of training and certification.

12. OCCUPATIONAL MEDICAL MONITORING REQUIREMENTS. All employees routinely engaged in field activities which present the probability of exposure to hazardous or toxic substances, which are arduous or physically taxing, or which require the use of respiratory protective equipment shall be included in the Agency's Occupational Medical Monitoring Program. Employees should not be permitted to engage in field activities unless they have undergone a baseline medical examination (as defined in the Agency's Occupational Medical Monitoring Guidelines), which will show physical fitness and provide a base to measure any adverse effects their activities may have on these individuals.

13. SAVING PROVISIONS. Changes in the Act, Executive Order, or EPA and OSHA standards and guidelines which occur after the effective date of this Order will automatically come under the purview of this Order on the effective date of the change.

Full implementation of this Order shall be within one year of its effective date

Edward J. Hanley
Director, Office of Management
Information and Support Services

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APPENDIX C

REVISED FACT SHEET: SAFETY AND HEALTH REQUIREMENTS FOR EPA INSPECTORS

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May 14, 2001

MEMORANDUM

SUBJECT: ***Revised Fact Sheet***: Safety and Health Requirements for EPA Compliance Inspectors

FROM: Michael Alushin, Director /S/
Compliance Assessment and Media Programs Division

TO: Regional Enforcement Division Directors, Regions 1, 2,4, 6, 8
Regional Media Division Directors, Regions 3, 5, 7, 9, 10
Regional Science and Technology Division Directors, Regions 1-10

This memorandum transmits a **revised fact sheet** to distribute to the regional inspectors in your respective organizations. We prepared the fact sheet in response to requests for a quick reference summary made at the National Inspector Workshop we held last November. If you wish more information, you should obtain copies of EPA Orders 1440.1, 1440.2, 3500.1, and the OSHA requirements in 29 CFR 1910.120. The fact sheet discusses how to obtain copies of these documents.

This revised fact sheet was developed to address concerns expressed by Regional safety and health officers dealing with refresher health and safety training. The following highlights considerations leading to the revisions we made to the fact sheet:

- Language in the various safety and health orders can be interpreted in several ways
- After reviewing Regional concerns, we have decided to revise the fact sheet to interpret the Orders as requiring **only a minimum of eight hours annual refresher training**
- EPA inspectors that have been trained to the intermediate or advanced level need different refresher training than inspectors trained to the basic level

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We encourage the Regions, based on the number of intermediate and advanced level inspectors in their Region, to provide training on the specific risks posed to these inspectors. The Regions should be providing safety and health refresher courses specific to the level the inspector has achieved (basic, intermediate or advanced). The basic level refresher course can generally be met by reviewing the "Safety, Health and Environmental Management Training for Field Activities", in conjunction with the field refresher requirement. We encourage you to review the various EPA Orders dealing with safety and health of EPA employees that are posted on the EPA Inspector Website. The website address is: **http://INTRANET.EPA.GOV/OECA/OC/METD/INSPECTOR**

Thank you for your attention. We sincerely hope the revised fact sheet will improve the understanding of the health and safety requirements in order to provide EPA inspectors with a safe and healthy working environment. If you have any questions about this fact sheet, you can contact either OECA (Ken Gigliello at 202-564-2300) or OARM (Jerry Oakley at 202-564-2082).

cc: OC Division Directors
ORE Division Directors
OCEFT Division Directors
OARM/Safety, Health and Management Division
Enforcement Coordinators, Regions I-X
Safety and Health Officers, Regions I-X

REVISED FACT SHEET
Safety and Health Requirements for EPA Compliance Inspectors

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(May 11, 2001)

Introduction This fact sheet is intended to be a quick reference guide for EPA compliance inspectors. It provides a **summary** of the requirements of EPA Orders 1440.1 and 1440.2, and OSHA 29 CFR 1910.120 (e)(3)-(9). EPA compliance inspectors should obtain copies of the specific Orders and the OSHA regulations for more specific information. EPA Orders dealing with safety and health are posted on the EPA Inspector Website. The website address is: **http://INTRANET.EPA.GOV/OECA/OC/METD/INSPECTOR**

Background EPA Order 1440.1, dated May, 1998, Safety, Health and Environmental Management Program, establishes new policies, delegates authorities, defines management functions and responsibilities, and creates Agency-wide organizational structure for the administration of Safety, Health and Environmental Management (SHEEP). Copies of the Order can be obtained from the Office of Administration and Resource Management (ARM), Safety, Health and Environmental Management Division (Phone: 202-564-1640), or the Regional Safety and Health Officer.

EPA Order 1440.1 is an omnibus Order designed to replace all specific EPA Orders dealing with safety, health and environmental management. This action was taken to minimize the number of orders and to enable more flexibility in modifying regulations through the use of guidelines.

When EPA Order 1440.1 was finalized, the ARM was beginning a review of the entire issue of training requirements for both field and laboratory employees. Until this review was completed, ARM did not want to make changes to the Orders related to training.

As a result, EPA Order 1440.2, Health and Safety Requirements for Employees Engaged in Field Activities, was not incorporated into EPA Order 1440.1. However, ARM expects to do so in the Spring of 2001. ARM is examining several alternatives and when the review is completed, they will produce a set of guidelines to be included under EPA Order 1440.1. This will eliminate EPA Order 1440.2. **Until that time, EPA Order 1440.2 remains in effect.**

The guidelines that have been, and will be developed to replace existing Orders will be issued to EPA personnel to explain statutory and regulatory

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mandates, to interpret their application to EPA activities, and to identify the knowledge, skills, and abilities of personnel who must implement them. *The guidelines are recommendations, and do not have to be followed exactly.*

Guidelines

Approximately 55 safety, health and environmental management guidelines have been developed to date to help EPA manage its safety, health and environmental management responsibilities. The guidelines developed to date covering a wide range of topics including management systems, environmental statutes, transferring real property, office building compliance, fire protection and life safety, chemical handling and safety, laboratory procedures, forklift operations, electrical safety, radiation, lockout/tagout, occupational noise, workplace hazards, hazard communication, handling of PCBs and asbestos, and personal protective equipment.

EPA Order 1440.2

EPA Order 1440.2, dated July 12, 1981, and titled Health and Safety Requirements for Employees Engaged in Field Activities, establishes policy, responsibilities, and **mandatory requirements** for occupational health and safety training and certification, and occupational medical monitoring of Agency employees engaged in field activities. The Order is seven (7) pages in length. The Order establishes three (3) levels of initial health and safety training: basic (24 hours), intermediate (8 hours), and advanced (8 hours). The specific requirements for each level are listed below. This Order is incorporated by reference into EPA Order 3500.1, Training and Development for Lead Compliance Inspectors/Field Investigators, dated June 29, 1988. This Order is currently being revised but the EPA Order 1440.1 reference will be included in the revised Order.

The Order only reflects EPA's internal training requirements and does NOT eliminate the requirements for field personnel working with hazardous materials covered by 29CFR 1910.120 (e)(3)-(9). These OSHA regulations require training for employees working at clean-up operations conducted under the Superfund or RCRA correction action programs, voluntary cleanup operations, operations involving hazardous waste at RCRA Treatment, Storage and Disposal Facilities (TSDF's), and emergency response operations for releases of hazardous substances. The requirements can be retrieved from the OSHA web site at http://www.osha-slc.gov/OshStd_data/1910_0120.html. While many of these requirements are similar and some training will count toward meeting both sets of requirements, it should be remembered that they are separate requirements.

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Basic

The basic level training shall include, but not be limited to, classroom instruction in all of the following areas:

- ➔ Employee rights and responsibilities
- ➔ Nature of anticipated hazards
- ➔ Emergency self-help and rescue
- ➔ Vehicles – mandatory rules and regulations
- ➔ Safe use of field equipment
- ➔ Use, handling, storage, and transportation of hazardous material
- ➔ Personal protective equipment and clothing, use, and care, and
- ➔ Safe sampling techniques

In addition to classroom instruction, the employee shall accompany an employee experienced in field activities and perform actual field activities for a minimum of three (3) days within a period of three months after classroom instruction.

Intermediate

The intermediate level training is required for employees who engage in activities at uncontrolled hazardous waste and hazardous spill site investigations or employees engaged in other activities which are determined at a later date to present unique hazards requiring additional training. The intermediate training shall include, but not be limited to, to the following subject areas:

- ➔ Site surveillance, observation, and safety plan development
- ➔ Use and decontamination of totally enclosed protective clothing/equipment
- ➔ Use of field test equipment for radioactivity, exclusivity, and other measurements
- ➔ Topics specific to other identified activities

In addition to classroom instruction, the employee shall accompany an employee experienced in hazardous waste and spill site investigations and/or cleanup operations and perform actual field activities for a minimum of three (3) days within a period of three months after classroom instruction.

Advanced

The advanced level training is required for employees who manage uncontrolled hazardous waste and spill site monitoring, sampling, investigations and cleanup operations. The advanced training shall include, but not be limited to, to the following subject areas:

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- ➔ Management of restricted and safe zones
- ➔ Rules of handling the press and VIP's
- ➔ Safe use of specialized sampling equipment

In addition to classroom instruction, the employee shall accompany an employee experienced in managing hazardous waste and spill site investigations or cleanup operations and perform actual field activities for a minimum of three (3) days within a period of three months after classroom instruction.

Refresher

Refresher training requirements are a minimum of eight (8) hours for all EPA inspectors. The type of training required depends upon which level of training the EPA inspector has completed. Basic level refresher training is probably appropriate for most EPA inspectors.

For EPA inspectors that have taken intermediate and advanced level safety and health training, refresher training should be tailored to the specific needs of the particular EPA inspectors, where possible. The Regions and/or ARM are responsible for developing and delivering this level-specific refresher training.

In addition to the classroom instruction, employees shall have demonstrated sufficient practical experience to perform their duties in a safe and healthful manner by having performed actual field tasks related to their level of training.

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Safety and Health Training Availability

Training	How to Get? Where Delivered?	Comments
EPA Safety and Health Environmental Management Training for Field Activities -- computer based CD-rom course	Jerry Oakey (ARM) 202-564-2082	Includes modules on employee rights and responsibilities, nature of anticipated hazards (in-depth), personal protective equipment, some safe use of field and sampling equipment, and transportation of hazardous materials. CD does **not** cover emergency self-help and rescue, mandatory rules and regulations for vehicles, and specific field and sampling equipment procedures. This CD was not available when EPA Order 1440.2 was written in 1981. ARM has approved CD-rom training as an acceptable alternative to traditional classroom training with a couple of caveats: 1) Some activities (e.g., respirator fit testing) require hands-on training, and are not covered by CD-rom training, 2) The one requirement that all technology-based training to be acceptable to EPA and OSHA is for the user have access, either on-site or by other means of communication, to a source of information to answer any specific questions that may occur during the technology-based training. Generally this is the supervisor, the local health and safety program manager, or an experienced employee. Under the existing CD-rom course (SHE'D Disk #2), ARM allows one hour of training credit per training module. The CD-rom includes 34 modules. Students are required to take a total of 24 modules to meet the health and safety requirements. Eighteen (18) specific modules are required to be taken. The student must then choose six (6) additional modules from the remaining 16 modules that address the type of work they routinely conduct. The SHE'D disk #2 only covers the basic EPA 24-hour course. Some of the modules can be used as part of the annual 8-hour refresher program.

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Health and Safety Training Live Course	Limited availability in Edison, NJ, Cincinnati, OH and selected Regions.	This course is a full 40-hour course that covers employee rights and responsibilities, nature of anticipated hazards (in-depth), personal protective equipment, some safe use of field and sampling equipment, and transportation of hazardous materials. This course also covers emergency self-help and rescue, mandatory rules and regulations for vehicles, and specific field and sampling equipment procedures.
First aid and CPR courses	American Red Cross and other commercial vendors	These two courses can be combined in a one day event or taken separately. First aid courses offered by the Red Cross only need to be taken every 3 years. CPR courses are required every year.
Vehicle rules and regulations	Regional Health and Safety Training Officer. GSA or commercial vendors offer a defensive driving course.	Since EPA inspectors spend a considerable amount of time driving to conduct inspections, it is required that they know what to do in case of an accident or other mishap. In addition, since driving is a hazard of the job, inspectors should, on some routine basis, take a defensive driving course to hone and sharpen their skills.
Shipment of Hazardous Materials	ARM distributed a DOT course on CD-rom to the Regions. Courses are commercially available.	All inspectors who ship hazardous materials should take the DOT or commercially available course. Contact the Regional Safety and Health Program manager for details. OC recently transmitted a fact sheet for inspectors on DOT training requirements for shipping hazardous materials.
Other courses	ARM	ARM can be contacted for additional CD-rom and web-based courses to supplement field personnel training on topics such as radiation protection, due diligence-real property transfers, and OECA compliance training manuals.

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APPENDIX E

SAMPLE SECTION 308 LETTER

Certified Mail—Return Receipt Requested

Date

Dear Sir:

Pursuant to the authority contained in Section 308 of the Clean Water Act (33 U.S.C. 1251 et seq.), representatives of the U.S. Environmental Protection Agency (EPA), or a contractor retained by EPA, is planning to conduct a compliance monitoring inspection of your operations, including associated waste treatment and/or discharge facilities located at (site of inspection). This inspection will ascertain the degree of compliance with the requirements of the National Pollutant Discharge Elimination System (NPDES) permit issued to your organization.

Our representatives may observe your process operations, inspect your monitoring and laboratory equipment and methods, collect samples, and examine appropriate records, and they will be concerned with related matters.

In order to facilitate easy access to the plant site, please provide the name of the responsible facility official who can be contacted upon arrival at the plant. Additionally, we would appreciate receiving a list of the safety equipment you would recommend that our representatives have in their possession in order to enter and conduct the inspection safely. Please provide the information requested within 14 days of receipt of this letter.

If you have any questions concerning this inspection, please call (appropriate designated official).

Sincerely,

Director
Water Management Division

Sample Section 308 Letter

A011025

APPENDIX F

FINAL FACT SHEET: THE DO'S AND DON'TS OF USING U.S. EPA CREDENTIALS

DATED: JUNE 1, 2000; SIGNED: MICHAEL STAHL

MEMORANDUM

SUBJECT: Final Fact Sheet:
The United States Environmental Protection Agency Credentials Fact Sheet

FROM: Michael Stahl, Acting Directors/ **MICHAEL STAHL**
Office of Compliance

TO: See Attached List

Purpose The purpose of this memo is to transmit the final fact sheet on the United States Environmental Protection Agency (U.S. EPA) credentials. The fact sheet does not change existing EPA policies on credentials. The fact sheet is designed to inform EPA managers, supervisors, and employees of the overall process regarding U.S. EPA credentials. The fact sheet pertains only to EPA employees. The fact sheet contains information on the definition, policy, authority, language, issuing procedures, accountability, renewal, potential penalties for improper use, and specific do's and don'ts.

Process A draft fact sheet was transmitted for your review on April 14, 2000. The Office of Compliance (OC) received comments on the draft fact sheet from Regions 2, 3, 4, 6, 7 and 8, and from the Office of General Counsel (OGC), the Office of Environmental Justice (OEJ), the Office of Regulatory Enforcement (ORE), and the Office of Administration and Resource Management (OARM). The fact sheet was revised based on the comments.

Request Please distribute a copy of the fact sheet to all EPA employees holding EPA credentials. The fact sheet will also be posted on the OC Compliance Inspector Web Site. (http://intranet.epa.gov/oeca/oc/metd/inspector)

Future Procedure OARM will include a copy of the fact sheet with the credentials when they are renewed every three (3 years).

Thank you for your attention to this request.

A011027

Addressees:

Eric Schaeffer, Director, ORE
Leo D'Amico, Director, OCEFT
Barry Breen, Director, OSRE
James C. Nelson, Associate General Counsel, Cross-Cutting Issues Law Office
Barry Hill, Director, Office of Environmental Justice
John Fogarty, Acting Director, Office of Planning and Policy Analysis
Craig Hooks, Director, Federal Facilities Enforcement Office
Rich Lemley, Director, Facilities Management and Services Division
Steve Zeigler, Chief, Security and Property Management Branch
Regional Enforcement Division Directors, Regions I-X
Regional Science and Technology Division Directors, Regions I-X
Regional Enforcement Coordinators, Regions I-X
Regional Security Managers, Regions I-X
ORE Division Directors
OC Division Directors
OSRE Division Directors
Louis Halkias, Acting Director, Criminal Investigations Division
Jonathan Cole, Director, Legal Counsel and Resource Management Division
Diana A. Love, Director, NEIC
Gerald Bryan, Director, NETI
Yvette Jackson, OARM
Ken Gigliello, OC

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The Do's and Don'ts of Using U.S. EPA Credentials

These do's and don'ts are established based on good management practices for ensuring the proper use of EPA credentials by *EPA employees*. The practical purpose of the do's and don'ts is to make EPA employees aware of the importance to safeguard credentials, and limit their use to ONLY enforcement functions.

DO'S	DON'TS
Do use for official duties described in the credentials	Do NOT use for non-enforcement government business
Do use to conduct compliance inspections	Do NOT allow anyone to hold or take possession of your credentials
Do use to conduct compliance investigations	Do NOT loan the credentials to anyone. This includes other EPA employees.
Do use when responding to environmental complaints and/or spills	Do NOT photocopy the credentials
Do use to conduct facility audits	Do NOT fail to report a lost or stolen credentials to your supervisor
Do use to verify status as an EPA official when interviewing witnesses in the field	Do NOT allow anyone else to photocopy or use the credentials
Do use as identification for entry into facilities regulated under federal environmental laws and regulations	
Do safeguard storage of credentials	
Do always immediately report if the EPA credentials is lost or stolen to your immediate supervisor	

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FACT SHEET ON CREDENTIALS ISSUED TO EPA EMPLOYEES
DO'S AND DON'TS
5/23/00

Source: *EPA Security Manual, Physical Security Section, Volume 4850-1, dated 7/16/84*

DEFINITION The 1984 Security Manual defines an EPA credential as: "An EPA credential is a pocket warrant authorized by the Administrator, Assistant Administrator, or Regional Administrator that identifies the bearer as having the authority to act in an enforcement, inspection, survey, or investigation capacity." However, the EPA's legal authority to perform the enforcement, inspection, survey, or investigation functions is based on the applicable federal environmental statutes passed by the United States Congress and signed by the President of the United States. **The credential evidences the proper delegation of this authority and does not provide independently the authority to undertake these activities.**

POLICY EPA credentials should be issued **only to those officers and employees who routinely need them to actively perform official enforcement, inspection, survey or investigative functions.** EPA credentials generally are not issued to non-EPA employees, but in certain situations may be issued to State or tribal personnel, contractors, or grantees. In the event that non-EPA employees are authorized by the Administrator, Regional Administrator, or Assistant Administrator to possess EPA credentials, the credentials will be issued by the Regional Office, Lab, or other organization which has responsibility for overseeing the duties of the credentialed non-EPA employee.

LANGUAGE The language on the EPA credential states:

United States of America Environmental Protection Agency
This is to Certify that (EPA Employee's Name)
Whose Signature and Photograph Appear Below is a Duly Commissioned
(blank space for insertion of title)

Each credential includes ONE of the following titles:
Inspector, Compliance Officer, Enforcement Officer,
On-Scene Coordinator, Remedial Project Manager,
Debarment Counselor or Law Judge

Authorized to Conduct Official Investigations and
Inspections Pursuant to All Federal Laws
Administered by the United States
Environmental Protection Agency

ISSUANCE The requesting Headquarters program, media office, Regional office or Lab, should transmit a brief memorandum of justification to the Headquarters Office of Administration and Resources Management (OARM) requesting credentials to be issued to specific EPA employees. The memo should include the names, titles, organization, official duties, date of request, and the signature of requesting official. The requesting party is responsible for ensuring that the bearer has met applicable training requirements (e.g., EPA Order 3500.1). OARM (Security Management) will issue the federal credentials to the named employees after review of the information.

ACCOUNTABILITY Since credentials are issued only to assist the bearer in the performance of official duties, the credentials should be returned to OARM when the bearer leaves the position requiring the EPA credentials. The employee's office should send OARM a brief note explaining the reason the credentials are being returned (e.g., retirement, employee reassigned to a position not requiring a credential)

If the EPA credentials are lost or stolen, the bearer should promptly notify his or her immediate supervisor, in writing, and a copy should be sent to OARM. A brief report of the circumstances surrounding the loss or theft should be forwarded to the Security Management Staff along with the new request. If a new set of credentials is required, the above procedures will be followed. **Failure to promptly notify the supervisor of a lost or stolen credential could result in disciplinary action against the bearer.**

RENEWAL EPA credentials will be renewed every three (3) years by OARM. The Security Management Official will transmit a list of Regional employees whose credentials will expire to the Security Representative in each Region for review. The Security representative is responsible for ensuring that all listed personnel still have a need for the credential and applicable training is up-to-date. Once the list has been updated and returned to the HQ Security Management Official, OARM will renew the Regional credentials. All credentials are reissued on a rolling monthly basis to each Region (e.g., January for Region I, February for Region II, etc.)

Each Headquarters Office will receive a listing of employees whose credentials will expire. The Office Director is responsible for ensuring that all listed personnel still have a need for the credential and applicable training is up-to-date. OARM will renew these credentials on a first-come, first-served basis. All Headquarters credentials expire in December of the calendar year.

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APPENDIX G

EPA'S MEMORANDUM ON ENTRY PROCEDURES

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

11 APR 1978

MEMORANDUM

OFFICE OF ENFORCEMENT

TO: Regional Administrators
Surveillance and Analysis Division Directors
Enforcement Division Directors

FROM: Assistant Administrator for Enforcement

SUBJECT: Conduct of Inspections After the Barlow's Decision

I. Summary

This document is intended to provide guidance to the Regions in the conduct of inspections in light of the recent Supreme Court decision in Marshall v. Barlow's, Inc., __ U.S.__, 98 S. Ct. 1816 (1978). The decision bears upon the need to obtain warrants or other process for inspections pursuant to EPA-administered Acts.

In Barlow's, the Supreme Court held that an OSHA inspector was not entitled to enter the non-public portions of a work site without either (1) the owner's consent, or (2) a warrant. The decision protects the owner against any penalty or other punishment for insisting upon a warrant.

In summary, Barlow's should only have a limited effect on EPA enforcement inspections:

- Inspections will generally continue as usual;
- Where an inspector is refused entry, EPA will seek a warrant through the U.S. Attorney;
- Sanctions will not be imposed upon owners of establishments who insist on a warrant before allowing inspections of the non-public portions of an establishment.

The scope of the Barlow's decision is broad. It affects all current inspection programs of EPA, including inspections conducted by State personnel and by contractors. The Agency's procedures for inspections, particularly where entry is denied, were largely in accord with the provisions of Barlow's before the Supreme Court issued its ruling. Nevertheless, a number of changes in Agency procedure are warranted. Thus, it is important that all personnel involved in the inspection process be familiar with the procedural guidelines contained in this document.

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This document focuses on the preparation for and conduct of inspections, including (1) how to proceed when entry is denied, (2) under what circumstances a warrant is necessary, and (3) what showing is necessary to obtain a warrant.

II. Conduct of Inspections

The following material examines the procedural aspects of conducting inspections under EPA-administered Acts. Inspections are considered in three stages: (1) preparation for inspection of premises, (2) entry onto premises, and (3) procedures to be followed where entry is refused.

A. Preparation

Adequate preparation should include consideration of the following factors concerning the general nature of warrants and the role of personnel conducting inspections.

(1) Seeking a Warrant Before Inspection

The Barlow's decision recognized that, on occasion, the Agency may wish to obtain a warrant to conduct an inspection even before there has been any refusal to allow entry. Such a warrant may be necessary when surprise is particularly crucial to the inspection, or when a company's prior bad conduct and prior refusals make it likely that warrantless entry will be refused. Pre-inspection warrants may also be obtained where the distance to a U.S. Attorney or a magistrate is considerable so that excessive travel time would not be wasted if entry were denied. At present, the seeking of such a warrant prior to an initial inspection should be an exceptional circumstance, and should be cleared through Headquarters. If refusals to allow entry without a warrant increase, such warrants may be sought more frequently. (For specific instructions on how to obtain a warrant, see Part D.)

(2) Administrative Inspections v. Criminal Investigations

It is particularly important for both inspectors and attorneys to be aware of the extent to which evidence sought in a civil inspection can be used in a criminal matter, and to know when it is necessary to secure a criminal rather than a civil search warrant. There are three basic rules to remember in this regard: (1) If the purpose of the inspection is to discover and correct, through civil procedures, noncompliance with regulatory requirements, and administrative inspection (civil) warrant may be used; (2) if the inspection is in fact intended , in whole or in part, to gather evidence for a possible criminal prosecution, a criminal search warrant must be obtained under Rule 41 of the Federal Rules of Criminal Procedure; and (3) evidence obtained during a valid civil inspection is generally admissible in criminal proceedings. These principles arise from the recent Supreme Court cases of Marshall v. Barlow's, Inc., supra; Michigan v. Tyler, __U.S.__, 98 S.Ct. 1942 (1978); and U.S. v. LaSalle National Bank, __U.S.__, 57 L. Ed: 2d 221 (1978). It is not completely clear whether a combined investigation for civil and criminal violations may be properly conducted under civil or "administrative" warrant, but we believe a civil warrant can properly be used unless the intention is clearly to conduct a criminal investigation.

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(3) The Use of Contractors to Conduct Inspections

Several programs utilize private contractors to aid in the conduct of inspections. Since, for the purpose of inspections, these contractors are agents of the Federal government, the restrictions of the Barlow's decision also apply to them. If contractors are to be conducting inspections without the presence of actual EPA inspectors, these contractors should be given training in how to conduct themselves when entry is refused. With respect to obtaining or executing a warrant, an EPA inspector should always participate in the process, even if he was not at the inspection where entry was refused.

(4) Inspections Conducted by State Personnel

The Barlow's holding applies to inspections conducted by State personnel and to joint Federal/State inspections. Because some EPA programs are largely implemented through the States, it is essential that the Regions assure that State-conducted inspections are conducted in compliance with the Barlow's decision, and encourage the State inspectors to consult with their legal advisors when there is a refusal to allow entry for inspection purposes. State personnel should be encouraged to contact the EPA Regional Enforcement Office when any questions concerning compliance with Barlow's arise.

With regard to specific procedures for States to follow, the important points to remember are: (1) The State should not seek forcible entry without a warrant or penalize an owner for insisting upon a warrant, and (2) the State legal system should provide a mechanism for issuance of civil administrative inspection warrants. If a State is enforcing an EPA program through a State statute, the warrant process should be conducted through the State judicial system. Where a State inspector is acting as a contractor to the Agency, any refusal to allow entry should be handled as would a refusal to an Agency inspector as described in section II.B.3. Where a State inspector is acting as a State employee with both Federal and State credentials, he would utilize State procedures unless the Federal warrant procedures are more advantageous, in which case, the warrant should be sought under the general procedures described below. The Regions should also assure that all States which enforce EPA programs report any denials of entry to the appropriate Headquarters Enforcement Attorney for the reasons discussed in section II.B.4.

B. Entry

(1) Consensual Entry

One of the assumptions underlying the Court's decision is that most inspections will be consensual and that the administrative inspection framework will thus not be severely disrupted. Consequently, inspections will normally continue as before the Barlow's decision was issued. This means that the inspector will not normally secure a warrant before undertaking an inspection but, in an attempt to gain admittance, will present his credentials and issue a notice of inspection where required. The establishment owner may complain about allowing an inspector to enter or otherwise express his displeasure with EPA or the Federal government. However, as long as he allows the inspector to enter, the entry is voluntary and consensual unless the inspector is expressly told to leave the premises. On the other hand, if the inspector has gained entry in a coercive manner (either in a verbal or physical sense), the entry would not be consensual.

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Consent must be given by the owner of the premises or the person in charge of the premises at the time of the inspection. In the absence of the owner, the inspector should make a good faith effort to determine who is in charge of the establishment and present his credentials to that person. Consent is generally needed only to inspect the non-public portions of an establishment - i.e., any evidence that an inspector obtains while in an area open to the public is admissible in an enforcement proceeding.

(2) Withdrawal of Consent

The owner may withdraw his consent to the inspector at any time. The inspection is valid to the extent to which it has progressed before consent was withdrawn. Thus, observations by the inspector, including samples and photographs, obtained before consent was withdrawn, would be admissible in any subsequent enforcement action. Withdrawal of consent is tantamount to a refusal to allow entry and should be treated as discussed in section II.B.3. below, unless the inspection had progressed far enough to accomplish its purposes.

(3) When Entry is Refused

Barlow's clearly establishes that the owner does have the right to ask for a warrant under normal circumstances.[1] Therefore, refusal to allow entry for inspection purposes will not lead to civil or criminal penalties if the refusal is based on the inspector's lack of warrant and one of the exemptions discussed in Part C does not apply. If the owner were to allow the inspector to enter his establishment only in response to a threat of enforcement liability, it is quite possible that any evidence obtained in such an inspection would be inadmissible. An inspector may, however, inform the owner who refused entry that he intends to seek a warrant to compel the inspection. In any event, when entry is refused, the inspector should leave the premises immediately and telephone the designated Regional Enforcement Attorney as soon as possible for further instructions. The Regional Enforcement Attorney should contact the U.S. Attorney's Office for the district in which the establishment desired to be inspected is located and explain to the appropriate Assistant United States Attorney the need for a warrant to conduct the particular inspection. The Regional Attorney should arrange for the United States Attorney to meet with the inspector as soon as possible. The inspector should bring a copy of the appropriate draft warrant and affidavits. Samples are provided in the appendix to this document.

(4) Headquarters Notification

It is essential that the Regions keep Headquarters informed of all refusals to allow entry. The Regional Attorney should inform the appropriate Headquarters Enforcement Attorney of any refusals to enter and should send a copy of all papers filed to Headquarters. It is necessary for Headquarters to monitor refusals and Regional success in obtaining warrants to evaluate the need for improved procedures and to assess the impact of Barlow's on our compliance monitoring progress.

[1] FIFRA inspections are arguably not subject to this aspect of Barlow's. See discussion, p. 5 and 6.

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C. Areas Where a Right of Warrantees Entry Still Exists

(1) Emergency Situations

In an emergency, where there is no time to get a warrant, a warrantees inspection is permissible. In Camera v. Municipal Court, 387 U.S. 523 (1967), the Supreme Court states that "nothing we say today is intended to foreclose prompt inspections, even without a warrant, that the law has traditionally upheld in emergency situations." Nothing stated in Barrow's indicates any intention by the court to retreat from this position. The Regions will always have to exercise considerable judgement concerning whether to secure a warrant when dealing with an emergency situation. However, if entry is refused during and emergency, the Agency would need the assistance of the U.S. Marshal to gain entry, and a warrant could probably be obtained during the time necessary to secure that Marshal's assistance.

An emergency situation would include potential imminent hazard situations, as well as situations where there is potential for destruction of evidence or where evidence of a suspected violation may disappear during the time that a warrant is being obtained.

(2) FIFRA Inspection

There are some grounds for interpreting Barrow's as not being applicable to FIFRA inspections. The Barrow's restrictions do not apply to areas that have been subject to a long standing and pervasive history of government regulation. An Agency administrative law judge held recently that even after the Barrow's decision, refusal to allow a warrantees inspection of a FIFRA regulated establishment properly subjected the owner to civil penalty. N. Jones & Co., Inc., I.F. & R Docket No. III-121C (July 27, 1978). For the present, however, FIFRA inspections should be conducted under the same requirements applicable to other enforcement programs.

(3) "Open Fields" and "In Plain View" Situations

Observation by inspectors of things that are in plain view, (i.e., of things that a member of the public could be in a position to observe) does not required a warrant. Thus, an inspector's observations from the public area of a plant or even from certain private property not closed to the public are admissible. Observations made even before presentation of credentials while on private property which is not normally closed to the public are admissible.

D. Securing a Warrant

There are several general rules for securing warrants. Three documents have to be drafted: (a) an application for a warrant, (b) an accompanying affidavit, and (c) the warrant itself. Each document should be captioned with the District Court of jurisdiction, the title of the action, and the title of the particular document.

The application for a warrant should generally identify the statutes and regulations under which the Agency is seeking the warrant, and should clearly identify the site or establishment desired to be inspected (including, if possible, the owner and/or operator of the site). The application can be a one or two page document if all of the factual background for seeking the warrant is stated in the affidavit, and the application so

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states. The application should be signed by the U.S. Attorney or by his Assistant U.S. Attorney.

The affidavits in support of the warrant application are crucial documents. Each affidavit should consist of consecutively numbered paragraphs, which describe all of the facts that support warrant issuance. If the warrant is sought in the absence of probable cause, it should recite or incorporate the neutral administrative scheme which is the basis for inspecting the particular establishment. Each affidavit should be signed by someone with personal knowledge of all the facts stated. In cases where entry has been denied, this person would most likely be the inspector who was denied entry. Note that an affidavit is a sworn statement that must either be notarized or personally sworn to before the magistrate.

The warrant is a direction to an appropriate official (an EPA inspector, U.S. Marshal or other Federal officer) to enter a specifically described location and perform specifically described inspection functions. Since the inspection is limited by the terms of the warrant, it is important to specify to the broadest extent possible the areas that are intended to be inspected, any records to be inspected, any samples to be taken, and any articles to be seized, etc. While a broad warrant may be permissible in civil administrative inspections, a vague or overly broad warrant will probably not be signed by the magistrate and may prove susceptible to constitutional challenge. The draft warrant should be ready for the magistrate's signature at the time of submission via a motion to quash and suppress evidence in Federal District court. Once the magistrate signs the draft warrant, it is an enforceable document. Either following the magistrate's signature or on a separate page, the draft warrant should contain a "return of service" or "certificate of service". This portion of the warrant should indicate upon whom the warrant was personally served and should be signed and dated by the inspector. As they are developed, more specific warrant issuance documents will be drafted and submitted to the Regions.

E. Standards or Bases for the Issuance of Administrative Warrants

The Barrow's decision establishes three standards or bases for the issuance of administrative warrants. Accordingly, warrants may be obtained upon a showing: 1) of traditional criminal probable cause, 2) of civil probable cause, or 3) that the establishment was selected for inspection pursuant to a neutral administrative inspection scheme.

(1) Civil Specific Probable Cause Warrant

Where there is some specific probable cause for issuance of a warrant such as an employee complaint or competitor's tip, the inspector should be prepared to describe to the U.S. Attorney in detail the basis for this probable cause.

The basis for probable cause will be stated in the affidavit in support of the warrant. This warrant should be used when the suspected violation is one that would result in a civil penalty or other civil action.

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(2) Civil Probable Cause Based on a Neutral Administrative Inspection Scheme

Where there is no specific reason to think that a violation has been committed, a warrant may still be issued if they Agency can show that the establishment is being inspected pursuant to a neutral administrative scheme. As the Supreme Court stated in Barrow's:

> "Probable cause in the criminal law sense is not required. For purposes of an administrative search, such as this, probable cause justifying the issuance of a warrant may be based not only on specific evidence of an existing violation, but also on a showing that "reasonable legislative or administrative standards for conducting an . . . inspection are satisfied with respect to a particular (establishment)." A warrant showing that a specific business has been chosen for an OSHA search on the basis of a general administrative plan for the enforcement of the act derived from neutral sources such as, for example, dispersion of employees in various type of industries across a given area, and the desired frequency of searches in any of the lesser divisions of the area, would protect an employers Fourth Amendment rights.

Every program enforced by the Agency has such a scheme by which it prioritizes and schedules its inspections. For example, a scheme under which every permit holder in a given program is inspected on an annual basis is a satisfactory neutral administrative scheme. Also, a scheme in which one out of ever three known PCB transformer repair shops is inspected on an annual basis is satisfactory, as long as neutral criteria such as random selection are used to select the individual establishment to be inspected. Headquarters will prepare and transmit to the Regions the particular neutral administrative scheme under which each program's inspections are to be conducted. Inspections not based on specific probable cause must be based on neutral administrative schemes for a warrant to be issued. Examples of two neutral administrative schemes are provided in the appendix. (Attachments II and III)

The Assistant U.S. Attorney will request the inspector to prepare and sign an affidavit that states the facts as he knows them. The statement should include the sequence of events culminating in the refusal to allow entry and a recitation of either the specific probable cause or the neutral administrative scheme which led to the particular establishment's selection for inspection. The Assistant U.S. Attorney will then present a request for an inspection warrant, a suggested warrant, and the inspector's affidavit to a magistrate or Federal district court judge.[2]

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[2] The Barrow's decision states that imposing the warrant requirement on OSHA would not invalidate warrantees search provisions in other regulatory statutes since many such statutes already "envision resort to Federal court enforcement when entry is refused". There is thus some question as to whether the existence of a non-warrant Federal court enforcement mechanism in a statute requires the use of that mechanism rather than warrant issuance. We believe that the Barrow's decision gives the Agency the choice of whether to proceed through warrant issuance or through an application for an injunction, since the decision is largely based on the fact that a warrant procedure imposes virtually no burden on the inspecting Agency. In addition, any Agency could attempt to secure a warrant prior to inspection on an ex parte basis, something not available under normal injunction proceedings. Several of the acts enforced by the EPA have provisions allowing the Administrator to seek injunctive relief to assure compliance with the various parts of a particular statute. There may be instances where it would be more appropriate to seek injunctive relief to gain entry to a facility than to attempt to secure a warrant for inspection, although at this point we cannot think of any. However, since the warrant process will be far more expeditious than the seeking of an injunction, any decision to seek such an injunction for inspection purposes should be cleared through appropriate Headquarters staff.

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(3) Criminal Warrants

Where the purpose of the inspection is to gather evidence for a criminal prosecution, the inspector and the Regional Attorney should request that the U.S. Attorney seek a criminal warrant under Rule 41 of the Federal Rules of Criminal Procedure. This requires a specific showing of probable cause to believe that evidence of a crime will be discovered. Agency policy on the seeking of criminal warrants has not been affected by Barrow's. The distinction between administrative inspections and criminal warrant situations is discussed in Section II.A.2.

F. Inspecting with a Warrant

Once the warrant has been issued by the magistrate or judge, the inspector may proceed to the establishment to commence or continue the inspection. Where there is a high probability that entry will be refused even with a warrant or where there are threats of violence, the inspector should be accompanied by a U.S. Marshal when he goes to serve the warrant on the recalcitrant owner. The inspector should never himself attempt to make any forceful entry of the establishment. If the owner refuses entry to an inspector holding a warrant but not accompanied by a U.S. Marshal, the inspector should leave the establishment and inform the Assistant to the U.S. Attorney and the designated Regional Attorney. They will take appropriate action such as seeking a citation for contempt. Where the inspector is accompanied by a U.S. Marshal, the Marshal is principally charged with executing the warrant. Thus, if refusal or threat to refuse occurs, the inspector should abide by the U.S. Marshal's decision whether it is to leave, to seek forcible entry, or otherwise.

The inspector should conduct the inspection strictly in accordance with the warrant. If sampling is authorized, the inspector must be sure to carefully follow all procedures, including the presentation of receipts for all samples taken. If records or other property are authorized to be taken, the inspector must receipt the property taken and maintain an inventory of anything taken from the premises. This inventory will be examined by the magistrate to assure that the warrant's authority has not been exceeded.

G. Returning the Warrant

After the inspection has been completed, the warrant must be returned to the magistrate. Whoever executes the warrant, (i.e., whoever performs the inspection), must sign the return of service form indicating to whom the warrant was served and the date of service. He should then return the executed warrant to the U.S. Attorney who will formally return it to the magistrate or judge. If anything has been physically taken from the premises, such as records or samples, an inventory of such items must be submitted to the court, and the inspector must be present to certify that the inventory is accurate and complete.

III. Conclusion

Except for requiring the Agency to formalize its neutral inspection schemes, and for generally ending the Agency's authority for initiating civil and/or criminal actions for refusal to allow warrantees inspections, Barrow's should not interfere with EPA enforcement inspections.

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APPENDIX H

EPA's DRAFT POLICY ON THE USE OF DIGITAL CAMERAS FOR INSPECTIONS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JUL 8 2002

OFFICE OF
ENFORCEMENT AND
COMPLIANCE ASSURANCE

MEMORANDUM

SUBJECT: Draft Policy on the Use of Digital Cameras in Civil Inspections

FROM: Michael S. Alushin, Director
Compliance Assessment and Media Programs Division

TO: Addressees

Digital photography is becoming more and more common-place, including use by Regional and State inspectors. Within EPA and at the State level, several offices have initiated development of draft policies to address the use of these cameras during inspections. In addition, Regions have raised a number of questions related to the use of digital cameras over the past couple of years by e-mail and during the National Inspector Workshops. As a result of this interest, we convened an informal workgroup including several offices that were in the process of developing policies to draft a National policy on the use of digital cameras during inspections.

I want to thank the following individuals for their work in developing this draft: Phyllis Flaherty, Sally Sasnett and Iliana Tamacas of OC; Walter Mugden, ORC, Region 2; Craig Kubick and Steve Sisk, NEIC; Rusty Herbert (ORC) and Richard Gigger of Region 6; and Kathy Clarke of ORE.

Please review and comment on the draft policy (attached) by August 9, 2002. Regional commentors are requested to provide their comments through the Regional Enforcement Coordinator, who can ensure a coordinated Regional response. The policy addresses: minimum requirements to ensure the credibility of digital photographs (photos); a brief overview of digital camera technology; recommended "Best Practices" for use in developing standard operating procedures (SOPs) tailored for specific needs; and some basic recommendations regarding selection of digital cameras and supporting equipment.

As you review the document, we would appreciate your thoughts and comments particularly concerning item #11 of the Requirements (page 3). This item deals with the necessity for printing the photos referenced in the Inspection Report. The draft policy currently requires that a printed copy of all photos referenced in the Inspection Report be included with it. We would appreciate your thoughts on whether: all photos must be printed, all referenced photos must be printed, key photos must be printed, or whether it is necessary to print any photos, provided the digital storage media accompanies the inspection report.

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Draft June 27, 2002

DRAFT, DO NOT CITE OR QUOTE

USE OF DIGITAL CAMERAS FOR INSPECTIONS

STATEMENT OF POLICY

EPA has determined that the use of digital cameras/photographs for documenting civil investigations is acceptable provided certain requirements related to their use are met.

INTRODUCTION

This document discusses the rationale for support of digital cameras for civil inspections, sets forth minimum requirements to ensure the credibility of digital photographs (photos) to document inspections, provides an overview of digital camera technology, suggests good practices related to digital camera use, and provides recommendations concerning the selection of digital cameras and supporting peripheral equipment.

REQUIREMENTS

Because digital photography is a somewhat new technology, taking a few precautions will assist in ensuring the credibility of the digital photos. Further discussion of the technology and technical considerations related to use of digital cameras and recommendations for "Best Practices" are provided later in this document, but certain steps are essential to ensuring digital photo credibility. The following are minimum requirements which must be met when using digital photographs to document EPA civil investigations:

1. The digital photo must be a fair representation of the object/scene at the relevant time and must not be manipulated as to be indistinguishable from the original image.

2. When the photo is used as evidence, the person testifying must be able to verify the authenticity of the image, how it was acquired, its relevance to the case and how it corroborates testimony as to issues which may be disputed in the case.

3. A digital camera with enough resolution to produce a photo equivalent to a 35 mm print or a Polaroid must be used. (At least 2.1 mega-pixel resolution is recommended to produce good quality 5" X 7"pictures, although resolution necessary is dependent on subject matter and final use. Please see the Basic Technical Information Section for more detail).

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4. Equipment must be available which will allow the secure use and storage of the digital photo images. (More detail is provided in the Basic Technical Information Section).

5. There must be a standard operating procedure (SOP) in place regarding digital camera use which includes guidance on: properly using digital cameras, capturing the digital images, securing the original images captured, and procedures on copying, storing, transferring, and handling of the "original" images. (Additional "Best Practices" recommendations for SOP elements are provided later in this document.) Each Regional or State office with inspectional authority which decides to use digital cameras should develop its own SOP governing their use.

6. A Photo Log (see attached example) must be kept for each inspection which is a record of: the identity of the photographer; the identity/type of camera used; the date, time, location, and conditions under which the photo image was taken; the name of the facility and the EPA facility registration system (FRS) number, (or any available EPA Facility Identification number), if known; and a brief description of the picture. The Photo Log must also include a record of the date, time, and identity of the person transferring the images from one storage media to another, and the date, time, type of change, and identity of the person making any change to an image which will be used as evidence. (No change should be made to the "original" image. Enhancements must be done only on a copy. Each change should be saved as a separate image file and documented so that all enhancements can be reconstructed, if necessary.)

7. Original images must be saved to alternate storage media to create an "archival original" as soon as possible after image capture. This "archival original" must be labeled as such and kept secure and any enhancements needed should be made only to a copy. NEVER EDIT THE ORIGINAL OR ARCHIVAL ORIGINAL [Ideally a read-only Compact Disk (CD-R) should be used as the "archival original" but if a CD-R or a CD-"burner" is not available, a floppy disk may be used for the "original" copy. If a CD-R is not used, an option is to use cyclic redundancy check software to verify the images. See discussion in the Basic Technical Information Section for more detail.]

8. Access to the "original" images must be limited and a Chain of Custody which identifies anyone having access must be maintained from the time the picture is taken until the case is closed. (See attached).

9. When mailing the "original" via postal mail, it must be placed in a jacket, pouch or equivalent with a custody seal. The same procedures used for

mailing samples must be used with the "original" to ensure its integrity.

10. If copies of the photos are given to a facility, a record of what has been given must be kept. This record may be a list of the photos noted as part of the field notes, a separate photo list, or a separate Photo Log. The record must identify and describe the photos.

11. The Photo Log and printed copies of the digital photo images which are referenced in the report with corresponding identifying information from the Photo-Log must be attached to the inspection report. If printing is not feasible, the Photo-Log with the properly labeled storage media containing the "original" digital images must accompany the inspection report.

Background Information

Rationale for Policy

Changes in photographic technology have made digital cameras common-place. Digital cameras offer many advantages over traditional cameras and could soon become more widely used than traditional film cameras. Many law enforcement agencies, including the FBI, have recognized the utility of digital imaging in field applications. Because the use of digital cameras and photos is becoming so common-place for enforcement purposes, and because it is a somewhat new technology, it could meet with resistance and challenges when used in case support, if proper precautions are not taken. Provided proper steps are taken to protect the chain of custody from the time of image capture until the case is closed and the records are archived, a photo taken by a digital camera is as much an "original" as one taken by traditional means.

Standard operating procedures which ensure the authenticity and document the chain of custody of the pictures are key to the defensibility of use of digital photos for case support. Just as in cases using other photographic evidence, the witness will need to identify the scene; explain how he/she is familiar with the scene; and establish that the picture is a fair representation of the scene at the relevant time.

Advantages of Digital Camera Use

Digital photos offer the user a fast and efficient way to collect documentation of visual observances during an inspection, such as to document violations observed, or

to convey a complex scene by e-mailing the pictures to others off-site and getting advice regarding appropriate actions. Digital photos can be reviewed at the site to be certain that important details are captured and notes can be corroborated. Any poor quality pictures can be deleted and shot again at the site before scene conditions change. Inspectors have reported that many facilities prefer the digital images and are more amenable to this type of photo being taken, particularly if they are given the opportunity to review them at the conclusion of the visit. Sharing the images at the conclusion of an inspection may provide facilities with a greater comfort level regarding what the inspection has revealed, particularly in terms of "proprietary information." This may result in fewer claims of confidential business information because unnecessary images containing proprietary or sensitive (i.e., military or government) information could be deleted at the scene. In addition, digital cameras can be used in unique settings when special detail is needed, as, for example, by taking a picture through a microscope using its lens as the enlarger.

Because digital photos can be stored as data files on a computer disk, hard drive, or CD, storage requires less space and the photos can be easily catalogued and quickly retrieved using a simple search query. Although digital images can be developed commercially, if the necessary equipment is available, in-house processing can offer some advantages. For example, there may be a security advantage by allowing control of the image from capture through use. When time is an essential element, hard copy photos can be produced quickly for review; and inexpensive copies can be produced when fast information-sharing is critical. Also, like traditional photos, digital photos can be enhanced and edited, but much faster and more easily. Because the processing generates less waste, digital photos are also more environmentally friendly than film.

Basic Technical Information Related to Digital Camera Use

Digital and film photography share many similarities. Both create an image through use of a light-sensitive medium. In the case of digital cameras, light falls on a grid of detectors known as a charge coupled device, or CCD, and produces a pattern of electrical charges that are measured, converted to numbers and stored. Each value in the grid corresponds to a picture element, (also known as a pixel) in the digital image[1]. The electrical output of the CCD is sent to a converter that changes the image to a digital output which is then stored in the camera as a computer data file with each file representing a different photograph[2]. Following is a discussion of some important factors relevant to digital camera use.

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[1] Erik C. Berg, "Legal Ramifications of Digital Imaging in Law Enforcement", *Forensic Science Communications*, October 2000.

[2] Penney Azcarate, "Digital Imaging Technology and the Prosecutor", *Prosecutor*, January/February 2000.

Resolution

Digital camera resolution is the amount of sharpness or detail in the image and is dependent on the number of pixels in the image. This is generally determined by the number of pixels across the width and height of the CCD. Pixel count is established by multiplying these numbers. Therefore, it is important to know the maximum CCD resolution (total number of pixels in a camera's sensor) in order to know the film equivalent capability of the digital camera. This is generally stated as "x" mega pixels. For example, 1280 x 960 pixels would give the film resolution of a 5" x 7" print and 1600 x 1200 pixels would give the film resolution of an average 8" x 10" print. A digital camera with this resolution as its maximum would be in the 2.0 mega pixel range. Although an 8" x 10" image from a camera having 2.0 mega pixels maximum resolution could be further enlarged, the quality of the photo would be degraded.

Digital cameras are available with a wide range of CCD resolution from around 1.0 mega pixels to 6.0+. Generally, low end cameras have a resolution of 1.0 mega pixels and cost around $100. These would probably be insufficient for all but the most basic of photographs.

The next CCD resolution level is about 2.0 mega pixels. This would allow for a picture at fine resolution roughly equivalent to an average 8" x 10" 35mm print taken by a conventional camera. If further enlargement is required, some image loss will occur. Cameras in this range currently cost around $300 with cost differences primarily depending on the image storage capacity and optical zoom capability.

For good quality, multi-purpose use, CCD resolution in the 3.0+ mega pixel range is needed. The higher the mega pixel level, the more and larger images with high resolution can be stored. This is important where larger photos may be necessary and where greater detail is important. It is also important if more than a few high resolution pictures are going to be needed during a session use. Cameras with this CCD resolution currently cost from $400 up.

Storage Media/Memory

A digital camera uses and/or contains random access memory (RAM) to store the images. When RAM is used up, it must be restored in order to take more pictures. There are currently several types of storage media used to record digital photos. The most common ones are Smart Media, Compact Flash and Stick memory. Additionally, some manufacturers use a standard 3.5" floppy to store images (although this technology is becoming outdated). Floppy disk cameras typically create lower resolution images than card-based cameras to keep file sizes small enough to fit on the floppy disk. Floppy disks can store 1.4 Mega Bytes (MB) compared to 8 - 16 MB on a standard memory card (with expanded ones available now up to 5 gigabytes). Also available now is another card-sized storage media, an IBM "Microdrive," which fits the Compact Flash Type II card slot and can store up to 1 gigabyte of data when used with a compatible camera. Regardless of the storage media used by the camera, pictures

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can be downloaded and stored either on the computer's hard drive, or on a compact disk (CD) if the computer is equipped with a CD "burner."

The number of photos which can be taken per session is a function of the resolution selected and the amount of memory required. This is somewhat dependent on the file format used. Most digital cameras use a file format which "compresses" the image so that more pictures can be stored on the storage media. There are two file types used to store the digital images on the storage media. A "lossless" file is one where no data is lost. Two file format types frequently used by digital cameras to capture "lossless" images are TIFF (Tagged Image File Format) and RAW. Lossless files or lossless compressed files tend to be quite large. Because these images require so much memory, to store more than one or two digital images in this format requires a very high capacity (and expensive) storage media, so this is primarily used only by professional photographers using high-end equipment.

Another file type in which some data may be lost is known as a "lossy" file. Images stored this way take up less much less room but may lose some data or image quality. However, the resultant "loss" may not be significant to over-all picture quality. One type of "lossy" file format that is currently used by most digital cameras is a standard file format known as JPEG (Joint Photographic Experts Group). This file format is designed to address the known limitations of the human eye and was named for the committee that devised and wrote the standard. At the highest JPEG resolution, even though there may be some small loss of image quality, it would not be obvious to the human eye. (This is less true for pictures of things like signs or other very hard-edged objects). When an image is captured by a digital camera using this file format, JPEG automatically compresses the file, allowing for a greater number of pictures to be stored on the storage media. Generally, a 3.1 Mega Pixel (MP) camera using a 16 Mega Byte (MB) storage medium at high resolution could store approximately only two TIFF files, but could store at least 12 JPEG photos with no noticeable image loss. However, if JPEG images are repeatedly compressed and decompressed (such as by repeated viewing before saving) or if the picture needs to be enlarged significantly, some noticeable image loss may occur.

Most digital cameras come with built-in picture file identifier (which assigns a unique number to each picture), date, and time stamps. This is an important feature for establishing chain of custody records.

Power Supply

Because they are electronic, digital cameras require significantly more power than other types. All or most of their functions are electronic, so batteries can drain quickly. This can be true even when batteries left in the camera are not in use. Repeated viewing of images through the camera's liquid crystal display (LCD) screen can rapidly deplete batteries. This is particularly significant for digital cameras because battery depletion can cause the camera settings to be lost, in addition to being problematic if the power suddenly disappears when needed during use.

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Most digital cameras take AA batteries. There are several types of these: nickel metal hydride (NiMH, rechargeable), nickel cadmium (NiCd, rechargeable), lithium (non-rechargeable), and, of course, alkaline (non-rechargeable). Of these, the NiMH is the most economic because of their basic cost, rechargeability, length of charge, and long service life. (They are also environmentally preferable to the nickel cadmium batteries which are gradually being phased out). The lithium batteries are useful as cold-weather back-ups. Having extra batteries sets is essential when using digital cameras for anything more than a few quick shots.

Other Technical Considerations

Optical Zoom

Another factor affecting picture quality, particularly for close-ups or distance, is optical zoom. Optical zoom is "true zoom" or telephoto, which makes the image appear closer without losing detail; digital zoom is really just built in image enlargement with some resulting loss of photo detail. Cameras with a higher degree of optical zoom allow for a greater degree of flexibility in use without loss of image quality.

Photo Storage and Printing

Storage and printing are other important considerations for use of digital cameras. The computer is most often the mechanism used to store and print digital photos. To transfer images from the digital camera's memory to the computer, the camera is connected to the computer using either a serial port or the Universal Serial Bus (USB) port (except when the camera uses a standard 3.5 inch floppy disk). Most computers have a USB port that simply connects to the camera with a plug-in cable and images can be downloaded to the hard drive. If a USB port is not available, a card reader can be connected to the printer port to transfer images to the computer and the images then can be stored on the computer's hard drive. However, if the hard drive were to fail, the images could be lost, so back-up storage is necessary. Some cameras are also equipped to transfer the images directly from the camera to the computer. The disadvantage of this system, however, is that if the transfer is interrupted some images could be lost.

If a computer is equipped with a CD "burner," the images can be stored on a read-only CD (CD-R). This has several advantages. Images stored to a read-only CD-R are created by permanently altering the disc with a laser light beam. CD writers cannot delete laser marks, so the images can be stored without alteration and any alteration would be detectable. (This is only true for CD-R, not CD-RW (read-write)). The "original" images could be stored this way to form an unalterable archive and it is feasible to store large numbers of images in a small amount of space. (A typical CD can store hundreds of images). Both CD burners and CD-Rs are now economically feasible with CD burners

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costing in $175 range and CD-Rs costing a dollar or less each. Once the images are archived to a CD-R, copies of the unaltered "originals" can be made on a CD-RW and any necessary enhancements, such as improving contrast or "cropping" can be done on the copies and properly noted in a photo log for future reference. (Each change should be saved as a separate image file and documented so that all enhancements can be reconstructed, if necessary).

An alternative to using the CD-R is to store the images on floppy disks and use commercially available software to perform a "Cyclic Redundancy Check" (CRC) on the stored images. The software performs a calculation that generates a unique number which can be checked later against the stored data to ensure that they match, indicating that the data also matches. NEIC uses MARESWARE software (see websites list) for this function.

Images can be printed at the same time they are downloaded, or printed as needed. For truly photographic quality prints, a commercial developer is recommended, particularly if large pictures are required. (Commercial developers have access to a different process that can provide better color and resolution than that afforded by in-house processing). For in-house viewing or most general purposes, a good quality color ink-jet printer using archival inks is recommended, particularly if the photos will be stored for a long period of time. For high quality images, premium glossy photo paper will give a great degree of color accuracy, even under magnification. For general purposes, plain paper, photo quality ink-jet paper, premium photo paper, etc. can be selected depending on the necessary quality outcome.

Computer Requirements

A computer has two types of memory, hard disk storage and Random Access Memory (RAM). The computer's hard disk drive is the memory used to store the digital images before transferring them to another storage medium, such as a CD-R. A high-capacity hard drive is needed if many digital images will be "down-loaded" at one time. A hard disk drive should not be filled to more than 70% of its maximum capacity in order to not cause performance deterioration. A computer with at least a 10 gigabyte hard drive is recommended at a minimum, but the amount of hard drive memory needed will depend on what other programs are resident which use memory, and how many pictures will be down-loaded from the camera's storage media before being transferred to CD-R or other permanent storage.

Computer speed is another consideration. Speed is normally measured in millions of cycles per second or MHz. Speed affects how fast the digital images can be down-loaded or edited. A speed of at least 233 MHz is recommended, although computers are now available at speeds of 2000 MHz (2Ghz).

Guidelines for Ensuring Credibility of Digital Photos

As long as the digital photo is a fair representation of the object/scene at the

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relevant time, has not been manipulated to be indistinguishable from the "original" image, and corroborates the witness's testimony as to the issues disputed in a case, it should provide the necessary documentation to support a case. It is up to the witness who is testifying to demonstrate the authenticity of the image and to explain what the image shows, how it was acquired, and its relevance to the case. This will support the authenticity of the images and the testimony of the witness.

Because digital images are easier to manipulate than traditional 35 mm or Polaroid photographs, critical to ensuring the credibility of digital photos is having a Standard Operating Procedure (SOP) in place that establishes the proper security and record-keeping procedures for taking, storing and documenting digital images. Inspectors using digital cameras during field inspections must have and use a standard operating procedure (SOP) regarding digital camera use. Each Regional or State office with inspectional authority which decides to use digital cameras should develop its own SOP governing their use. The SOP should include: guidance on properly using digital cameras, securing the original images captured, copying the captured images and using a chain of custody (COC). If the digital images captured during inspections are used in civil cases as evidence, inspectors may need to defend the images in court, and the use of an SOP may increase the validity of the images as authentic evidence. In addition to the minimum requirements detailed previously, the following are "Best Practices" recommendations for items which should be included in Regional or State SOPs.

Best Practices

1. Have the necessary equipment to capture, store, and distribute digital images. Use a digital camera with the required resolution to get pictures that are equivalent to a 35 mm print or a Polaroid. At least 2.1 mega-pixel resolution is recommended to produce good quality 5" X 7" pictures. Other equipment is needed to store, print, and reproduce digital images. Necessary equipment includes but is not limited to: computer (hard drive) with sufficient memory; electronic storage media (for example, Memory Stick, Compact Flash, Smart Card, CD, and/or floppy disk); USB cable; card reader (optional); battery and backup battery(ies); printer; and authentication software (optional). Before digital cameras are used for field activities, all the equipment should be available that is needed to capture images, store the images, produce unalterable "original" copies of the images, produce backup copies of the images, print the images, and any other equipment that may be required depending on the activity for which the camera will be used. This includes a computer with sufficient memory for down-loading images to the hard-drive before transferring them to the archival media.)

2. Be familiar with the camera and able to use it properly for capturing images during field activities. Anyone issued a digital camera should become familiar with its operation by reading the instruction manual of the camera. A person should know how to store an image; the capacity of the storage media being used; how to transfer images from one storage media to another; how and what is needed to print

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good quality images; how to use the different settings (resolution choice, digital zoom, flash, etc.) in the camera; and the camera's limitations (weather, zooming). Digital cameras are susceptible to damage from extreme temperature, strong magnetic fields, dust, noise, and/or vibrations. Note that digital images are not damaged by X-ray machines such as those found at security check points. It is recommended that digital cameras and their components NOT be left in vehicles where they will be subjected to extreme heat or cold. Efforts are to be taken to prevent theft, loss, or damage. It is very important to be aware of the limitations of digital cameras. An inspector should refer to the camera's manual to be familiar with the optimum operating conditions of the camera. (Note: it may be useful to have a conventional camera and film available as "back-up" in case of unforeseen circumstances).

3. Verify the digital camera's date, time and other applicable settings. All digital images are electronically inscribed with the date and time the image was taken and with the image number. This information automatically becomes a permanent part of the electronic image file and usually can be imprinted on the image when it is printed to hard copy. This information can be viewed through the camera. Before taking any pictures at a facility or site, the inspector should make sure that the camera's setting for the date, time and calendar are correct, so it reflects the correct date and time on the digital image. Depending on the camera, any additional settings in the camera should be calibrated and set to optimize the camera's capabilities according to the conditions in which it will be used (for example: resolution, zoom, lighting, file folders, and so forth). Note that the camera resolution setting should be high enough to produce the equivalent of at least an 8" X 10" traditional 35 mm print, particularly if detail is important to the image. Settings will vary depending on the camera, so refer to your camera's manual.

4. Take into account power considerations and/or limitations: Batteries must be checked at least weekly when not used. At least one extra set of Nickel Metal Hydride (NiMH) rechargeable batteries should be taken by the inspector to the field and a charger to recharge the batteries at the end of the day. Recommendations and instructions accompanying the chargers and camera should be followed. When changing the batteries always change the entire set. Batteries of different types should not be mixed. The cameras will operate on AA alkaline[3] batteries. Never try to recharge alkaline batteries. Never mix alkaline batteries and rechargeable batteries in the camera. Lithium batteries are a good option as back up batteries (especially for cold weather).

5. Ensure sufficient storage media is available for each inspection and clearly identify pictures captured for each session. The storage media may be any of the following (depending on the type of camera): compact flash, memory stick, smart media,

[3] While cameras will operate on alkaline batteries, they will last a very short time and cause the camera to respond slowly. Alkaline batteries should only be used in an emergency situation.

compact disc, and/or floppy disc. In situations where more than one incident or case is to be worked closely together, images from more than one incident may be captured on the same electronic storage card. If images from more than one incident need to be captured on a single storage card, you may do so by inserting a "blank" image after the "end card" image. It is recommended that an "end-card" image be labeled and photographed before starting a new session. Images from one incident should not be split between two electronic storage cards unless a large quantity of images requires two cards or the storage media does not have enough memory to store all the images from one inspection. The different disks, floppy disks, and/or cards should be sequentially numbered and labeled with the name of the facility and date taken and should indicate what pictures from the inspection are contained in each.

6. Transfer the digital images to another storage medium to make an "archival original." An "archival original" should be made so that the storage media can be re-used and to secure the digital images from loss or tampering. To be certain that images are not lost in the transfer process, first transfer the images from the camera's electronic storage media card or floppy disk onto the hard drive of your computer. Make sure the computer hard drive has enough memory to store the pictures. Then, verify that the images have been successfully transferred. An "archival original" should be made from the hard drive image files. The original copy should NOT be changed in any way. The archival original should be labeled with the time, date, name of facility/site and filed in a secure location, and should have a chain of custody that contains the names of people with access to it. (See example, attached). At least one additional copy should be made as a back-up copy. This copy may be edited if the image needs to be enhanced. Any changes made to a picture must be noted on the photo log and inspection report. Originals should be labeled as such and copies should be identified as copies.

   There are two alternatives in current use for creating a secure archival original. One is to transfer the images to a CD-R (read-only). The other is to use commercially available soft-ware to create a verifiable copy. In either case, the transfer should be documented in the Photo Log. The following is a brief description of each alternative.

   A). If your computer is equipped with a "CD-burner," after down-loading the images to the hard drive, copy them onto a CD-R. A CD-R can be used to make an unalterable archival copy. This CD-R will be the "original" document of the digital images (similar to the negatives of a conventional camera). If changes need to be made to the images (such as enlargement, cropping or contrast), they can be made on another, writeable CD. Any change should be replicable and should be documented in the Photo Log.

   B). A floppy disk also may be used as the storage media for the archival "original." (Note: floppy disks do not have as much memory as CD-Rs, so more than one floppy disk may be needed to store the images). If a floppy disk is used, it should

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be changed to the "read only" position when it is full and a custody seal should be used. When using a floppy disk as the archival original storage medium, the "Cyclic Redundancy Check" (CRC) software should be used to ensure verifiable images.

7. Use proper procedures for storing archival original images. The archival CD "Read Only" version (or other archival original storage media) of the digital images should be stored in a secure place with limited access. When the archival original is filed, a log should be kept and anyone accessing the archival original should sign off before using it. The archival original should be labeled and a proper chain of custody form should accompany it. (A sample chain of custody form may be found as an attachment to this document). It is up to each Region to use the archiving method that best suits them. Each Region should use a method that follows the guidelines for the applicable program. The archival original may be stored with the case file and/or in a separate area designated to store and archive all digital photo originals. Again, proper labeling and chain of custody procedures should be used at all times. Finally, it is very important that if a digital image is considered Confidential Business Information (CBI) by the facility, inspectors must have clearance to handle the information as such and that all CBI procedures must be followed.

Recommendations for Selecting/Using a Digital Camera

There is a wide selection of digital cameras available now from the very basic "point and shoot" to the elaborate professional models with various types of storage media and many other options. In selecting a digital camera for use to support inspection documentation, the typical use conditions should first be considered, but potential extremes should also be considered in order to select the best digital camera for the anticipated use conditions. It should be remembered that traditional 35mm or Polaroid cameras may be the best choice for some scenes/conditions, such as where vibration, dust, or strong magnetic fields may be present or where a level of detail is desired which cannot be achieved using a digital camera.

For use in general field conditions and for average level of detail photos, a digital camera should have at least a 2.1 mega pixel capability. (Higher mega pixel capacity is important if photos will need to be enlarged to more than 8' x 10" or where a high degree of detail is needed). The camera should have external memory storage media capable of identifying each photo separately; have date/time stamp capability; and have a USB or card reader port so that images can be down-loaded to a computer hard drive. The amount of light present in most use situations should also be considered to select a camera with the appropriate ISO sensitivity. It is also helpful if the camera provides for resolution selection and has optical zoom capability. (This is useful for taking pictures from a distance without losing image quality. Digital zoom will enlarge the image, but some detail may be lost). A camera with these basic features should cost about $300. These are basic recommendations, but camera selection will be dependent on the Region/Program's particular needs and resources. Most cameras come with at least 8

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MB of external storage memory. Additional external storage media cards holding 32 MB cost between $23 - $34 each, depending on the type. Nickel metal hydride(NIMH) batteries cost about $5 for a pack of four or $30 for a pack of four with a re-charger. A lithium battery pack is around $10.

For whatever camera is selected, there must also be sufficient computer speed and hard drive capability. At a minimum, a computer should have at least a 10 gigabyte hard drive with enough memory available to fit the number of pictures that will be down-loaded from the camera's storage media during a session. Computer speed is less important but will impact how quickly the transfer can occur and any copying or editing that will take place. A minimum of 233MHz is recommended for the average digital camera storage medium of 16 MB. A CD "burner" is also highly recommended for storing "archival originals." CD "burners" currently cost around $175 and are included in many newer computers.

A good ink-jet printer is recommended for printing copies of the photos to include with the inspection report. Epson makes printers specifically designed for this task but there are many other printers available as well. They cost between $150 - $500, depending on print speed and resolution.

References/Additional Information

1. Berg, Erik, "Legal Ramifications of Digital Imaging In Law Enforcement," Forensic Science Communications, Vol 2, No. 4, October 2000, available at www.fbi.gov/hq/lab/fsc/backissu/oct2000/berg.htm

2. Azcarate, Penney, "Digital Imaging Technology and the Prosecutor," Prosecutor, January/February 2000, (34 FEB Prosecutor 26)

3. "Guidelines for Field Applications of Imaging Technologies," Scientific Working Group on Imaging Technologies (SWGIT), Version 2.0, June 8, 1999, Forensic Science Communications, Vol. 2, No. 1, January 20000, available at www.fbi.gov/hq/lab/fsc/backissu/jan2000/swgit.htm

4. "Definitions and Guidelines for Use of Imaging Technologies in the Criminal Justice System," Scientific Working Group on Imaging Technologies, Version 2.2, December 7, 2000, Forensic Science Communications, Vol. 3, No. 3, July 2001, available at www.fbi.gov/hq/lab/fsc/july2001/swgit.htm

5. Camp, William W., "Practical Uses of Digital Photography In Litigation," ATLA Annual Convention Reference Materials, July 2000, Volume 2, Attorney's Information Exchange Group (AIEG).

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6. Keane, James I. , "585 Prestidigitalization: Magic, Evidence and Ethics In Forensic Digital Photography," Ohio Northern Law Review, 1999, Twenty-second Annual Law Review Symposium Courtroom 2000: Technology and the Legal System Symposium Article (25 Ohio
N U I. Rev.585).

7. Carbine, James E. and McLain, Lynn, "Proposed Model Rules Governing the Admissibility of Computer-Generated Evidence," January 1999, Santa Clara Computer and High Technology Law Journal (15 Santa Clara Computer & High Tech L.J. 1).

8. Lynch, Peter A. "Digital Cameras and the Fire Investigator: A Trap for the Unwary?" , Cozen & O'Connor, San Diego Regional Office available at www.interfire.org/features/camera.htm

9. "Digital Imaging Issues and Image Verification Presentation" - Waynesboro VA Police Department, Investigations Division, at www1.br.cc.va.us/wpd

10. Staggs, Steven, "The Admissibility of Digital Photographs In Court," available at www.crime-scene-investigator.net/admissibilityofdigital.html

11. Herbert, Rusty and Gigger, Richard, (EPA Region 6), "Background Information for Digital and Photographic Imaging," and "Draft Region 6 Standard Operating Procedure Digital Camera Imaging," June 2001.

Websites:

1. www.digital-camerastore.com/digitalinfor2.htm - good basic info and lists of cameras/prices.

2. www.cliffshade.com/dpfwiw/advice.htm – "Advice for first-time digital camera users" –good overview of digital camera use with links to more information

3. www.cooking-italian-food.com/photography.htm – "Digital Camera Guide - Photography Definitions and Terminology," - discussion of resolution, optical/digital zoom, ISO, storage media, and other basic terminology.

4. "An Introduction to Image Compression" - www.debugmode.com/imagecmp/

5. "Resolution, File Size & Image Quality" - www.haroldsphoto.com/res.htm

6. "Frequently Asked Questions on Digital Photography" - www.photodrive.ru/faq6_e.htm

7. Maresware Forensic and Analysis Software - a list of commercial forensic software, including cyclic redundancy check. www.dmares.com/maresware/DOCS/press_release.htm

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8. "Error Detection and Correction" - description of Cyclic Redundancy Check - www.linktionary.com/e/error.html

9. "Understanding Cyclic Redundancy Check - http://4d.com/acidoc/CMU/CMU79909.htm
a description of how the CRC error detection system algorithm works

10. photoalley.com - on-line digital camera "store"

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Attachment #1

DIGITAL IMAGE CHAIN OF CUSTODY FOR "ARCHIVAL" ORIGINAL IMAGES (Sample Form)

IMAGE RECORD

PHOTOGRAPHER(signature)	INCIDENT NUMBER/Facility EPA Identification Number
DATE PHOTOS TAKEN	IMAGE NUMBERS FOR THIS INCIDENT
LOCATION(S) PHOTOS TAKEN	THESE IMAGES HAVE NOT BEEN CHANGED, ALTERED OR MANIPULATED IN ANY WAY.
COMMENTS	SIGNATURE OF PHOTOGRAPHER

ACCESS RECORD

Name	Organization/Division	Phone Number	

A011058

Attachment #2

Example Facility Photograph Log

1. Photographer_____
2. Facility Name_____
3. Facility EPA Identification Number (if available)_____
4. Type of Camera Used_____
5. Digital recording media _____
6. All digital photos were copied by _____
7. All Digital Photos were copied to _____
8. Original Copy is stored in:_____
   (ie. Laptop, PC hard drive (or zip disk).
   At the end of each day, digital photos were downloaded to a zip drive disk, then transferred to the hard-drive, all by ..... Subsequently they were transferred by ..... to a CD-R. No changes were made in the original image files prior to storage on the CD-R.)
9. Log

Date	Time (camera recorded time)	Photo Filename (MVC-xxx.jpg)	Modification's made to digital image (if any)	Description of Image
5/21/01	0909	001		Facility: <90 day storage area at Power House #1
	0915	002		Facility: Satellite accumulation area, within tank truck unloading pad containmen northwest corner of #1 steam plant
	0915	003		Facility: Satellite accumulation area, within tank truck unloading pad containmen northwest corner of #1 steam plant
	0921	004		Facility: Satellite accumulation area, within Tank 121 containment dike
	0929	005		Facility: Satellite accumulation area, fly ash drumming area on south side of stea
	0932	006		Facility: Satellite accumulation area, residue receiving manifold area on first floo plant
	0936	007		Facility: Satellite accumulation area, residue receiving manifold area on first floo plant
	0942	008		Facility: Satellite accumulation area, adjacent to boiler on second floor of steam
	0945	009		Facility: Satellite accumulation area, adjacent to boiler on second floor of Steam
	1019	010		Facility: Satellite accumulation area, Bldg. 3, Laboratory, room 1 (hood area)
	1023	011		Facility: Satellite accumulation area, Bldg. 3, Laboratory, room A (semi-volatile h
	1027	012		Facility: Satellite accumulation area, Bldg. 3, Laboratory, room A (volatile hood a

A011059

APPENDIX I

EPA'S MEMORANDUM ON DEFICIENCY NOTICE GUIDANCE

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

WASHINGTON, D.C. 20460

MEMORANDUM

OFFICE OF ENFORCEMENT

SUBJECT: "Deficiency Notice" Implementation to Improve Quality Assurance in NPDES Permittee Self-Monitoring Activities

FROM: Director, Enforcement Division (EN-338)

TO: Enforcement Division Directors, Regions I - X
Surveillance and Analysis Division Directors, Regions I - X
Director, National Enforcement Investigations Center, Denver

The Enforcement Divisions and the Surveillance and Analysis Divisions in several Regions have developed a form, called a Deficiency Notice, which their inspectors issue at the end of compliance inspections. This Deficiency Notice alerts NPDES permittees to problems in their routine self-monitoring activities. On June 11, 1979, the Office of Water Enforcement proposed that all the Regional offices adopt this form along with the Guidance for its use, and asked for your comments on this proposal. The Deficiency Notice and Guidance, which are attached, reflect your comments.

We have ordered the Deficiency Notice Forms, which will be printed on no-carbon-required paper and will be color coded in pads to correlate with the NPDES Compliance Inspection Form (EPA 3560-3). You may reproduce the attached form for use until you receive these forms.

The Deficiency Notice was designed so that State NPDES programs might easily use it. However, EPA cannot now sanction its use by the States since the Office of Management and Budget (OMB) has not authorized the form for non-Federal use. We will attempt to get OMB approval.

Since the Deficiency Notice provides a swift and simple mechanism for responding to deficiencies in self-monitoring data, I believe that its use will substantially improve the performance of wastewater treatment facilities without creating additional resource burdens or enforcement problems. If you have any questions about the Deficiency Notice or its use, please do not hesitate to call Gary Polvi of my staff at 755-0994.

J. Brian Molloy

Attachments

A011061

DEFICIENCY NOTICE GUIDANCE

Purpose

The purpose for using the Deficiency Notice is to provide a swift and simple method for improving the quality of data from NPDES self-monitoring activities. Since an inspector may issue a Deficiency Notice during any NPDES compliance inspection to alert the permittee to either existing or potential problems in self-monitoring, its receipt prompts the permittee to quickly take corrective action, as close as possible to the time the inspector perceives the problem.

Scope

The Deficiency Notice is a tool for use in conjunction with any type of EPA NPDES compliance inspection (i.e., compliance evaluation, sampling, performance audit, biomonitoring, etc.), during which the inspector identifies problems with self-monitoring that warrant response.

The Deficiency Notice and Guidance were designed so that State NPDES compliance monitoring programs could also easily use them. (Note the use of the term "regulatory authority" throughout this guidance.) However, EPA cannot yet sanction the States' use of this form because the Office of Management and Budget (OMB) has not yet approved the form for non-Federal use.

Use of the Deficiency Notice does not apply to a wide range of possible permit violations. It is to be used by the inspector to alert permittees to deficiencies in their self-monitoring activities only. The enforcement office of the regulatory authority (i.e., the EPA Regional Enforcement Division or its State counterpart), not the inspector, will continue to handle violations relative to compliance schedules or effluent limitations.

Form Description

The Deficiency Notice (see attachment) is one page long and is for use in conjunction with the standard EPA Compliance Inspection Form (EPA 3560-3 September, 1977). The reverse side of the Notice contains general instructions to inspectors for completing the form. The regulatory authority using the form may add other specific instructions that do not conflict with this guidance.

The form has four sections: (1) basic facility data, (2) deficiencies, (3) comments, and (4) inspector identification. These sections contain individual spaces where the inspector during an inspection can log deficiencies in the following self-monitoring activities: (1) monitoring location, (2) flow measurement, (3) sample collection/holding time, (4) sample preservation, (5) test procedures, (6) record keeping, (7) other self-monitoring deficiencies (i.e., sampling frequency, instrument calibration, etc.). Since the existing Compliance Inspection Form (which inspectors now complete) includes questions and answers relating to the above seven activities, inspectors should not need much additional time to complete this Deficiency Notice.

A011062

Administrative Procedures

With few exceptions (see March 7, 1977 EMS Guide), the handling and tracking of Deficiency Notices will follow the normal EPA Enforcement Management System (EMS) procedures. Inspectors can issue the Deficiency Notice to a permittee immediately following a compliance inspection if they discover any permit deficiencies which the Notice includes. Under unusual circumstances inspectors may delay issuing a Deficiency Notice until after conferring with other officials of the regulatory authority.

EMS requires the offices responsible for inspections and for NPDES enforcement to jointly establish a policy delineating the procedure for the permittee to appropriately respond to the Deficiency Notice. In the EPA Regions, the Directors of the Enforcement Division and the Surveillance and Analysis (S&A) Division will develop this policy. If the offices agree to allow the permittee to submit a separate written response rather than to include the response as part of a regular Discharge Monitoring Report (DMR) submission, they will require the inspector to record the necessary mailing instructions and deadline for response under the additional comment section of the Deficiency Notice. The inspector indicates the appropriate method for the permittee's response in the "requested action" section of the Deficiency Notice. Due to the nature of most self-monitoring problems it is reasonable for the regulatory authority to ask that the permittee submit a written description of any corrective actions within 15 work days after receiving the Notice. Where the permittee is asked to respond as part of a regular DMR submission, a similar reporting time allowance should be allotted. In either response option, the inspector should always indicate in the Deficiency Notice the requested date for permittee response.

Having the permittee document Deficiency Notice corrective actions as part of a regular DMR submission establishes accountability for the compliance inspection in the official NPDES permit compliance file even before a compliance review is undertaken. This is a resource efficient method of documenting the minimum benefit from performing inspections.

The issuance of a Deficiency Notice is not a formal enforcement action. It is not intended and must not be construed as an administrative or legal order to the permittee. Therefore, the action by the permittee to respond is voluntary, but incentive for such response comes from the positive consideration it may have on further formal enforcement follow-up of the inspection.

When the regulatory authority receives the permittee's response to the Deficiency Notice, they will review the inspection data and the permittee's response according to EMS procedures. If during routine reviews of inspection data, the authorities note deficiencies in self-monitoring data and note that the inspector did not issue a Deficiency Notice, they may issue one at any time.

The responsibility for all enforcement activity shall always remain in the enforcement/compliance review office of the regulatory authority. After agreement between the Directors of the Regional Enforcement Division and the S&A Division, these offices should incorporate details for insuring which office retains which responsibility into the Regional EMS. Whether or not a Deficiency Notice has been issued, the enforcement office of the regulatory authority can take administrative or legal action at any time. Also, a Deficiency Notice may not be appropriate in those cases where additional enforcement action is expected or litigation against the permittee is already underway.

A011063

EPA Deficiency Notice Form

DEFICIENCY NOTICE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) *(Read instructions on back of last part before completing)*	PERMITTEE *(Facility)* NAME AND ADDRESS
PERMITTEE REPRESENTATIVE *(Receiving this Notice)*/Title	NPDES PERMIT NO.

During the compliance inspection carried out on *(Date)* _____ the deficiencies noted below were found. Additional areas of deficiency may be brought to your attention following a complete review of the Inspection Report and other information on file with the REGULATORY AUTHORITY administering your NPDES PERMIT.

D E F I C E N C I E S

MONITORING LOCATION *(Describe)*

FLOW MEASUREMENT *(Describe)*

SAMPLE COLLECTION / HOLDING TIME *(Describe)*

SAMPLE PRESERVATION *(Describe)*

TEST PROCEDURES SECTION 304(h). 40 CFR 136 *(Describe)*

RECORD KEEPING *(Describe)*

OTHER SELF-MONITORING DEFICIENCIES *(Describe)*

ADDITIONAL COMMENTS

REQUESTED ACTION—Your attention to the correction of the deficiencies noted above is requested. Receipt of a description of the corrective actions taken will be considered in the determination of the need for further Administrative or Legal Action. Your response is to be (**inspector line out inappropriate response method**): (1) Include with your next *NPDES Discharge Monitoring Report (DMR) or (2) submitted as directed by the inspector.* Questions regarding possible follow-up action can be answered by the REGULATORY AUTHORITY to which your DMRs are submitted and which administers your NPDES Permit.

INSPECTOR'S SIGNATURE	INSPECTOR'S ADDRESS/PHONE NO.	REGULATORY AUTHORITY/ADDRESS	DATE
INSPECTOR'S PRINTED NAME			

EPA Form 3560-4 (2-80)

A011064

APPENDIX J

NPDES COMPLIANCE INSPECTION REPORT FORM 3560-3

This Form Is Under Revision
Revised Form Will Be Effective October 1, 2004

United States Environmental Protection Agency
Washington, D.C. 20460

Water Compliance Inspection Report

Section A: National Data System Coding (i.e., PCS)

Transaction Code	NPDES	yr/mo/day	Inspection Type	Inspector	Fac Type	
1 [ ] 2 [5]	3 [ ] 11	12 [ ] 17	18 [ ]		19 [ ]	20 [ ]

Remarks
21 [ ] 66

Inspection Work Days	Facility Self-Monitoring Evaluation Rating	B1	QA	Reserved	
67 [ ] 69	70 [ ]	71 [ ]	72 [ ]	73 [ ] 74	75 [ ] 80

Section B: Facility Data

Name and Location of Facility Inspected *(For industrial users discharging to POTW, also include POTW name and NPDES permit number)*	Entry Time/Date	Permit Effective Date
	Exit Time/Date	Permit Expiration Date

Name(s) of On-Site Representative(s)/Title(s)/Phone and Fax Number(s)	Other Facility Data
Name, Address of Responsible Official/Title/Phone and Fax Number **Contacted** ☐ Yes ☐ No	

Section C: Areas Evaluated During Inspection *(Check only those areas evaluated)*

☐ Permit	☐ Self-Monitoring Program	☐ Pretreatment	☐ Pollution Prevention
☐ Records/Reports	☐ Compliance Schedules	☐ Storm Water	☐ Multimedia
☐ Facility Site Review	☐ Laboratory	☐ Combined Sewer Overflow	☐ Other:
☐ Effluent/Receiving Waters	☐ Operations & Maintenance	☐ Sanitary Sewer Overflow	☐ Other:
☐ Flow Measurement	☐ Sludge Handling/Disposal	☐ CAFO	☐ Other:

Section D: Summary of Findings/Comments *(Attach additional sheets of narrative and checklists as necessary)*

Name(s) and Signature(s) of Inspector(s)	Agency/Office/Phone and Fax Numbers	Date
Signature of Management Q A Reviewer	Agency/Office/Phone and Fax Numbers	Date

A011066

INSTRUCTIONS

Section A: National Data System Coding *(i.e., PCS)*

Column 1: Transaction Code: Use N, C, or D for New, Change, or Delete. All inspections will be *new* unless there is an error in the data entered.

Columns 3-11: NPDES Permit No. Enter the facility's NPDES permit number. *(Use the Remarks columns to record the State permit number, if necessary.)*

Columns 12-17: Inspection Date. Insert the date entry was made into the facility. Use the year/month/day format (e.g., 94/06/30 = June 30, 1994).

Column 18: Inspection Type. Use one of the codes listed below to describe the type of inspection:

A	Performance Audit	M	Multimedia	2	IU Sampling Inspection
B	Compliance Biomonitoring	O	Compliance Evaluation (oversight)	3	IU Non-Sampling Inspection
C	Compliance Evaluation (non-sampling)	P	Pretreatment Compliance Inspection	4	IU Toxics Inspection
D	Diagnostic	R	Reconnaissance	5	IU Sampling Inspection with Pretreatment
E	Corps of Engineers Inspection	S	Compliance Sampling	6	IU Non-Sampling Inspection with Pretreatment
F	Pretreatment Follow-up	U	IU Inspection with Pretreatment Audit	7	IU Toxics with Pretreatment
G	Pretreatment Audit	X	Toxics Inspection		
I	Industrial User (IU) Inspection	Z	Sludge		
L	Enforcement Case Support				

Column 19: Inspector Code. Use one of the codes listed below to describe the *lead agency* in the inspection.

- C — Contractor or Other Inspectors *(Specify in Remarks columns)*
- E — Corps of Engineers
- J — Joint EPA/State Inspectors—EPA Lead
- N — NEIC Inspectors
- R — EPA Regional Inspector
- S — State Inspector
- T — Joint State/EPA Inspectors—State lead

Column 20: Facility Type. Use one of the codes below to describe the facility.

- 1 — Municipal. Publicly Owned Treatment Works (POTWs) with 1987 Standard Industrial Code (SIC) 4952.
- 2 — Industrial. Other than municipal, agricultural, and Federal facilities.
- 3 — Agricultural. Facilities classified with 1987 SIC 0111 to 0971.
- 4 — Federal. Facilities identified as Federal by the EPA Regional Office.
- 5 — Oil & Gas. Facilities classified with 1987 SIC 1311 to 1389.

Columns 21-66: Remarks. These columns are reserved for remarks at the discretion of the Region.

Columns 67-69: Inspection Work Days. Estimate the total work effort (to the nearest 0.1 work day), up to 99.9 days, that were used to complete the inspection and submit a QA reviewed report of findings. This estimate includes the accumulative effort of all participating inspectors; any effort for laboratory analyses, testing, and remote sensing; and the billed payroll time for travel and pre and post inspection preparation. This estimate does not require detailed documentation.

Column 70: Facility Evaluation Rating. Use information gathered during the inspection (regardless of inspection type) to evaluate the quality of the facility self-monitoring program. Grade the program using a scale of 1 to 5 with a score of 5 being used for very reliable self-monitoring programs, 3 being satisfactory, and 1 being used for very unreliable programs.

Column 71: Biomonitoring Information. Enter D for static testing. Enter F for flow through testing. Enter N for no biomonitoring.

Column 72: Quality Assurance Data Inspection. Enter Q if the inspection was conducted as followup on quality assurance sample results. Enter N otherwise.

Columns 73-80: These columns are reserved for regionally defined information.

Section B: Facility Data

This section is self-explanatory except for "Other Facility Data," which may include new information not in the permit or PCS (e.g., new outfalls, names of receiving waters, new ownership, and other updates to the record).

Section C: Areas Evaluated During Inspection

Check only those areas evaluated by marking the appropriate box. Use Section D and additional sheets as necessary. Support the findings, as necessary, in a brief narrative report. Use the headings given on the report form (e.g., Permit, Records/Reports) when discussing the areas evaluated during the inspection. The heading marked "Multimedia" may indicate medias such as CAA, RCRA, and TSCA. The heading marked "Other" may indicate activities such as SPCC, BMPs, and concerns that are not covered elsewhere.

Section D: Summary of Findings/Comments

Briefly summarize the inspection findings. This summary should abstract the pertinent inspection findings, not replace the narrative report. Reference a list of attachments, such as completed checklists taken from the NPDES Compliance Inspection Manuals and pretreatment guidance documents, including effluent data when sampling has been done. Use extra sheets as necessary.

A011067

APPENDIX K

SAMPLE DISCHARGE MONITORING REPORT FORM

A0110688

Paperwork Reduction Act Notice

Public reporting burden for this collection of information is estimated to vary from a range of 10 hours as an average per response for some minor facilities, to 110 hours as an average per response for some major facilities, with a weighted average for major and minor facilities of 18 hours per response, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding the burden estimate or any other aspect of this collection of information, including strategies for reducing this burden, to Chief, Information Policy Branch, PM-223, U.S. Environmental Protection Agency, 401 M Street, SW, Washington, DC 20460; and to the Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, DC 20503.

General Instructions

1. If form has been partially completed by preprinting, disregard instructions directed at entry of that information already preprinted.
2. Enter "*Permittee Name/Mailing Address* (and facility name/location, if different)," "Permit Number," and "Discharge Number" where indicated. (A separate form is required for each discharge.)
3. Enter dates beginning and ending "*Monitoring Period*" covered by form where indicated.
4. Enter each "*Parameter*" as specified in monitoring requirements of permit.
5. Enter "*Sample Measurement*" data for each parameter under "*Quantity*" and "*Quality*" in units specified in permit. "*Average*" is normally arithmetic average (geometric average for bacterial parameters) of all sample measurements for each parameter obtained during "*Monitoring Period*"; "*Maximum*" and "*Minimum*" are normally extreme high and low measurements obtained during "*Monitoring Period.*" (Note to municipals with secondary treatment requirement: Enter 30-day average of sample measurements under "*Average*," and enter maximum 7-day average of sample measurements obtained during monitoring period under "*Maximum.*")
6. Enter "*Permit Requirement*" for each parameter under "*Quantity*" and "*Quality*" as specified in permit.
7. Under "*No Ex*" enter number of sample measurements during monitoring period that exceed maximum (and/or minimum or 7-day average as appropriate) permit requirement for each parameter. If none, enter "*0.*"
8. Enter "*Frequency of Analysis*" both as "*Sample Measurement*" (actual frequency of sampling and analysis used during monitoring period) and as "*Permit Requirement*" specified in permit. (e.g., Enter "*Cont*," for continuous monitoring, "*1/7*" for one day per week, "*1/30*" for one day per month, "*1/90*" for one day per quarter, etc.)
9. Enter "*Sample Type*" both as "*Sample Measurement*" (actual sample type used during monitoring period) and as "*Permit Requirement*," (e.g., Enter "*Grab*" for individual sample, "*24HC*" for 24-hour composite, "*N/A*" for continuous monitoring, etc.)
10. Where violations of permit requirements are reported, attach a brief explanation to describe cause and corrective actions taken, and reference each violation by date.
11. If "*no discharge*" occurs during monitoring period, enter "No Discharge" across form in place of data entry.
12. Enter "*Name/Title of Principal Executive Officer*" with "*Signature of Principal Officer of Authorized Agent*," "*Telephone Number*," and "*Date*" at bottom of form.
13. Mail signed Report to Office(s) by date(s) specified in permit. Retain copy for your records.
14. More detailed instructions for use of this *Discharge Monitoring Report (DMR)* form may be obtained from Office(s) specified in permit.

Legal Notice

This report is required by law (33 U.S.C. 1318; 40 C.F.R. 125.27). Failure to report or failure to report truthfully can result in civil penalties not to exceed $10,000 per day of violation; or in criminal penalties not to exceed $25,000 per day of violation, or by imprisonment for not more than one year, or by both.

EPA Form 3320-1 (Rev. 3/99)

A011069

PERMITTEE NAME/ADDRESS *(Include Facility Name/Location if Different)*
Approved

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM *(NPDES)*

Form

NAME
ADDRES

PERMIT NUMBER

DISCHARGE NUMBER

FACILIT
LOCATI

	MONITORING PERIOD						
	YEAR	MO	DAY		YEAR	MO	DAY
FROM				TO			

NOTE: Read Instructions

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		AVERAGE	MAXIMUM	UNITS	MINIMUM	AVERAGE	MAXIMUM	UNITS			
	SAMPLE										
	PERMIT										
	REQUIREMENT										
	SAMPLE										
	PERMIT										
	REQUIREMENT										
	SAMPLE										
	PERMIT										
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	REQUIREMENT										
	SAMPLE										
	PERMIT										
	REQUIREMENT										

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER			TELEPHONE		DATE		
	I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.						
TYPED OR PRINTED		SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	AREA	NUMBER	YEAR	MO	DAY

COMMENT AND EXPLANATION OF ANY VIOLATIONS *(Reference all attachments here)*

EPA Form 3 320-1 (Rev. 03-99) *Previous editions may be used.*

This is a 4-part form

PAGE

K-2

A011070

APPENDIX L

APPROVED METHODS FOR THE ANALYSIS OF SEWAGE SLUDGE (40 *CFR* 503)

APPROVED METHODS FOR THE ANALYSIS OF SEWAGE SLUDGE
(40 CFR Part 503)

Parameter	Analysis Method a/
Arsenic	SW-846 Method 6010B b/ SW-846 Method 6020 b/ SW-846 Method 7060B b/ SW-846 Method 7061B b/
Cadmium	SW-846 Method 6010B b/ SW-846 Method 6020 b/ SW-846 Method 7130 b/ SW-846 Method 7131B b/
Copper	SW-846 Method 6010B b/ SW-846 Method 6020 b/ SW-846 Method 7210 b/ SW-846 Method 7211 b/
Lead	SW-846 Method 6010B b/ SW-846 Method 6020 b/ SW-846 Method 7420 b/ SW-846 Method 7421 b/
Mercury	SW-846 Method 7471B
Molybdenum	SW-846 Method 6010B b/ SW-846 Method 6020 b/ SW-846 Method 7481 b/
Nickel	SW-846 Method 7521 b/ SW-846 Method 6010B b/ SW-846 Method 6020 b/ SW-846 Method 7520 b/
Selenium	SW-846 Method 6010B b/ SW-846 Method 6020 b/ SW-846 Method 7740 b/ SW-846 Method 7741B b/
Zinc	SW-846 Method 6010B b/ SW-846 Method 6020 b/ SW-846 Method 7950 b/ SW-846 Method 7951 b/
Fecal Coliform (MPN)	SM-18th Method 9221 E (MPN) & Appendix F, EPA/625/R-92/013
Salmonella bacteria	Appendix G, EPA/625/R-92/013
Helminth Ova	Appendix I, EPA/625/R-92/013
Enteric Viruses	Appendix H, EPA/625/R-92/013
Nitrate (as N)	SM-18th Method 4500-NO_3^- SW-846 Method 9056 SW-846 Method 9210
Nitrite (as N)	SM-18th Method 4500-NO_2
Ammonia (as N)	SM-18th Method 4500-NH_3

Organic Nitrogen	Value calculated TKN minus NH3-N
Total Kjeldahl Nitrogen (TKN)	SM-18th Method 4500-N_{org}
Total Solids	SM-18th Method 2540 G
Total Volatile Solids	SM-18th Method 2540 G
Total Phosphorus	SM-18th Method 4500-P
pH	SW-846 Method 9045C
TCLP	SW-846 Method 1311
Paint Filter Test	SW-846 Method 9095A

a/ The references for the specified analytical methods are listed below:

EPA/626/R-92/013 means *Environmental Regulations and Technology, Control of Pathogens and Vector Attraction in Sewage Sludge (Including Domestic Septage) Under 40 CFR Part 503*, EPA Publication EPA/625/R-92/013, Revised October 1999. Use the indicated appendix. A copy of the document can be downloaded in PDF format from the Region 8 Biosolids Web page at http://www.epa.gov/region8/water/wastewater/biohome/biohome.html. Click on "Biosolids Documents", "New Documents", then "625r92013.pdf".

SM-18th means *Standard Methods for the Examination of Water and Wastewater*, 18th Edition, 1992, American Public Health Association, 1015 15th Street, NW., Washington, DC 20005.

SW-846 means *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, EPA publication SW-846 Third Edition (September 1986), Update I (July 1992), Update II (September 1994), Update IIA (August 1993), Update IIB (January 1995), and Update III (December 1996). Available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

b/ All samples must be digested using SW-846 Method 3050B (using equivalent to 1 gram dry weight) prior to analysis by any of the procedures indicated. Methods 3051 or 3052 may be used only with permission of the permit issuing authority. The AA direct Aspiration analyses are applicable at moderate concentration levels in clean complex matrix systems. AA Furnace methods can increase sensitivity if matrix effects are not severe. Inductively Coupled Plasma (ICP) methods are applicable over a broad linear range and are especially sensitive for refractory elements. Detection limits for AA Furnace methods are generally lower than for ICP methods.

APPENDIX M

EXAMPLE CHAIN-OF-CUSTODY FORM

U.S. ENVIRONMENTAL PROTECTION AGENCY

REGION VIII, ONE DENVER PLACE
999 18TH STREET
DENVER, CO 80202-2413

	PROJECT NAME							NO OF CONTAINERS							
(Signature)					CHAIN OF CUSTODY RECORD										
		TIME	COMP	GRAB											
					STATION LOCATION										REMARKS

APPENDIX N

UPDATED FACT SHEET: DEPARTMENT OF TRANSPORTATION HAZARDOUS MATERIALS TRAINING

DEPARTMENT OF TRANSPORTATION HAZARDOUS MATERIALS TRAINING

What are DOT training requirements?

DOT's training requirements can be found at 49 CFR Part 172, Subpart H. In general, any employee who has a responsibility working with hazardous materials (hazmat) that is placed in commerce must have hazmat training. The employee must be familiar or aware of the requirements enabling the employee to recognize and identify hazardous materials, i.e., hazardous samples vs. non-hazardous samples, consistent with the hazard communication standards. The training must be commensurate with functions and responsibilities of the employee.

Why does hazmat training apply to me?

As an inspector, you are likely to be a hazmat employee because you collect samples during an inspection and prepare the hazmat samples for transportation. The EPA is a hazmat employer because the Agency causes hazmat to be transported or shipped in commerce through its employees. DOT defines "hazmat employer" to include any department, agency, or instrumentality of the United States, a State, a political subdivision of a State, or an Indian Nation. Administrative and secretarial staff are also subject to DOT training if their responsibilities cause hazmat materials to be placed into commerce, i.e., preparing shipping papers.

Does my EPA training substitute for DOT training requirements?

The EPA Health & Safety course provides the inspector with information on protecting oneself for on-the-job hazards and would meet DOT's Safety training requirement. It does **not** meet the General awareness/familiarization requirement. See DOT's training requirements.

What type of DOT training do I need?

DOT hazmat training is function-specific. For most inspectors, the general awareness hazardous materials training course found on the DOT's website will be sufficient to meet the DOT training requirements. Alternatively, the employer can provide function specific training from other sources.(see below).

What are DOT's training requirements for hazardous materials?

DOT's hazmat training, 49 CFR §172.704, focuses on three requirements applicable to inspectors and administrative staff:

- General awareness/familiarization
  - ✓ Each hazmat employee shall be provided general awareness/familiarization training designed to provide familiarity with the hazmat requirements and to enable the employee to recognize and identify hazardous materials consistent with the hazard communication standards.

What are DOT's training

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requirements for hazardous materials? cont.

- Function-specific
  - ✓ Each hazmat employee shall be provided function-specific training as it applies to the employee's job responsibilities.
- Safety
  - ✓ Emergency response information required by part 172, subpart G, i.e., information that can be used in the mitigation of an incident involving hazardous materials;
  - ✓ Measures to protect the employee from the hazards associated with hazardous materials to which they may be exposed in the work place, including specific measures the hazmat employer has implemented to protect employees from exposure; and
  - ✓ Methods and procedures for avoiding accidents, such as the proper procedures for handling packages containing hazardous materials.

Where can I find training opportunities?

A good training resource is DOT's hazmat page, hazmat.dot.gov/training. You can download the instructor's and student's training manual for in-house use. The training manual does include test questions. Self-training is acceptable by DOT so long as 49 CFR §172.704 training requirements are met. The DOT's Transportation Safety Institute in Oklahoma City, OK offers training on-site. Course dates are available from the website.

In addition to DOT's hazmat site, this web link, hazmat.dot.gov/thirdpty.htm identifies third party providers who offer a variety of hazmat training courses.

How long does the certification last?

The hazardous materials training is required to be completed within the first 90 days of employment. The certification period is good for three years and then the hazardous materials training program must be retaken. If your job responsibilities change, your training needs may change.

Who is responsible for training?

The employer is responsible. DOT's definition of employer is not clear in terms of EPA's administrative structure. "Employer" could be defined as the Administrator or any other manager in direct supervisory line of the employee.

Who is responsible for keeping the training record?

The employer is responsible for keeping the employee's records.

What should be in the training record?

completed the necessary training, and has been tested and certified.

Specifically, what documents need to be retained?

A record of current training, inclusive of the preceding three years must be retained for as long as the employee is employed by that employer as a hazmat employee and for 90 days thereafter. The record shall include the following information:

(1) The inspector's name;
(2) The most recent training completion date of the inspector's training;
(3) A description, copy, or the location of the training materials used to meet the requirements;
(4) The name and address of the person providing the training; and
(5) Certification that the hazmat employee has been **trained and tested.**

Does the employee have to "pass" the test?

The requirements do not state that the employee must "pass" a test; however, an employee may only be certified in areas in which he/she can successfully perform their hazmat duties.

Know Your Shipper's Requirements!

Before collecting samples, know which shipping company you will be using to ship your samples. Some require additional training and certification beyond the basic DOT requirements. Here are three common carriers with some of their requirements for shipping hazmat materials.

Federal Express (FedEx)

The shipping method you select determines what type of training FedEx expects you to have completed. If you plan to ship samples by ground, the DOT training requirements are sufficient. If you plan to ship the samples by air, then you must be trained according to International Air Transport Association (IATA) regulations. Successful completion of the IATA requirements will meet DOT's hazard communications requirements. IATA training and information can be found at: www.iata.org.

Documentation that shows the employee has

Know Your Shipper's Requirements! cont.

awareness training is acceptable by UPS for ground shipments. Shipments by air require IATA training.

United States Postal Service (USPS)

DOT's general awareness training and testing is acceptable by USPS for both shipping by ground and air. However, the Postal Service does have limits which are more stringent than DOT's regulations. Check this website for further details - http://pe.usps.gov/text/dmm/c023.htm

Before shipping, you should inquire with the shipping company if they have additional requirements for handling, packaging and shipment limitations for the hazmat materials.

Here are a few issues an inspector may face with the different shippers:

- Do you want them to meet you at the site? You may need to call ahead to schedule the pickup before you arrive at the site to collect samples.
- Do you plan on dropping the shipment off? Not all offices can accept dangerous goods and hazmat.
- Shipping papers may need to be typed, not handwritten. Do you bring a portable typewriter with you or type the shipping papers before leaving the office?

United Parcel Service (UPS)

DOT's general

APPENDIX O

SUPPLEMENTAL FLOW MEASUREMENT INFORMATION

SUPPLEMENTAL FLOW MEASUREMENT INFORMATION

Basic Hydraulic Calculations

The relationship between the flow rate (Q), the average velocity (V), and the cross-sectional area of the flow (A) is given by the following equation:

$$Q = VA$$

where Q = flow in cubic feet per second
V = velocity in feet per second
A = area in square feet.

To convert flow in cubic feet of water per second to flow in gallons of water per minute, the following proportionality is used:

$$\frac{\text{cubic feet}}{\text{second}} \times \frac{7.48 \text{ gallons water}}{\text{cubic foot of water}} \times \frac{60 \text{ seconds}}{\text{minute}} = \frac{\text{gallons}}{\text{minute}}$$

To convert from cubic feet per second to million gallons per day, multiply the number of cubic feet per second by 0.6463.

The cross-sectional area (A) of a pipe is described by:

$$A = \tfrac{1}{4}\pi d^2$$

where d = diameter of the pipe in feet.

Flow Measurement Devices

Flow data may be collected instantaneously or continuously. Instantaneous flows must be measured when samples are taken so that the pollutant concentrations can be correlated to flow data. In a continuous flow measurement system, flow measurements are summed to obtain a value for the total flow to verify NPDES permit compliance.

A typical continuous flow measurement system consists of a flow device, a flow sensor, transmitting equipment, a recorder, and a totalizer.

Instantaneous flow data can be obtained without using such a system. The primary flow device is constructed to yield predictable hydraulic responses related to the rate of wastewater or water flowing through the device. As previously mentioned, examples of such devices include weirs and flumes, which relate water depth (head) to flow; Venturi meters, which relate differential pressure to flow; and electromagnetic flowmeters, which relate induced electric voltage to flow.

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In most cases, a standard primary flow device has undergone detailed testing and experimentation and its accuracy has been verified.

Flow is measured by many methods; some are designed to measure open channel flows, and others are designed to measure flows in pipelines. A complete discussion of all available flow measurement methods, their supporting theories, and the devices used are beyond the scope of this manual. The most commonly used flow measurement devices and procedures for inspecting them will be described briefly in the following paragraphs. For more detail, inspectors should consult the publications listed in "References" at the end of this chapter.

Primary Devices

Weirs. A weir consists of a thin vertical plate with a sharp crest that is placed in a stream, channel, or partly filled pipe. Figure I-1 shows a profile of a sharp-crested weir and indicates the appropriate nomenclature. Four common types of sharp-crested weirs are shown in Figure I-2. This figure illustrates the difference between suppressed and contracted rectangular weirs and illustrates Cipolletti (trapezoidal) and V-notch (triangular) weirs.

To determine the flow rate, it is necessary to measure the hydraulic head (height) of water above the crest of the weir. For accurate flow measurements, the crest must be clean, sharp, and level. The edge of the crest must not be thicker than 1/8 inch.

The rate of flow over a weir is directly related to the height of the water (head) above the crest at a point upstream of the weir where the water surface is level. To calculate the discharge over a weir, the head must first be measured by placing a measuring device upstream of the weir, at a distance of at least 4 times an approximate measurement of the head. A measurement can be taken at the weir plate to approximate the head. However, if this measurement is used to calculate the discharge, this value will provide only a rough estimate of the discharge.

The head-discharge relationship formulas for nonsubmerged contracted and suppressed rectangular weirs, Cipolletti weirs, and V-notch weirs are provided in Table I-1. Discharge rates for the 90-degree V-notch weir (when the head is measured at the weir plate) are included in Table I-2. Flow rates for 60- and 90-degree V-notch weirs can be determined from the graph in Figure I-3. Minimum and maximum recommended flow rates for Cipolletti weirs are provided in Table I-3. Figure I-4 is a nomograph for flow rates for rectangular weirs using the Francis formulas.

Parshall Flume. The Parshall flume is composed of three sections: a converging upstream section, a throat or contracted section, and a diverging or dropping downstream section. When there is free fall out of the throat of a Parshall flume, no diverging downstream section is required. It operates on the principle that when open channel water flows through a constriction in the channel, it produces a hydraulic head at a certain point upstream of the constriction that is proportional to the flow. The hydraulic head is used to calculate the flow. Flow curves are shown in Figure I-5 to determine free flow through 3 inches to 50 feet Parshall flumes.

The Parshall flume is good for measuring open channel waste flow because it is self cleaning; therefore, sand or suspended solids are unlikely to affect the operation of the device. The flume is both simple and accurate.

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The flume size is given by the width of the throat section. Parshall flumes have been developed with throat widths from 1 inch to 50 feet. The configuration and standard nomenclature for Parshall flumes are provided in Figure I-6. Strict adherence to all dimensions is necessary to achieve accurate flow measurements. Figure I-6 provides Parshall flume dimensions for various throat widths, and Table I-4 provides the minimum and maximum flow rates for free flow through Parshall flumes.

For free nonsubmerged flow in a Parshall flume of throat and upstream head (Ha in feet), the discharge relationship for flumes of 8 feet or less is given by the general equation Q = CWHan, where Q = flow.

Table I-5 provides the values of C, n, and Q for different sizes (widths) of the Parshall flumes. Nomographs, curves, or tables are readily available to determine the discharge from head observations.

Flow through a Parshall flume may also be submerged. The degree of submergence is indicated by the ratio of the downstream head to the upstream head (Hb/Ha), which is the submergence ratio. Hb is the height of water measured above the crest. The flow is submerged if the submerged ratio is:

- Greater than 0.5 for flumes under 3 inches
- Greater than 0.6 for flumes 6 to 9 inches
- Greater than 0.7 for flumes 1 to 8 feet
- Greater than 0.8 for flumes larger than 8 feet.

If submerged conditions exist, the inspector should apply a correction factor to the free flow determined using the relationship Q= CWHn. These correction factors are shown in Figure I-7 for different sizes of the Parshall flume.

Palmer-Bowlus Flume. The Palmer-Bowlus flume is also composed of three sections: a converging upstream section, a contracted section or throat, and a diverging downstream section (Figure I-8). The upstream depth of the water (head) above the raised step in the throat is related to the discharge rate. The head should be measured at a distance d/2 upstream of the throat where d is the size (width) of the flume. The height of the step is usually unknown until the manufacturer's data are consulted, it is difficult to manually measure the height of water above the step at an upstream point. The dimensions for Palmer-Bowlus flumes are not standardized as they are for Parshall flumes. Therefore, no standard flow equation exists. Instead, rating curves are provided by manufacturers of Palmer-Bowlus flumes to relate the head to the discharge rate.

The flume must be installed with a minimum channel slope downstream to maintain critical flow through the flume and prevent the flume from becoming submerged. A small jump or rise in the water surface below the throat indicates that critical flow through the flume has probably occurred and submerged conditions do not exist. Accurate flow measurements can usually be obtained with upstream depths that are up to 95 percent of the pipe diameter. Table I-6 provides a table of the maximum slopes recommended for installation of Palmer-Bowlus flumes. Advantages of this type of flow measurement device are the following:

- It is easily installed in existing systems.
- Head loss is insignificant.
- Unit is self cleaning.

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Venturi Meter. The Venturi (differential pressure) meter is one of the most accurate primary devices for measuring flow rates in pipes. The Venturi meter is basically a pipe segment consisting of an inlet section, a converging section, and a throat, along with a diverging outlet section as illustrated in Figure I-9. The water velocity is increased in the constricted portion of the inlet section resulting in a decrease in the static pressure. The pressure difference between the inlet pipe and the throat is proportional to the square of the flow. The pressure difference can easily be measured very accurately, resulting in an accurate flow measurement. An advantage of the Venturi meter is that it causes little pressure (head) loss. The formula for calculating the flow in a Venturi meter is as follows:

$$Q = cKd_2^2\sqrt{h_1 - h_2} \qquad \text{(King1963)}$$

where Q = volume of water, in cubic feet per second
c = discharge coefficient, obtain from Table I-7. C varies with Reynold's number, meter surfaces, and installation

h1 = pressure head at center of pipe at inlet section, in feet of water
h2 = pressure head at throat, in feet of water
K = constant which relates d2 to d1 for Venturi meters. Obtain values of K from Table I-8 or calculate according to the formula

$$K = \sqrt{\frac{2g}{1 - \left[\frac{d_2}{d_1}\right]^4}}$$

where d_2 = throat diameter, in feet
d_1 = diameter of inlet pipe, in feet

Electromagnetic Flowmeter. The electromagnetic flowmeter operates according to Faraday's Law of Induction: the voltage induced by a conductor moving at right angles through a magnetic field will be proportional to the velocity of the conductor through the field. In the electromagnetic flowmeter, the conductor is the liquid stream to be measured and the field is produced by a set of electromagnetic coils. A typical electromagnetic flowmeter is shown in Figure I-10. The induced voltage is transmitted to a converter for signal conditioning. The meter may be provided with recorder and totalizer using electric or pneumatic transmission systems. This type of flowmeter is useful at sewage lift stations and for measuring total raw wastewater flow or raw or recirculated sludge flow.

Electromagnetic flowmeters are used in full pipes and have many advantages, including: accuracies of +1 percent, a wide flow measurement range, a negligible pressure loss, no moving parts, and rapid response time. However, they are expensive and buildup of grease deposits or pitting by abrasive wastewaters can cause error. Regular checking and cleaning of the electrodes is necessary. The meter electronics can be checked for proper operation with devices specially made for this purpose. The meter should be checked at least annually. The calibration of an electromagnetic flowmeter cannot be verified except by returning it to the

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factory or by the dye dilution method.

Propeller Meter. The propeller meter (Figure I-11) operates on the principle that liquid hitting the propeller will cause the propeller to rotate at a speed proportional to the flow rate. The meter is self-contained and requires no energy or equipment other than a mechanical totalizer to obtain a cumulative flow reading. Equipment may be added to the meter to produce a flow reading, to pace chemical feed equipment, and to control telemetering equipment for remote readout. The calibration of a propeller meter can be checked by returning it to the factory, by comparing its readings to another meter measuring the same flow, or by using the dye dilution method.

Secondary Devices

Secondary devices are the devices in the flow measurement system that translate the interaction of primary devices in contact with the fluid into the desired records or readout. They can be organized into two broad classes:

- Nonrecording type with direct readout (e.g., a staff gauge) or indirect readout from fixed points (e.g., a chain, wire weight, float)
- Recording type with either digital or graphic recorders (e.g., float in well, float in flow, bubbler, electrical, acoustic).

The advantages and disadvantages of various secondary devices are provided in Table G-9.

Transit-Time Flowmeter. The transit-time flowmeter (Figure I-12) is a new ultrasonic technology that can be used as a secondary device. As a secondary device, the transit-time flowmeter must be used in conjunction with one of the primary devices described above. The transit-time flowmeter utilizes a minimum of one pair of transducers that alternately transmit and receive an ultrasonic signal. The transducers are placed on or in the pipe at a defined spacing based on a predetermined angle. The signal between the pair of transducers is alternately transmitted, first upstream and then downstream. At a zero flow condition, the time for the two signals to be transmitted and received are equal. However, as flow begins, the liquid's flow velocity speeds up the signal in the up to downstream direction while slowing the signal in the down to upstream direction. The difference in time between the two signals is proportional to the liquid's velocity. Knowing the liquid's flow velocity and the pipe inner diameter area provides the instantaneous flow rate. The flowmeter provides analog and discrete outputs for remote recorder and totalization of flow.

Transit-time flowmeters are suitable for the typical range of liquids found in full pipe applications. The clamp-on nature of the meter allows for its installation without the need to shut down the existing line. Transit-time flowmeters are available in both permanent and portable configurations.

Pumps

Some wastewater facilities may need to measure flow by means of pumps in which discharge-versus-power relationships have been determined from measurements of the average output or input during a period in which discharge measurements were made. Suitable curves may be developed from these test data. When readily available from the manufacturer, pump curves may be used by the inspector to estimate flow.

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Because of wear on pumps and uncertainty regarding actual discharge heads, pump curves at best only provide an estimate of the flow. Pump curves are not normally accurate enough to be used for NPDES permit discharge flow measurements. Pump curves have been used for determining large flows, such as the cooling water discharge from large steam electric power plants, where a high degree of accuracy was not necessary.

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Table O-1

Head-Discharge Relationship Formulas for Nonsubmerged Weirs*

Weir Type	Contracted	Suppressed	Remarks	Reference
Rectangular				
Francis formulas	$Q = 3.33 (L - 0.1 nH)H^{1.5}$	$Q = 3.33 L H^{1.5}$	Approach velocity neglected	King 1963
	$Q = 3.33 [(H + h)^{1.5}-h^{1.5}](L - 0.1nH)$	$Q = 3.33 L[(H + h)^{1.5} - h^{1.5}]$	Approach velocity considered	King 1963
Cipolletti	$Q = 3.367 L H^{1.5}$	NA	Approach velocity neglected	King 1963
	$Q = 3.367 L (H + h)^{1.5} - h^{1.5}$	NA	Approach velocity considered	EPA 1973
V-notch				
Formula for 90° V-notch only	$Q = 2.50 H^{2.5}$	NA	Not appreciably affected by approach velocity	King 1963
	$Q = 3.01 H_w 2.48$	NA	Head measured at weir plate	Eli and Peterson 1979 (EPA-61809A-2B)

Q = discharge in cubic feet
H = head in feet
NA = not applicable
H_w = head in feet at weir plate
n = number of end contractions
L = crest length in feet
h = head in feet due to the approach velocity = $v^2/2g$
V = approach velocity
g = gravity (32.2 ft/sec^2)

*Selection of a formula depends on its suitability and parameters under consideration.

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Table O-2

Discharge of 90° V-Notch Weir—Head Measured at Weir Plate

Head@ Weir in Feet	Flow Rate in CFS	Head@ Weir in Feet	Flow Rate in CFS	Head@ Weir in Feet	Flow Rate in CFS
0.06	0.003	0.46	0.439	0.86	2.071
0.07	0.004	0.47	0.463	0.87	2.140
0.08	0.006	0.48	0.488	0.88	2.192
0.09	0.008	0.49	0.513	0.89	2.255
0.10	0.010	0.50	0.540	0.90	2.318
0.11	0.013	0.51	0.567	0.91	2.382
0.12	0.016	0.52	0.595	0.92	2.448
0.13	0.019	0.53	0.623	0.93	2.514
0.14	0.023	0.54	0.653	0.94	2.582
0.15	0.027	0.55	0.683	0.95	2.650
0.16	0.032	0.56	0.715	0.96	2.720
0.17	0.037	0.57	0.747	0.97	2.791
0.18	0.043	0.58	0.780	0.98	2.863
0.19	0.049	0.59	0.813	0.99	2.936
0.20	0.056	0.60	0.848	1.00	3.010
0.21	0.063	0.61	0.883	1.01	3.085
0.22	0.070	0.62	0.920	1.02	3.162
0.23	0.079	0.63	0.957	1.03	3.239
0.24	0.087	0.64	0.995	1.04	3.317
0.25	0.097	0.65	1.034	1.05	3.397
0.26	0.107	0.66	1.074	1.06	3.478
0.27	0.117	0.67	1.115	1.07	3.556
0.28	0.128	0.68	1.157	1.08	3.643
0.29	0.140	0.69	1.199	1.09	3.727
0.30	0.152	0.70	1.243	1.10	3.813
0.31	0.165	0.71	1.287	1.11	3.889
0.32	0.178	0.72	1.333	1.12	3.987
0.33	0.193	0.73	1.379	1.13	4.076
0.34	0.207	0.74	1.426	1.14	4.166
0.35	0.223	0.75	1.475	1.15	4.257
0.36	0.239	0.76	1.524	1.16	4.349
0.37	0.256	0.77	1.574	1.17	4.443
0.38	0.273	0.78	1.625	1.18	4.538
0.39	0.291	0.79	1.678	1.19	4.634
0.40	0.310	0.80	1.730	1.20	4.731
0.41	0.330	0.81	1.785	1.21	4.829
0.42	0.350	0.82	1.840	1.22	4.929
0.43	0.371	0.83	1.896	1.23	5.030
0.44	0.393	0.84	1.953	1.24	5.132
0.45	0.415	0.85	2.012	1.25	5.235

Equation $Q = 3.01\ Hw^{2.48}$, where Hw, head, is in feet at the weir and Q is in cubic feet per second.

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Table O-3

Minimum and Maximum Recommended Flow Rates for Cipolletti Weirs

Crest Length, ft.	Minimum Head, ft.	Minimum Flow Rate		Maximum Head, ft.	Maximum Flow Rate	
		MGD	CFS		MGD	CFS
1	0.2	0.195	0.301	0.5	0.769	1.19
1.5	0.2	0.292	0.452	0.75	2.12	3.28
2	0.2	0.389	0.602	1.0	4.35	6.73
2.5	0.2	0.487	0.753	1.25	7.60	11.8
3	0.2	0.584	0.903	1.5	12.0	18.6
4	0.2	0.778	1.20	2.0	24.6	38.1
5	0.2	0.973	1.51	2.5	43.0	66.5
6	0.2	0.17	1.81	3.0	67.8	105.0
8	0.2	0.56	2.41	4.0	139.0	214.0
10	0.2	1.95	3.01	5.0	243.0	375.0

Table O-4

Minimum and Maximum Recommended Flow Rates for Free Flow Through Parshall Flumes

Throat Width, W	Minimum Head, ft.	Minimum Flow Rate		Maximum Head, ft.	Maximum Flow Rate	
		MGD	CFS		MGD	CFS
1 in.	0.07	0.003	0.005	0.60	0.099	0.153
2 in.	0.07	0.007	0.011	0.60	0.198	0.306
3 in.	0.10	0.018	0.028	1.5	1.20	1.86
6 in.	0.10	0.035	0.054	1.5	2.53	3.91
9 in.	0.10	0.05	0.091	2.0	5.73	8.87
1 ft.	0.10	0.078	0.120	2.5	10.4	16.1
1.5 ft.	0.10	0.112	0.174	2.5	15.9	24.6
2 ft.	0.15	0.273	0.423	2.5	21.4	33.1
3 ft.	0.15	0.397	0.615	2.5	32.6	50.4
4 ft.	0.20	0.816	1.26	2.5	43.9	67.9
5 ft.	0.20	1.00	1.55	2.5	55.3	85.6
6 ft.	0.25	1.70	2.63	2.5	66.9	103
8 ft.	0.25	2.23	3.45	2.5	90.1	139
10 ft.	0.30	3.71	5.74	3.5	189	292
12 ft.	0.33	5.13	7.93	4.5	335	519

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Table O-5

Free-Flow Values of C and N for Parshall Flumes

Based on the Relationship $Q = CWH^n$
(American Petroleum Institute 1969)

Flume Throat, W		C	n	Max. Q CFS
1	in.	0.338	1.55	0.15
2	in.	0.676	1.55	0.30
3	in.	0.992	1.55	1.8
6	in.	2.06	1.58	3.9
9	in.	3.07	1.53	8.9
1	ft.	4W*	$1.522W^{0.026}$	16.1
1.5	ft.	4W*	$1.522W^{0.026}$	24.6
2	ft.	4W*	$1.522W^{0.026}$	33.1
3	ft.	4W*	$1.522W^{0.026}$	50.4
4	ft.	4W*	$1.522W^{0.026}$	67.9
5	ft.	4W*	$1.522W^{0.026}$	85.6
6	ft.	4W*	$1.522W^{0.026}$	103.5
7	ft.	4W*	$1.522W^{0.026}$	121.4
8	ft.	4W*	$1.522W^{0.026}$	139.5

Where W = Flume throat width

Q = Flow (CFS)

C = Constant

n = Constant

H = Head upstream of the flume throat (feet)

* = W should be represented in feet to calculate C

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Table O-6

Minimum and Maximum Recommended Flow Rates for Free Flow Through Plasti-Fab Palmer-Bowlus Flumes

D Flume Size (in.)	Maximum Slope for Upstream (%)	Minimum Head (ft.)	Minimum Flow Rate		Maximum Head (ft.)	Maximum Flow Rate	
			MGD	CFS		MGD	CFS
6	2.2	0.11	0.023	0.035	0.36	0.203	0.315
8	2.0	0.15	0.048	0.074	0.49	0.433	0.670
10	1.8	0.18	0.079	0.122	0.61	0.752	1.16
12	1.6	0.22	0.128	0.198	0.73	1.18	1.83
15	1.5	0.27	0.216	0.334	0.91	2.06	3.18
18	1.4	0.33	0.355	0.549	1.09	3.24	5.01
21	1.4	0.38	0.504	0.780	1.28	4.81	7.44
24	1.3	0.44	0.721	1.12	1.46	6.70	10.4
27	1.3	0.49	0.945	1.46	1.64	8.95	13.8
30	1.3	0.55	1.26	1.95	1.82	11.6	18.0

Table O-7

Coefficients of Discharge c for Venturi Meters (King 1963)

Diameter of Throat, in.	Throat Velocity, ft. per sec.								
	3	4	5	10	15	20	30	40	50
1	0.935	0.945	0.949	0.958	0.963	0.966	0.969	0.970	0.972
2	0.939	0.948	0.953	0.965	0.970	0.973	0.974	0.975	0.977
4	0.943	0.952	0.957	0.970	0.975	0.977	0.978	0.979	0.980
8	0.948	0.957	0.962	0.974	0.978	0.980	0.981	0.982	0.983
12	0.955	0.962	0.967	0.978	0.981	0.982	0.983	0.984	0.985
18	0.963	0.969	0.973	0.981	0.983	0.984	0.985	0.986	0.986
48	0.970	0.977	0.980	0.984	0.985	0.986	0.987	0.988	0.988

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Table O-8

Values of K in Formula for Venturi Meters
(King 1963)

$\frac{d^2}{d^1}$	K	$\frac{d^2}{d^1}$	K	$\frac{d^2}{d^1}$	K	$\frac{d^2}{d^1}$	K	$\frac{d^2}{d^1}$	K
0.20	6.31	0.33	6.34	0.46	6.45	0.59	6.72	0.72	7.37
0.21	6.31	0.34	6.34	0.47	6.46	0.60	6.75	0.73	7.45
0.22	6.31	0.35	6.35	0.48	6.47	0.61	6.79	0.74	7.53
0.23	6.31	0.36	6.35	0.49	6.49	0.62	6.82	0.75	7.62
0.24	6.31	0.37	6.36	0.50	6.51	0.63	6.86	0.76	7.72
0.25	6.31	0.38	6.37	0.51	6.52	0.64	6.91	0.77	7.82
0.26	6.31	0.39	6.37	0.52	6.54	0.65	6.95	0.78	7.94
0.27	6.32	0.40	6.38	0.53	6.54	0.66	7.00	0.79	8.06
0.28	6.32	0.41	6.39	0.54	6.59	0.67	7.05	0.80	8.20
0.29	6.32	0.42	6.40	0.55	6.61	0.68	7.11	0.81	8.35
0.30	6.33	0.43	6.41	0.56	6.64	0.69	7.17	0.82	8.51
0.31	6.33	0.44	6.42	0.57	6.66	0.70	7.23	0.83	8.69
0.32	6.33	0.45	6.43	0.58	6.69	0.71	7.30	0.84	8.89

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Table O-9

Advantages and Disadvantages of Secondary Devices

Device	Advantages	Disadvantages
Hook Gauge	Common	Requires training to use, easily damaged
Stage Board	Common	Needs regular cleaning, difficult to read top of meniscus
Pressure Measurement		
a. Pressure Bulb	Since no compressed air is used, source can be linked directly to sampler	Openings can clog, expensive
b. Bubbler Tube	Self-cleaning, less expensive, reliable	Needs compressed air or other air source
Float	Inexpensive, reliable	Catches debris, requires frequent cleaning to prevent sticking and changing buoyancy, and corroding hinges
Dipper	Quite reliable, easy to operate	Oil and grease foul probe, causing possible sensor loss
Ultrasonic	No electrical or mechanical contact	Errors from heavy turbulence and foam, calibration procedure is more involved than for other devices

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Figure I-1

Profile and Nomenclature of Sharp-Crested Weirs
(Associated Water and Air Resource Engineers, Inc., 1973)

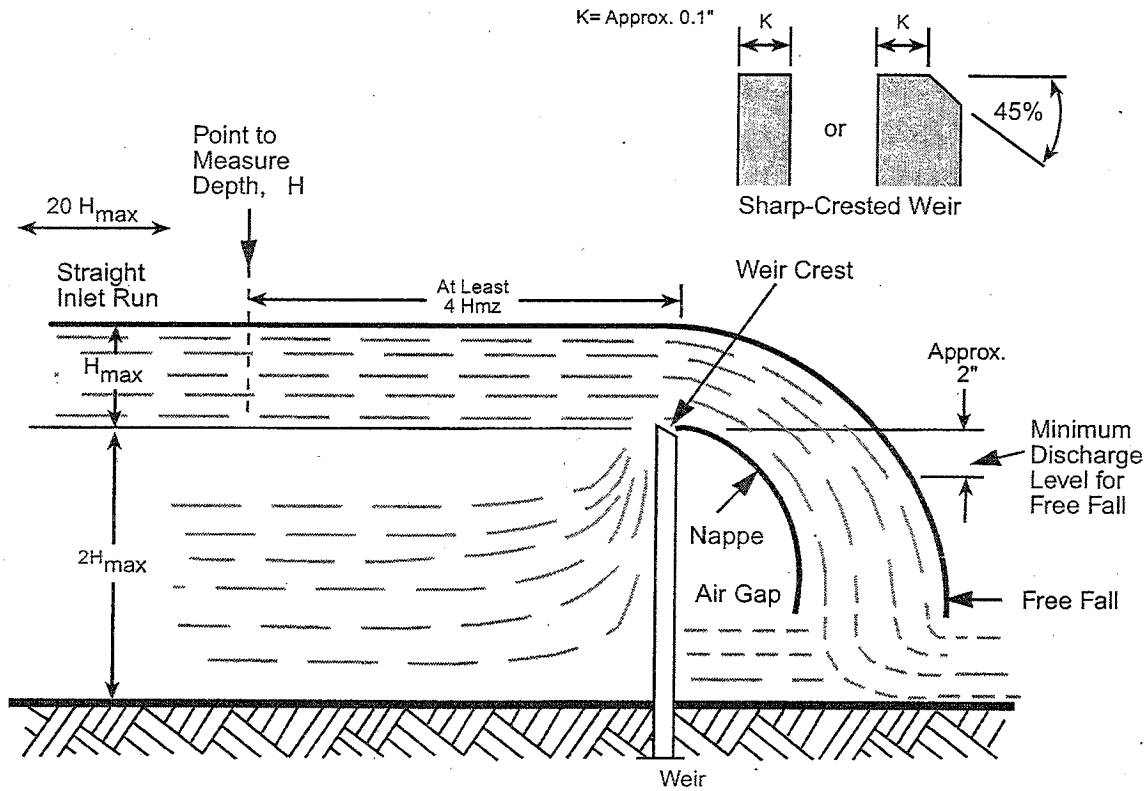

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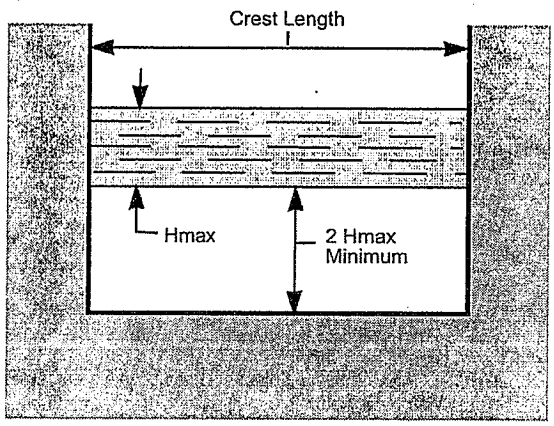
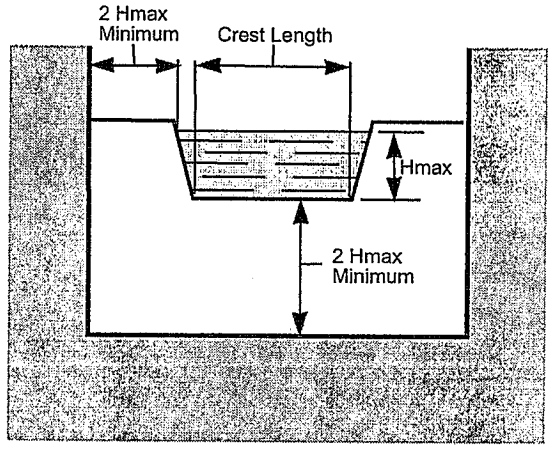
Figure I-2

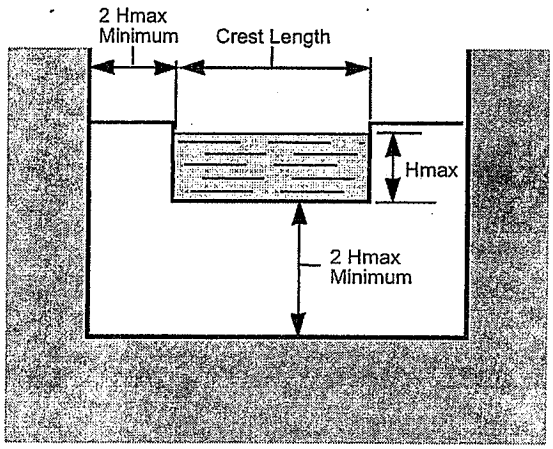
Three Common Types of Sharp-Crested Weirs
(Associated Water and Air Resource Engineers, Inc., 1973)



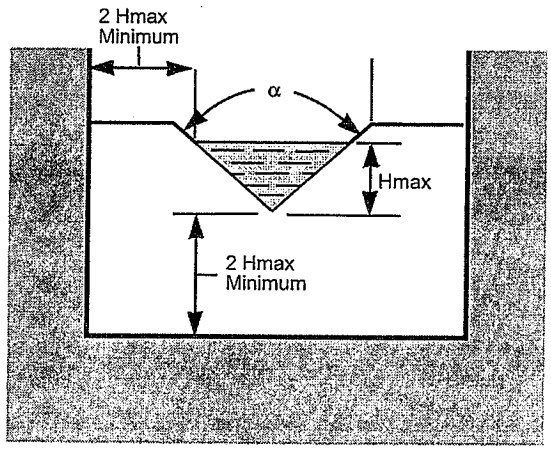
Suppressed (Without End Contractions) Rectangular Weir



Trapezoidal (Cipolletti) Sharp-Crested Weir



Contracted (With End Contractions) Rectangular Weir



V-Notch (Triangular) Sharp-Crested Weir

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Figure I-3

Flow Rates for 60° and 90° V-Notch Weirs
(Associated Water and Resource Engineers, Inc., 1973)

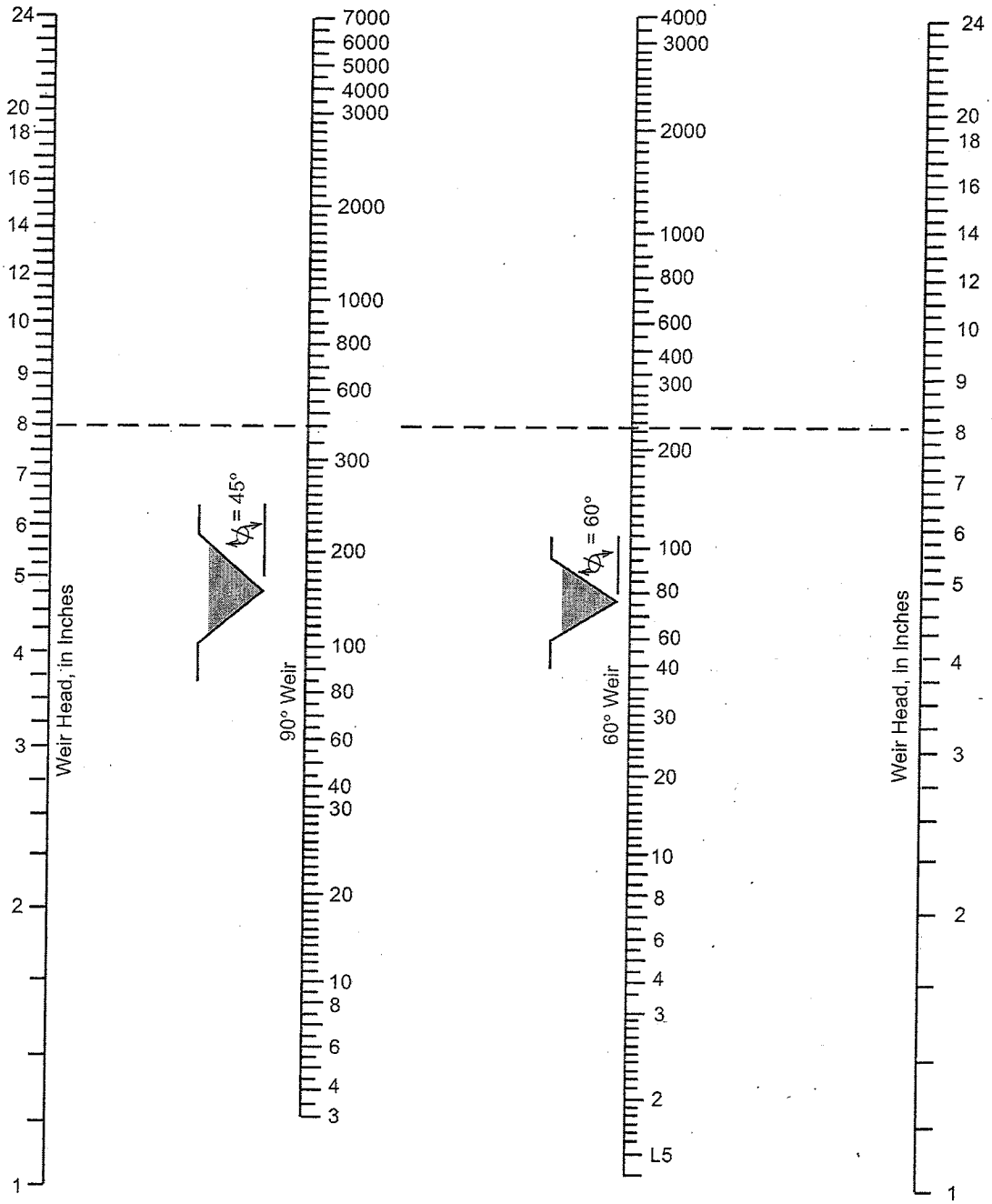

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Figure I-4

Nomograph for Capacity of Rectangular Weirs
(Associated Water and Air Resource Engineers, Inc., 1973)

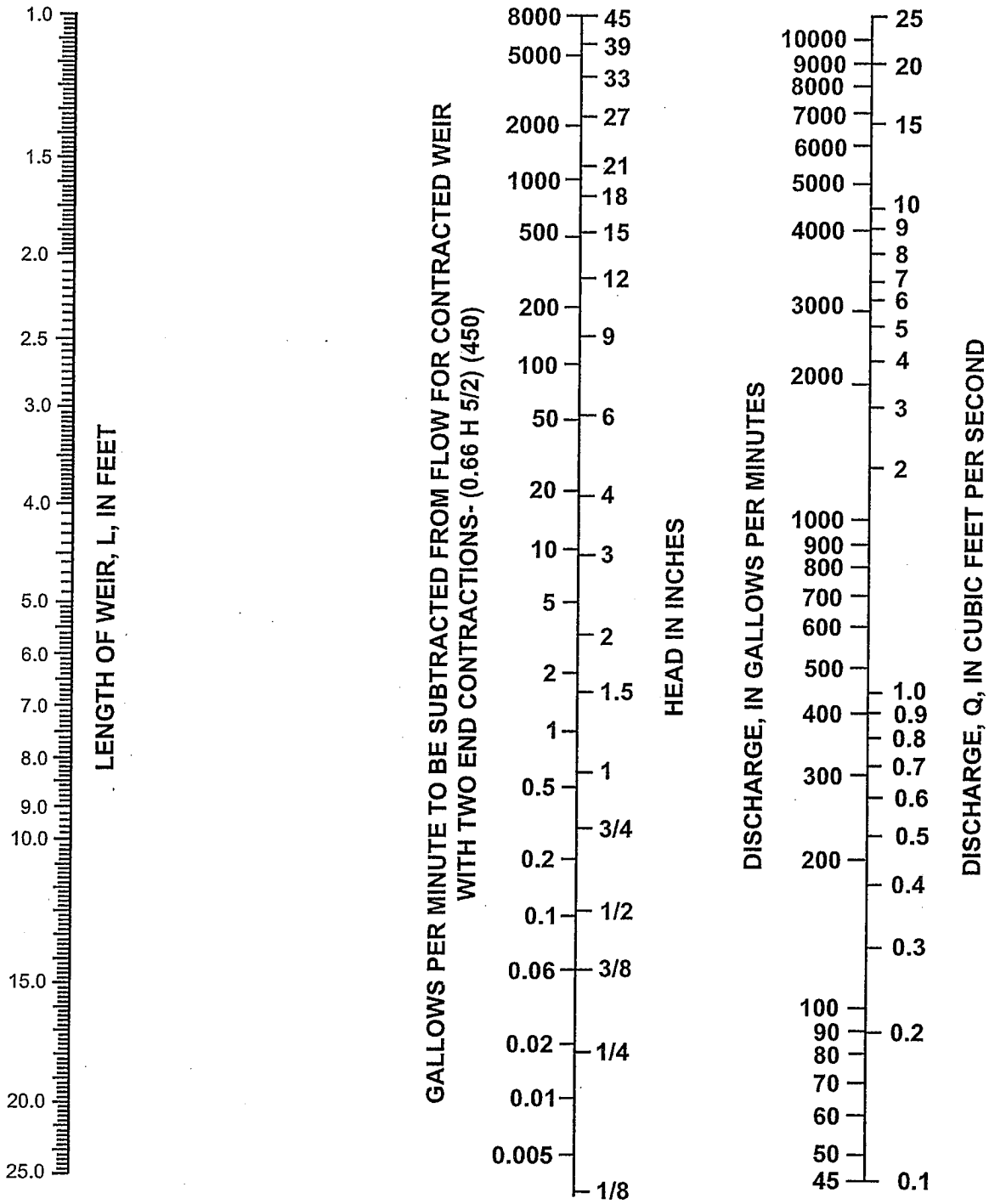

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Figure I-5

Flow Curves for Parshall Flumes
(Associated Water and Air Resource Engineers, Inc., 1973)

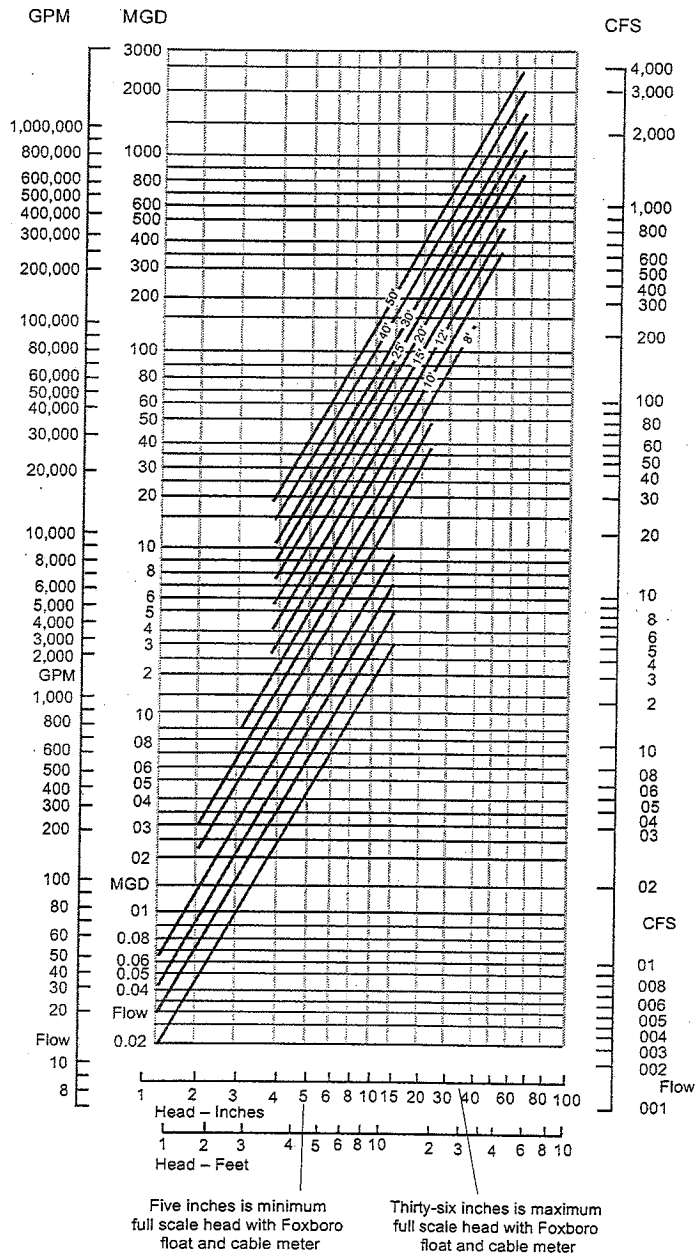

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Figure I-6

Dimensions and Capacities of Parshall Measuring Flumes for Various Throat Widths (Associated Water and Air Resource Engineers, Inc., 1973)

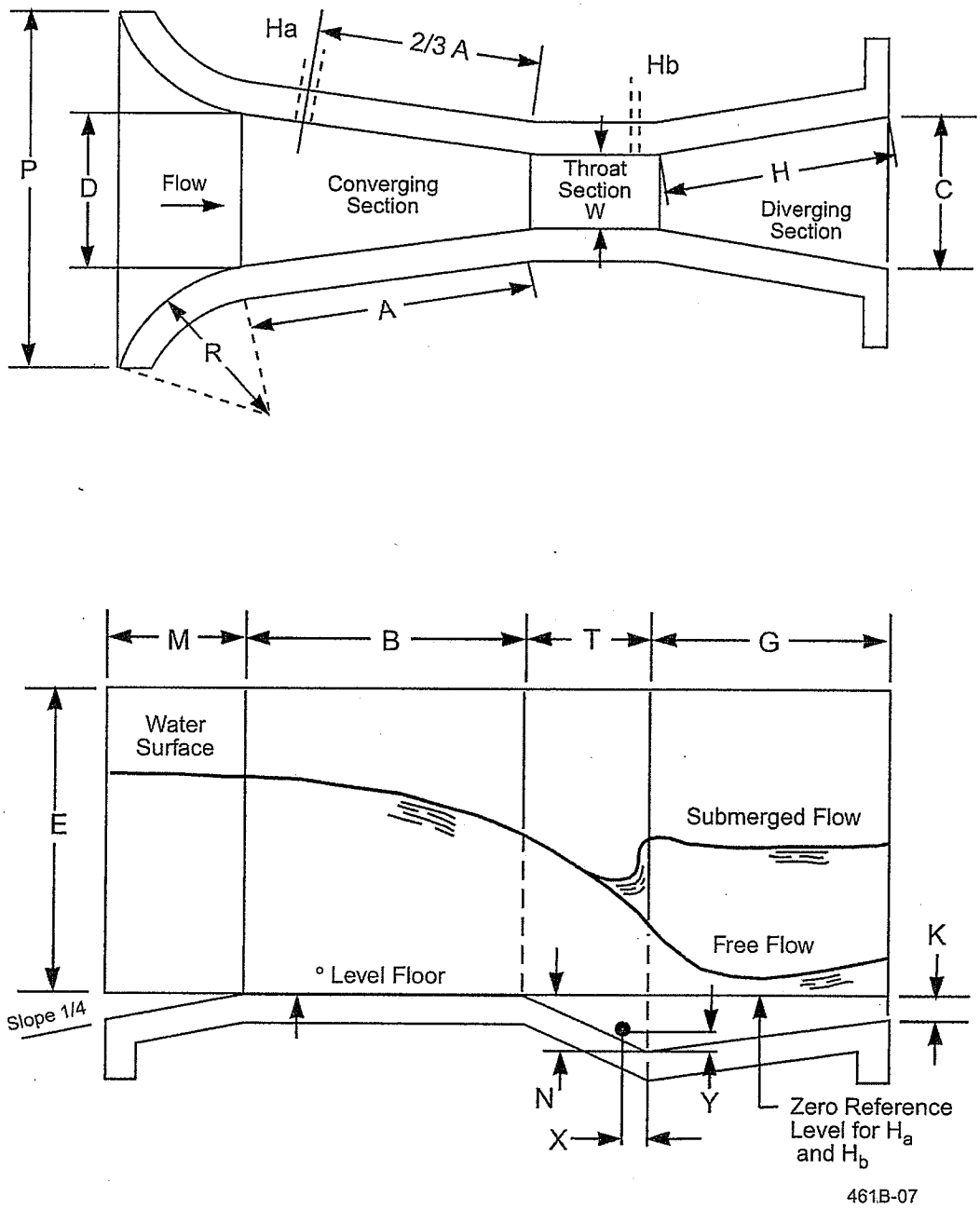

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Figure I-6
Dimensions and Capacities of Parshall Measuring Flumes for Various Throat Widths (Continued)

W		A		⅔A		B		C		D		E		T		G		H		K		M		N		P		R		X	Y	Free-Flow Capacity (Second-Foot*)	
Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	In.		Ft.	In.	In.		Ft.	In.	Ft.	In.	In.	In.	Mini-mum	Maxi-mum
0	3	1	6⅜	1	¼	1	6	0	7	0	10⅜	1-1½	0	0	6	1	0	1	5/32	1	0	0	0	2¼	0	0	0	0	1	1½	3	0.03	1.9
0	6	2	7/16	1	4 5/16	2	0	1	3½	1	3⅝	2	0	1	0	2	0	0	0	3	1	0	4½	2	11½	1	4	2	3	3	0.05	3.9
0	9	2	10⅝	1	11⅛	2	10	1	3	1	10⅝	2	6	1	0	1	6	0	0	3	1	0	4½	3	6½	1	4	2	3	3	0.09	8.9
1	0	4	6	3	0	4	4⅞	2	0	2	9¼	3	0	2	0	3	0	0	0	3	1	3	9	4	10¾	1	8	2	3	3	0.11	16.1
1	6	4	9	3	2	4	7⅞	2	6	3	4⅜	3	0	2	0	3	0	0	0	3	1	3	9	5	6	1	8	2	3	3	0.15	24.6
2	0	5	0	3	4	4	10⅞	3	0	3	11½	3	0	2	0	3	0	0	0	3	1	3	9	6	1	1	8	2	3	3	0.42	33.1
3	0	5	6	3	8	5	4¾	4	0	5	17⅛	3	0	2	0	3	0	0	0	3	1	3	9	7	3½	1	8	2	3	3	0.61	50.4
4	0	6	0	4	0	5	10⅝	5	0	6	4¼	3	0	2	0	3	0	0	0	3	1	6	9	8	10¼	2	0	2	3	3	1.30	67.9
5	0	6	6	4	4	6	4½	6	0	7	6⅝	3	0	2	0	3	0	0	0	3	1	6	9	10	1¼	2	0	2	3	3	1.60	85.6
6	0	7	0	4	8	6	10⅝	7	0	8	9	3	0	2	0	3	0	0	0	3	1	6	9	11	3½	2	0	2	3	3	2.60	103.5
7	0	7	6	5	0	7	4¼	8	0	9	11⅜	3	0	2	0	3	0	0	0	3	1	6	9	12	6	2	0	2	3	3	3.00	121.4
8	0	8	0	5	4	7	10⅛	9	0	11	1¼	3	0	2	0	3	0	0	0	3	1	6	9	13	8¼	2	0	2	3	3	3.50	139.5

*Equals 1 cu. ft. per sec.

LEGEND:

W	Width of flume throat.
A	Length of side wall of converging section.
⅔A	Distance back from end of crest to gauge point.
B	Axial length of converging section.
C	Width of downstream end of flume.
D	Width of upstream end of flume.
E	Depth of flume.
T	Length of flume throat.
G	Axial length of diverging section.
H	Length of side wall of the diverging section.
K	Difference in elevation between lower end of flume and crest.
M	Length of approach floor.
N	Depth of depression in throat below crest.
P	Width between ends of curved wing walls.
R	Radius of curved wing wall.
X	Horizontal distance to H_b gauge point from low point in throat.
Y	Vertical distance to H_b gauge point from low point in throat.

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Figure I-7

Effect of Submergence on Parshall Flume Free Discharge
(Civil Engineering, ASCE)

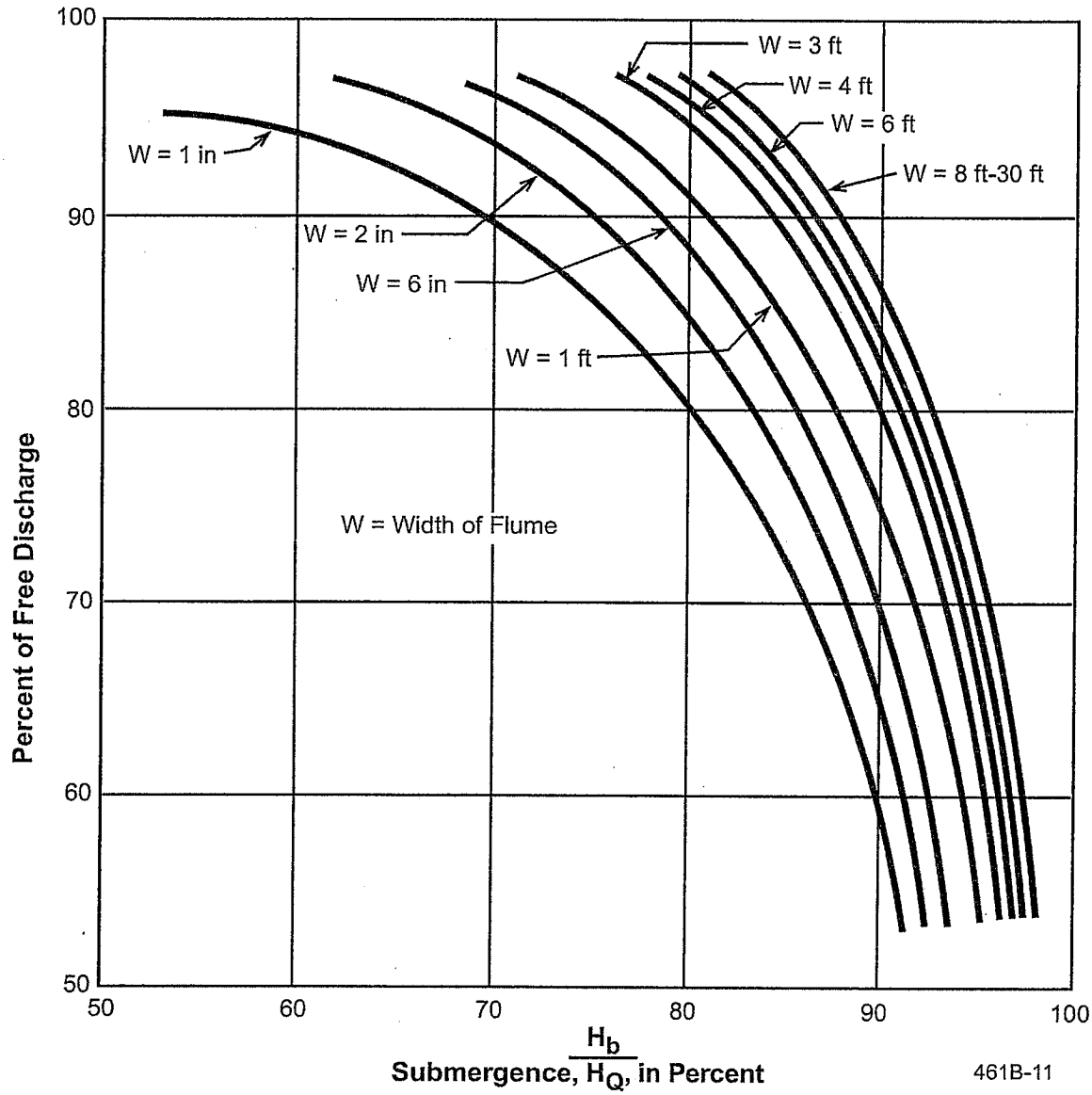

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Figure I-8

Free-Flowing Palmer-Bowlus Flume

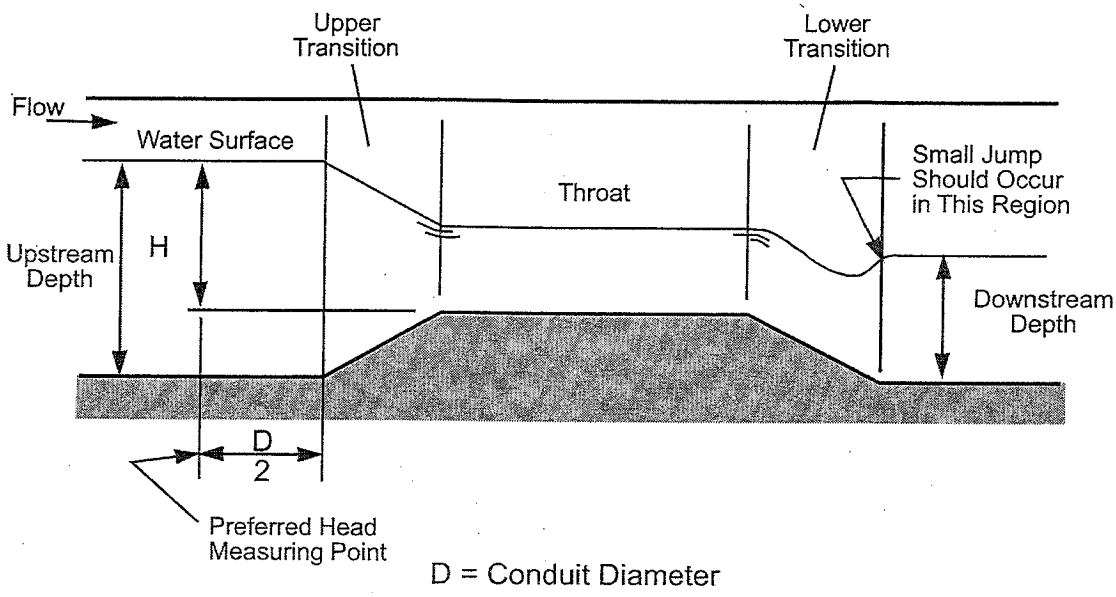

Figure I-9

Configuration and Nomenclature of Venturi Meter

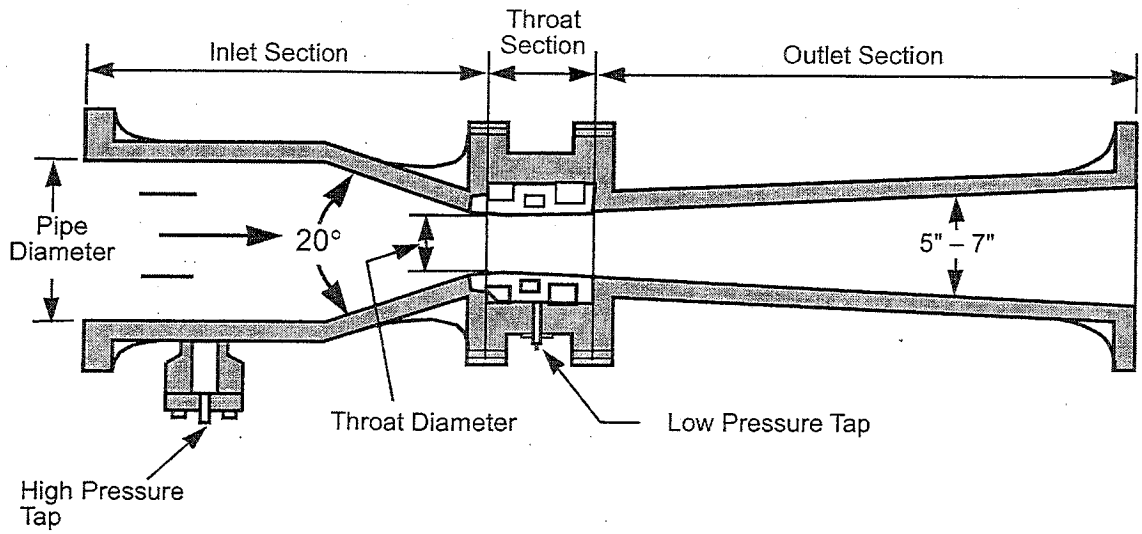

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Figure I-10

Electromagnetic Flowmeter

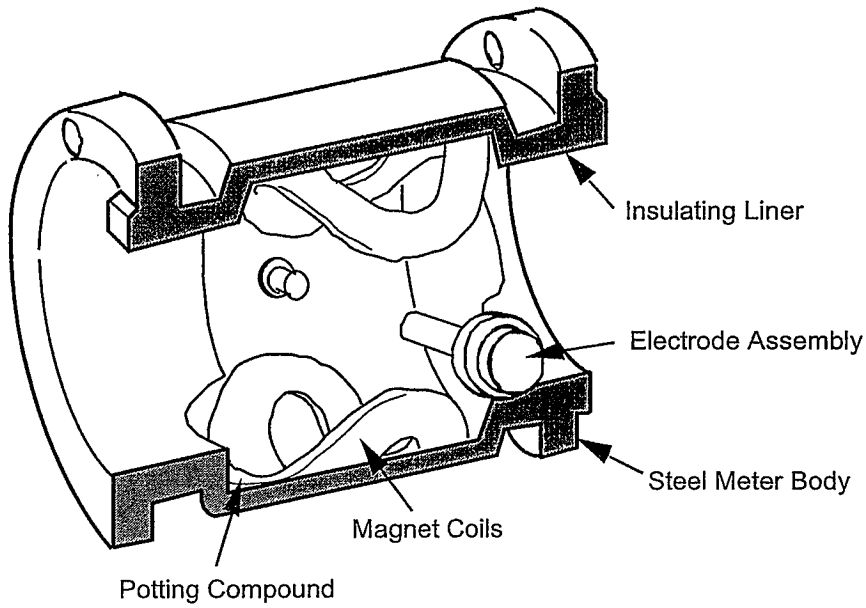

Figure I-11

Propeller Flowmeter

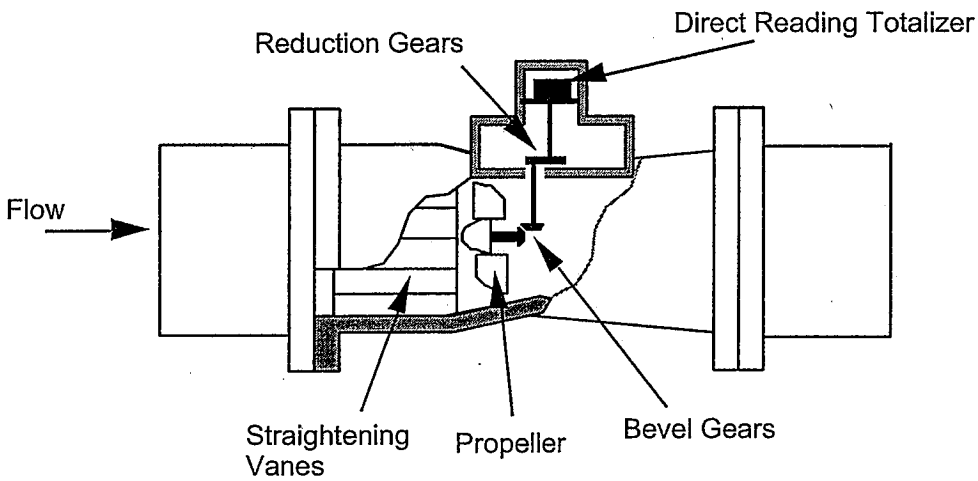

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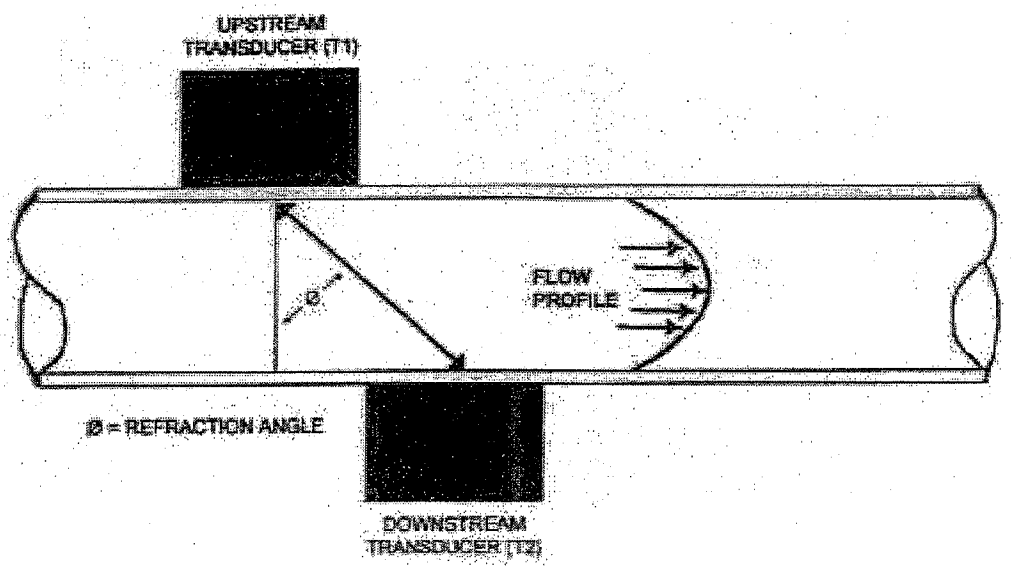
Figure I-12

Transit-Time Flowmeter



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APPENDIX P

NPDES INDUSTRIAL STORM WATER INVESTIGATION AND CASE DEVELOPMENT WORKSHEET (INDUSTRIAL)

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NPDES Industrial Storm Water Worksheet (Industrial)

Background Information *(complete in field)*

National Database Information

Inspection Type	W		
NPDES ID Number			
Inspection Date			
Inspector Type	EPA	State	EPA Oversight
Facility Type			

General

Inspector Name	
Telephone	
Entry Time	
Exit Time	
Signature	

Facility Location Information

Name/Location/ Mailing Address				
GPS Coordinates	Latitude		Longitude	
Receiving Water(s)/MS4's				

Contact Information

	Name	Telephone
Owner/Permittee		
Operator		
Co-Permittee		
Facility Contact		
Authorized Official(s)		

Site Information:

Industrial Activity that qualifies the facility for permit coverage	
SIC Code(s)	

Basic Permit Information *(circle one)*

Permit Coverage	Y	N
Permit Type	General	Individual
Copy of NOI on site?	Y	N
NOI Date		

Basic SWPPP Information

SWPPP on site	Y	N
SWPPP Satisfactory*	Y	N
SWPPP Implementation Satisfactory	Y	N

*A Satisfactory SWPPP must be both current and complete (see pages 4, 5, and 6 of this checklist).

A011108

NPDES Industrial Storm Water Worksheet (Industrial)

SWPPP Implementation *(complete in field)*

General

Industrial Activity	*(describe principal product, production rate, potential pollutants, areas exposed to precipitation, direction of storm water flow)*
Facility Description	*(describe age and size of facility, number of employees, hours of operation)*

Storm Water Controls

List the structural and non-structural controls employed by the facility.	*(provide a brief description of each)*
Are the controls reasonable and appropriate for the facility?	*(indicate "yes" or "no", or if not appropriate, explain)*
Are the controls installed correctly and maintained in effective operating condition?	*(indicate "yes" or "no", or if not appropriate, explain)*

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NPDES Industrial Storm Water Worksheet (Industrial)

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NPDES Industrial Storm Water Worksheet (Industrial)

SWPPP Implementation *(continued)*

Storm Water Controls (continued)

Provide a brief description of other controls that manage/prevent/ minimize storm water runoff.	*(e.g., erosion and sediment controls, exposure minimization, diversion structures, pollution prevention, inlet protection/control at storm drains)*

Miscellaneous

Any evidence of discharge to receiving waters?	*(e.g., storm water runoff, dry weather discharge, co-mingling of process waste water)*
Do the storm water outfalls on site correspond with those listed on the site map and in SWPPP?	*(indicate "yes" or "no", or if not appropriate, explain)*

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NPDES Industrial Storm Water Worksheet (Industrial)

SWPPP Review *(can be completed in office)*

General			Notes:
Is there a SWPPP?	Y	N	
Is a copy of the SWPPP on site?	Y	N	
Did all "operators" and co-permittees sign the SWPPP?	Y	N	
Did the signatures include the certification statement?	Y	N	
Were the signatories authorized to sign?	Y	N	
Is an individual/team responsible for developing/implementing SWPPP identified (e.g., pollution prevention team)?	Y	N	
Are employee training records regarding storm water pollution prevention topics included in SWPPP?	Y	N	
Operator evaluation of ESA requirements.	Y	N	

Site Map			Notes:
Is there a site map?	Y	N	
Drainage patterns/ outfalls?	Y	N	
Identification of types of pollutants likely to be discharged from each drainage area?	Y	N	
Location of major structural controls used to reduce pollutants in runoff?	Y	N	
Name of receiving water(s) or MS4's listed?	Y	N	
Is receiving water a tributary to waters of the U.S. (if "yes" indicate name of tributary)?	Y	N	
Location of significant materials exposed to storm water?	Y	N	
Locations of major spills occurring within 3 years from date of NOI?	Y	N	
Location of fueling, maintenance, loading and unloading, material storage, waste disposal?	Y	N	

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NPDES Industrial Storm Water Worksheet (Industrial)

SWPPP Review (*continued*)

Summary of Potential Pollutant Sources			Notes:
Description of activities, materials, features of site with potential to contribute significant amounts of pollutants to storm water?	Y	N	

Significant Spills & Leaks			Notes:
List of significant spills and leaks over 3 year time period, description of response taken, and actions to prevent similar spills in the future?	Y	N	

Storm Water Controls			Notes:
Does the SWPPP describe the *non-structural* controls that will be used to prevent/reduce discharge of pollutants in storm water runoff?	Y	N	
Does the SWPPP describe the *structural* controls that will be used to prevent/reduce discharge of pollutants in storm water runoff?	Y	N	
Does the SWPPP describe other controls that will be used to prevent/reduce off-site tracking or blowing of sediment, dust and raw, final or waste materials, or other solid materials and floating debris?	Y	N	
Does the SWPPP incorporate the 8 baseline controls (good housekeeping, minimizing exposure, PM, spill prevention/response procedures, routine inspections and comprehensive site evaluations, employee training, sediment and erosion control, runoff management)?	Y	N	
Does the SWPPP contain completed routine inspection reports/logs regarding reportable implementation of 8 baseline controls?	Y	N	
Does the SWPPP describe the pollutant or activity to be controlled by each selected control and provide an implementation schedule?	Y	N	

NPDES Industrial Storm Water Worksheet (Industrial)

Non-Storm Water Discharges			Notes:
Certification that facility has been tested for non-storm water discharges from the site?	Y	N	
Description of testing method, drainage points, observed results, and date of test?	Y	N	

Monitoring			Notes:
Are samples collected within 30 minutes of measurable weather events occurring 72 hours after previous measurable weather event?	Y	N	
Were the samples collected and preserved in accordance with 40 CFR 136?			
Was proper chain-of-custody procedures followed?			

Photograph Log

1.
2.
3.
4.

A0111114

APPENDIX Q

INDUSTRIAL SOURCE CONTROL BMP QUESTIONS

Industrial Source Control BMP Questions

FUELING

1. Has spill and overfill prevention equipment been installed?
2. Are vehicle fuel tanks often "topped off"?
3. Have steps been taken to protect fueling areas from rain?
4. Is runon to the fueling area minimized?
5. Are oil/water separators or oil and grease traps installed in storm drains in the fueling area?
6. Is the fueling area cleaned by hosing or washing?
7. Do you control petroleum spills?
8. Are employees aware of ways to reduce contamination of storm water at fueling stations?
9. Where does the water drain from the fueling area?
10. Do any of the drains connect to wells?

SUMMARY OF FUELING STATION BMPs
• Consider installing spill and overflow protection. • Discourage topping off of fuel tanks. • Reduce exposure of the fuel area to storm water. • Use dry cleanup methods for the fuel area. • Use proper petroleum spill control. • Encourage employee participation.

MAINTAINING VEHICLES AND EQUIPMENT

1. Is maintenance which involves cleaning of vehicle and/or equipment parts (including engine, transmission, brake or other miscellaneous parts) performed on-site?
2. Does the cleaning involve the use of solvents or surfactants?
3. Has the facility looked into using nontoxic or less toxic cleaners or solvents?
4. Are work areas and spills washed or hosed down with water?
5. Are spills or materials washed or poured down the drain?
6. Are oil filters completely drained before recycling or disposal?
7. Are incoming vehicles and equipment checked for leaking oil and fluids?
8. Are wrecked vehicles or damaged equipment stored onsite?
9. Does the facility recycle any of the automotive fluids or parts?
10. Can the facility reduce the number of different solvents used?
11. Are wastes separated?
12. Does the facility use recycled products?

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SUMMARY OF VEHICLE MAINTENANCE AND REPAIR BMPs
• Check for leaking oil and fluids. • Use nontoxic or low-toxicity materials. • Drain oil filters before disposal or recycling. • Do not pour liquid waste down drains. • Recycle engine fluids and batteries. • Segregate and label wastes. • Buy recycled products.

PAINTING VEHICLES AND EQUIPMENT

1. Are vehicles or other equipment painted on site?
2. In preparation for painting, is old paint removed physically (sanding, sand blasting, etc.) or chemically (solvent paint stripper)?
3. Before applying new paint, are surfaces chemically prepared (coating, etching, cleaning etc.)?
4. Is care taken to prevent paint wastes from contaminating storm water runoff?
5. Are wastes from sanding contained?
6. Are parts inspected before painting?
7. Is the facility using painting equipment that creates little waste?
8. Are employees trained to use spray equipment correctly?
9. Does the facility recycle paint, paint thinner, or solvents?
10. Are wastes separated?
11. Can the facility reduce the number of solvents used?
12. Does the facility use recycled products?

SUMMARY OF PAINTING OPERATION BMPs
• Inspect parts prior to painting. • Contain sanding wastes. • Prevent paint waste from contacting storm water. • Use proper interim storage of waste paint, solvents, etc. • Evaluate efficiency of equipment. • Recycle paint, paint thinner, and solvents. • Segregate wastes. • Buy recycled products.

WASHING VEHICLES AND EQUIPMENT

1. Has the facility considered using phosphate-free biodegradable detergents?
2. Are vehicles, equipment, or parts washed over the open ground?

SUMMARY OF VEHICLE AND EQUIPMENT WASHING BMPs
• Consider use of phosphate-free detergent. • Use designated cleaning areas. • Consider recycling wash water.

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LOADING AND UNLOADING MATERIALS

1. Are tank trucks and material delivery vehicles located where spills or leaks can be contained?
2. Is loading/unloading equipment checked regularly for leaks?
3. Are loading/unloading docks or areas covered to prevent exposure to rainfall?
4. Are loading/unloading areas designed to prevent storm water runon?
5. Is piping system routinely checked for leaks?
6. Are there alarms to alert staff of potential problems such as high levels in receiving tanks or pressure irregularities in transmission lines?
7. Where appropriate (especially where transmission lines are long or buried), is the piping system outfitted with flow meters to ensure that the amount unloaded equals the amount received?

SUMMARY OF LOADING/UNLOADING OPERATIONS BMPs
• Contain leaks during transfer. • Check equipment regularly for leaks. • Limit exposure of material to rainfall. • Prevent storm water runon.

LIQUID STORAGE IN ABOVE-GROUND TANKS

1. Do storage tanks contain liquid hazardous materials, hazardous wastes, or oil?
2. Are operators trained in correct operating procedures and safety activities?
3. Does the facility have safeguards against accidental discharge?
4. Are tank systems inspected, and is tank integrity tested regularly?
5. Are tanks bermed or surrounded by a secondary containment system?

SUMMARY OF BMPs FOR LIQUID STORAGE IN ABOVE-GROUND TANKS
• Comply with applicable State and Federal laws. • Properly train employees. • Install safeguards against accidental release. • Routinely inspect tanks and equipment. • Consider installing secondary containment.

INDUSTRIAL WASTE MANAGEMENT AND OUTSIDE MANUFACTURING

1. Has the facility looked for ways to reduce waste at the facility?
2. Has the facility considered waste reduction BMPs?
3. Are industrial waste management and outside manufacturing areas checked often for spills and leaks?
4. Are industrial waste management areas or manufacturing activities covered, enclosed, or

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bermed?
5. Are vehicles used to transport wastes to the land disposal or treatment site equipped with anti-spill equipment?
6. Does the facility use loading systems that minimize spills and fugitive losses such as dust or mists?
7. Are sediments or wastes prevented from being tracked offsite?
8. Is storm water runoff minimized from the land disposal site?

SUMMARY OF INDUSTRIAL WASTE MANAGEMENT AND OUTSIDE MANUFACTURING BMPs
• Conduct a waste reduction assessment. • Institute industrial waste source reduction and recycling BMPs. • Prevent runoff and runon from contacting the waste management area. • Minimize runoff from land application sites.

OUTSIDE STORAGE OF RAW MATERIALS, BY-PRODUCTS, OR FINISHED PRODUCTS

1. Are materials protected from rainfall, runon, and runoff?

SUMMARY OF BMPs FOR OUTSIDE STORAGE OF RAW MATERIALS, BY-PRODUCTS, OR FINISHED PRODUCTS
• Cover or enclose materials.

SALT STORAGE

1. Are salt piles protected from rain?
2. Is storm water runon prevented from contacting storage piles and loading and unloading areas?

SUMMARY OF SALT STORAGE FACILITIES BMPs
• Put salt under a roof. • Use temporary covers. • Enclose or berm transfer areas.

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APPENDIX R

NPDES INDUSTRIAL STORM WATER INVESTIGATION AND CASE DEVELOPMENT WORKSHEET (CONSTRUCTION)

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NPDES Industrial Storm Water Worksheet (Construction)

National Database Information

Inspection Type			
NPDES ID Number			
Inspection Date			
Inspector Type *(circle one)*	EPA	State	EPA Oversight
Facility Type *(circle one)*	Commercial/ Industrial	Residential	Municipal

General

Inspector Name	
Telephone	
Entry Time	
Exit Time	
Signature	

Facility Location Information

Name/Location/ Mailing Address					
GPS Coordinates	Latitude		Longitude		
Receiving Water(s)					
Disturbed Area		Start Date		Stop Date	

Contact Information

	Name(s)	Telephone
Name(s) and Role(s) of All Parties Meeting the Definition of Operator		
Facility Contact		
Authorized Official(s)		

Site Information: *(circle all that apply)*

Nature of Project	Residential	Commercial/ Industrial	Roadway	Private	Federal	State/ Municipal	Other
Construction Stage	Clearing/ Grubbing	Rough Grading	Infrastructure	Building Const.	Final Grading	Final Stabilization	

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NPDES Industrial Storm Water Worksheet (Construction)

Basic Permit Information

Permit Coverage *ESO Element 3 & 4*	Y	N
Permit Type	General	Individual
Permit notice/sign visibly posted including: copy of NOI, contact name & phone number, location of SWPPP *ESO Element 41*	Y	N
NOI Date		
If applicable, is waiver certification & approval on file?	Y	N

Basic SWPPP Information

SWPPP Prepared & Available *ESO Element 5 & 30*	Y	N
SWPPP Contents Satisfactory *ESO Elements 5 - 31*	Y	N
SWPPP Implementation Satisfactory *ESO Elements 32 - 48*	Y	N
SWPPP Date		
Intentionally left blank		

SWPPP Review *(can be completed in office)*

General			Notes:
Is there a SWPPP? *ESO Element 5*	Y	N	
SWPPP completed prior to NOI submission? *ESO Element 6*	Y	N	
Copy of permit language? *ESO Element 25*	Y	N	
Is SWPPP consistent with state/tribal/local regulations and permits? *ESO Element 26*	Y	N	
SWPPP updated to incorporate changes to State, Tribal, Local erosion plans? *ESO Element 27*	Y	N	
Have copies of inspection reports/all other documentation been retained as part of the SWPPP for 3 years from date permit coverage expires? *ESO Element 28*	Y	N	
Is a copy of the SWPPP on site or made available? *ESO Element 30*	Y	N	
Did all "operators" sign/certify the SWPPP? *ESO Element 31*	Y	N	

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NPDES Industrial Storm Water Worksheet (Construction)

Site Description			Notes:
SWPPP identifies potential sources of pollution? *ESO Element 7*	Y	N	
SWPPP identifies all operators and their areas of control? *ESO Element 8*	Y	N	
Is there a site description? *ESO Element 9*	Y	N	
Nature/sequence of construction activity? *ESO Element 9A - 9B*	Y	N	
Total area of site and total area to be disturbed? *ESO Element 9C*	Y	N	
Is there a general location map? *ESO Element 9D*	Y	N	
Is there a site map? *ESO Element 9E*	Y	N	
Drainage patterns/outfalls on site map? *ESO Element 9F*	Y	N	
Area of soil disturbance on site map? *ESO Element 9F*	Y	N	
Location of major structural controls on site map? *ESO Element 9F*	Y	N	
Location of storm water discharges to a surface water on site map? *ESO Element 9F*	Y	N	
Location of materials or equipment storage on site map (on-site or off-site)? *ESO Element 9F*	Y	N	
Location/description industrial activities? *ESO Element 9G*	Y	N	
Name of Receiving water(s) or MS4 listed?	Y	N	*Note: Indicate whether receiving water is 303(d) listed.*

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NPDES Industrial Storm Water Worksheet (Construction)

Site Description			Notes:
Does the SWPPP include dates of major grading activities, temporary/permanent construction cessation, and initiation of stabilization practices? *ESO Element 14*	Y	N	
Endangered Species Documentation? *ESO Element 23*	Y	N	

Controls to Reduce Pollutants			Notes:
Does the SWPPP include a description of all pollution control measures (BMPs) that will be implemented to control pollutants in storm water discharges, including sequence and which operator responsible for implementation? *ESO Element 10A - C*	Y	N	
Does the SWPPP include a description of interim and permanent *stabilization practices* (e.g., seeding, mulching, riprap for the site)? *ESO Element 11; 12*	Y	N	
Does the SWPPP identify the contractor(s) and timing by which *stabilization practices* will be implemented? *ESO Element 13*	Y	N	
Does the SWPPP include a description of *structural practices* (e.g., vehicle track-out, silt fences, sediment traps, storm drain inlet protection) for the site? *ESO Element 15*	Y	N	
Does the SWPPP identify the contractor(s) and timing by which *structural practices* will be implemented? *ESO Element 10B - 10C*	Y	N	
Does the SWPPP identify storm water management measures to address storm water runoff once the construction is completed (e.g., retention ponds, velocity dissipation controls)? *ESO Element 16*	Y	N	

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NPDES Industrial Storm Water Worksheet (Construction)

Controls to Reduce Pollutants			Notes:
Does SWPPP describe measures to prevent discharge of dredge/fill materials to waters of the U.S.? Does site have 404 permit? *ESO Element 17*	Y	N	
Does SWPPP describe measures to minimize off-site vehicle tracking and generation of dust? *ESO Element 18*	Y	N	
Does SWPPP describe controls for pollutants from storage of construction or waste materials? *ESO Element 19*	Y	N	
Does the SWPPP describe controls for pollutants from non-construction activities? *ESO Element 20*	Y	N	
Does SWPPP identify allowable non-storm water discharges? *ESO Element 21*	Y	N	
Does SWPPP ensure implementation of pollution prevention measures for non-storm water discharges? *ESO Element 22*	Y	N	
Is SWPPP revised when BMPs added/modified within 7 days after inspection reveals problems? *ESO Element 29*	Y	N	

Inspections			Notes:
Inspections performed once every 7 days, or every 14 days within 24 hours of a rain event greater 0.5"? *ESO Element 32*	Y	N	
Inspections performed by qualified personnel? *ESO Element 33*	Y	N	
All disturbed areas and/or used for storage and exposed to rain inspected? *ESO Element 34*	Y	N	
All pollution control measures inspected to ensure proper operation? *ESO Element 35*	Y	N	

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NPDES Industrial Storm Water Worksheet (Construction)

Inspections			Notes:
All discharge locations inspected if accessible, or if not accessible, are nearby downstream locations inspected? *ESO Element 36; 37*	Y	N	
Entrance/exit inspected for off-site tracking? *ESO Element 38*	Y	N	
Inspection report contain all required items and certified? *ESO Element 39; 40*	Y	N	

Site Description:

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NPDES Industrial Storm Water Worksheet (Construction)

SWPPP Implementation *(complete in field)*

Stabilization Practices

List and describe stabilization practices *ESO Element 43, 48*	*(e.g., seeding, mulching, geotextiles, sod stabilization)*

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NPDES Industrial Storm Water Worksheet (Construction)

Stabilization Practices

Are stabilization measures initiated no more than 14 days after temporary or permanent construction cessation? *ESO Element 46*	*(e.g., indicate "yes" or "no"; if "yes", how long without stabilization measures?)*

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NPDES Industrial Storm Water Worksheet (Construction)

Structural Practices

List and describe structural controls *ESO Element 42, 43, 47*	*(e.g., silt fences, hay bales, storm drain inlet protection, sedimentation pond, rip rap, check dam, diversion structure, off-site vehicle track-out)*

Non-Structural Practices

Street Cleaning *ESO Element 44*	*(e.g., describe measures taken to remove offsite accumulation of sediment)*

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NPDES Industrial Storm Water Worksheet (Construction)

Non-Structural Practices

Good Housekeeping & Waste Disposal Practices *ESO Element 45*	*(e.g., describe measures taken to prevent litter and debris from becoming a pollutant source)*
Equipment Wash/ Maintenance Area *ESO Elements 43*	*(provide brief description)*
Concrete Washout Areas *ESO Elements 43*	*(provide brief description)*

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NPDES Industrial Storm Water Worksheet (Construction)

Miscellaneous

Evidence of Sediment Deposition to Surface Waters **ESO Eligibility - if "yes," site not eligible for ESO*	*(e.g., significant turbidity observed in a receiving water body)*
Pollution prevention measures for non-storm water discharges? **ESO Eligibility - If evidence of non-allowable non-storm water discharges, site not eligible for ESO*	*(provide brief description and determine whether/if non-storm water discharges allowable)*
Has implementation of additional/modified BMPs been completed before next anticipated storm event? *ESO Element 43.C.1*	*(provide brief description)*

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NPDES Industrial Storm Water Worksheet (Construction)

Notes on SWPPP Implementation

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NPDES Industrial Storm Water Worksheet (Construction)

Photograph Log

1.	*Insert additional rows as needed

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APPENDIX S

CONSTRUCTION SOURCE CONTROL BMP QUESTIONS

Construction Source Control BMP Questions

SOIL EROSION AND SEDIMENT CONTROL PRACTICES

MINIMIZE THE AMOUNT OF DISTURBED SOIL

1. Does the site plan require a significant amount of grade changes?
2. Are there portions of the site that do not have to be cleared for construction to proceed?
3. Can construction be performed in stages, so that the entire site does not have to be cleared at one time?
4. Are there portions of the site that will be disturbed then left alone for long periods of time?
5. Does the facility stabilize all disturbed areas after construction is complete?
6. Does snow prevent the facility from seeding an area?
7. Is there enough rainfall to allow vegetation to grow?

PREVENT RUNON FROM FLOWING ACROSS DISTURBED AREAS

1. Does runoff from the undisturbed uphill areas flow onto the construction site?
2. Will runoff flow down a steeply sloped, disturbed area on the site?
3. Is there a swale or stream that runs through the construction site?
4. Does construction traffic have to cross drainage swales or streams?

SLOW DOWN THE RUNOFF TRAVELING ACROSS THE SITE

1. Is the site gently sloped?
2. Is the site stabilized with vegetation?
3. Does runoff concentrate into drainage swales on the site?

REMOVE SEDIMENT FROM ONSITE RUNOFF BEFORE IT LEAVES THE SITE

1. Does the construction disturb an area 10 acres or larger that drains to a common location?
2. Is a sediment basin attainable on the site?
3. Does runoff leave the disturbed area as overland flow?
4. Is the flow concentrated in channels as it leaves the disturbed areas?
5. Are structural controls located along the entire downhill perimeter of all disturbed areas?
6. Is there a piped storm drain system with inlets in a disturbed area?

MEET OR EXCEED LOCAL/STATE REQUIREMENTS FOR EROSION AND SEDIMENT CONTROL

1. Does the State or local government require erosion and sediment control for construction projects?
2. Does the State or local government have an erosion and sediment control requirement that is different from the requirements of the NPDES storm water permit?

OTHER CONTROLS

GOOD HOUSEKEEPING

1. Does the facility appear to implement good housekeeping practices?

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WASTE DISPOSAL

1. What steps are taken to ensure that construction waste is properly disposed of?
2. What management practices are used to minimize or prevent impacts on storm water from hazardous products on the construction site?
3. Are concrete trucks allowed to washout or dump onsite?
4. Is sandblasting performed at the site? If so, what is done with the used grit?

MINIMIZING OFFSITE VEHICLE TRACKING OF SEDIMENTS

1. What measures have been taken to prevent offsite vehicle tracking?

SANITARY/SEPTIC DISPOSAL

1. How are sanitary or septic wastes managed?
2. How does the facility demonstrate compliance with State or local sanitary or septic system regulations?

MATERIAL MANAGEMENT

1. What types of materials are found on the construction site?
2. How are these materials managed?
3. What risks are present onsite as a result of material management practices?
4. Is the facility implementing any methods to reduce potential risks from material management?
5. If applicable, how are pesticides managed at the site?
6. If applicable, how are petroleum products managed at the site?
7. If applicable, what steps are taken to reduce nutrient pollution from fertilizers and detergents?

SPILLS

1. Does the facility have a spill control plan for the site?
2. Does the facility know what spill prevention methods and responses will be used?

CONTROL OF ALLOWABLE NON-STORM WATER DISCHARGES

1. What non-storm water discharges are present at the site?
2. How does the facility manage the non-storm water discharges?
3. How are allowable non-storm water discharges addressed in the storm water Pollution Prevention Plan?

4. What types of controls or practices are used to prevent pollution from non-storm water discharges?
5. What types of controls are used for discharges that have sediments?

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APPENDIX T

NOI FORM FOR STORMWATER

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This Form Replaces Form 3510-9 (8-98)
Refer to the Following Pages for Instructions

Form Approved OMB Nos. 2040-0188 and 2040-0211

NPDES Form

United States Environmental Protection Agency
Washington, DC 20460

Notice of Intent (NOI) for Storm Water Discharges Associated with Construction Activity Under an NPDES General Permit

Submission of this Notice of Intent (NOI) constitutes notice that the party identified in Section II of this form requests authorization to discharge pursuant to the NPDES Construction General Permit (CGP) permit number identified in Section I of this form. Submission of this NOI also constitutes notice that the party identified in Section II of this form meets the eligibility requirements of the CGP for the project identified in Section III of this form. Permit coverage is required prior to commencement of construction activity until you are eligible to terminate coverage as detailed in the CGP. To obtain authorization, you must submit a complete and accurate NOI form. Refer to the instructions at the end of this form.

I. Permit Number

II. Operator Information

Name:

IRS Employer Identification Number (EIN): -

Mailing Address:

Street:

City: State: Zip Code: -

Phone: - - Fax (optional): - -

E-mail (optional):

III. Project/Site Information

Project/Site Name:

Project Street/Location:

City: State: Zip Code: -

County or similar government subdivision:

Latitude/Longitude (Use one of three possible formats, and specify method)

Latitude 1. _° _′ _″ N (degrees, minutes, seconds) Longitude 1. _° _′ _″ W (degrees, minutes, seconds)
2. _° _ _ . _′ N (degrees, minutes, decimal) 2. _ _ _° . _′ W (degrees, minutes, decimal)
3. . _° N (decimal) 3. . _° W (decimal)

Method: U.S.G.S. topographic map ☐ EPA web site ☐ GPS ☐ Other:
• If you used a U.S.G.S. topographic map, what was the scale:

Project Located in Indian country? ☐ Yes ☐ No
If so, name of Reservation or if not part of a Reservation, put "Not Applicable":

Estimated Project Start Date: / / Estimated Project Completion Date: / /
Month Date Year Month Date Year

Estimated Area to be Disturbed (to the nearest quarter acre):

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IV. SWPPP Information

Has the SWPPP been prepared in advance of filing this NOI? ☐ Yes ☐ No

Location of SWPPP for viewing: ☐ Address in Section II ☐ Address in Section III ☐ Other

If Other:

SWPPP Street:

City:

State: Zip Code: -

SWPPP Contact Information (if different than that in Section II):

Name:

Phone: ____ - - Fax (optional): ____ - -

E-mail (optional):

V. Discharge Information

Identify the name(s) of waterbodies to which you discharge. _____

_____

Is this discharge consistent with the assumptions and requirements of applicable EPA approved or established TMDL(s)?

☐ Yes ☐ No

VI. Endangered Species Information

Under which criterion of the permit have you satisfied your ESA eligibility obligations?

☐ A ☐ B ☐ C ☐ D ☐ E ☐ F

- If you select criterion F, provide permit tracking number of operator under which you are certifying eligibility:

VII. Certification Information

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Print Name: _____

Print Title: _____

Signature: _____

Date: _____

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Instructions for Completing EPA Form 3510-9

Notice of Intent (NOI) for Storm Water Discharges Associated with Construction Activity Under an NPDES General Permit

NPDES Form | This Form Replaces Form 3510-9 (8/98) | Form Approved OMB Nos. 2040-0188 and 2040-0211

Who Must File an NOI Form

Under the provisions of the Clean Water Act, as amended (33 U.S.C. 1251 et.seq.; the Act), federal law prohibits storm water discharges from certain construction activities to waters of the U.S. unless that discharge is covered under a National Pollutant Discharge Elimination System (NPDES) Permit. Operator(s) of construction sites where one or more acres are disturbed, smaller sites that are part of a larger common plan of development or sale where there is a cumulative disturbance of at least one acre, or any other site specifically designated by the Director, must submit an NOI to obtain coverage under an NPDES general permit. Each person, firm, public organization, or any other entity that meets either of the following criteria must file this form: (1) they have operational control over construction plans and specifications, including the ability to make modifications to those plans and specifications; or (2) they have day-to-day operational control of those activities at the project necessary to ensure compliance with SWPPP requirements or other permit conditions. If you have questions about whether you need an NPDES storm water permit, or if you need information to determine whether EPA or your state agency is the permitting authority, refer to *www.epa.gov/npdes/stormwater/cgp* or telephone the Storm Water Notice Processing Center at (866) 352-7755.

Where to File NOI Form

See the applicable CGP for information on where to send your completed NOI form.

Completing the Form

Obtain and read a copy of the appropriate EPA Storm Water Construction General Permit for your area. To complete this form, type or print, using uppercase letters, in the appropriate areas only. Please place each character between the marks (abbreviate if necessary to stay within the number of characters allowed for each item). Use one space for breaks between words, but not for punctuation marks unless they are needed to clarify your response. If you have any questions on this form, refer to *www.epa.gov/npdes/stormwater/cgp* or telephone the Storm Water Notice Processing Center at (866) 352-7755. Please submit original document with signature in ink - do not send a photocopied signature.

Section I. Permit Number

Provide the number of the permit under which you are applying for coverage (see Appendix B of the general permit for the list of eligible permit numbers).

Section II. Operator Information

Provide the legal name of the person, firm, public organization, or any other entity that operates the project described in this application. An operator of a project is a legal entity that controls at least a portion of site operations and is not necessarily the site manager. Provide the employer identification number (EIN from the Internal Revenue Service; IRS), also commonly referred to as your taxpayer ID. If the applicant does not have an EIN enter "NA" in the space provided. Also provide the operator's mailing address, telephone number, fax number (optional) and e-mail address (if you would like to be notified via e-mail of NOI approval when available). Correspondence for the NOI will be sent to this address.

Section III. Project/Site Information

Enter the official or legal name and complete street address, including city, state, zip code, and county or similar government subdivision of the project or site. If the project or site lacks a street address, indicate the general location of the site (e.g., Intersection of State Highways 61 and 34). Complete site information must be provided for permit coverage to be granted.

The applicant must also provide the latitude and longitude of the facility either in degrees, minutes, seconds; degrees, minutes, decimal; or decimal format. The latitude and longitude of your facility can be determined in several different ways, including through the use of global positioning system (GPS) receivers, U.S. Geological Survey (U.S.G.S.) topographic or quadrangle maps, and EPA's web-based siting tools, among others. Refer to *www.epa.gov/npdes/stormwater/cgp* for further guidance on the use of these methodologies. For consistency, EPA requests that measurements be taken from the approximate center of the construction site. Applicants must specify which method they used to determine latitude and longitude. If a U.S.G.S. topographic map is used, applicants are required to specify the scale of the map used.

Indicate whether the project is in Indian country, and if so, provide the name of the Reservation. If the project is in Indian Country Lands that are not part of a Reservation, indicate "not applicable" in the space provided.

Enter the estimated construction start and completion dates using four digits for the year (i.e., 05/27/1998). Enter the estimated area to be disturbed including but not limited to: grubbing, excavation, grading, and utilities and infrastructure installation. Indicate to the nearest quarter acre. Note: 1 acre = 43,560 sq. ft.

Section IV. SWPPP Information

Indicate whether or not the SWPPP was prepared in advance of filing the NOI form. Check the appropriate box for the location where the SWPPP may be viewed. Provide the name,

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Instructions for Completing EPA Form 3510-9

Notice of Intent (NOI) for Storm Water Discharges Associated with Construction Activity Under an NPDES General Permit

NPDES Form | This Form Replaces Form 3510-9 (8/98) | Form Approved OMB Nos. 2040-0188 and 2040-0211

fax number (optional), and e-mail address (optional) of the contact person if different than that listed in Section II of the NOI form.

Section V. Discharge Information

Enter the name(s) of receiving waterbodies to which the project's storm water will discharge. These should be the first bodies of water that the discharge will reach. (Note: If you discharge to more than one waterbody, please indicate all such waters in the space provided and attach a separate sheet if necessary.) For example, if the discharge leaves your site and travels through a roadside swale or a storm sewer and then enters a stream that flows to a river, the stream would be the receiving waterbody. Waters of the U.S. include lakes, streams, creeks, rivers, wetlands, impoundments, estuaries, bays, oceans, and other surface bodies of water within the confines of the U.S. and U.S. coastal waters. Waters of the U.S. do not include man-made structures created solely for the purpose of wastewater treatment. U.S. Geological Survey topographical maps may be used to make this determination. If the map does not provide a name, use a format such as "unnamed tributary to Cross Creek". If you discharge into a municipal separate storm sewer system (MS4), you must identify the waterbody into which that portion of the storm sewer discharges. That information should be readily available from the operator of the MS4.

Indicate whether your storm water discharges from construction activities will be consistent with the assumptions and requirements of applicable EPA approved or established TMDL(s). To answer this question, refer to *www.epa.gov/npdes/stormwater/cgp* for state- and regional-specific TMDL information related to the construction general permit. You may also have to contact your EPA regional office or state agency. If there are no applicable TMDLs or no related requirements, please check the "yes" box in the NOI form.

Section VI. Endangered Species Information

Indicate for which criterion (i.e., A, B, C, D, E, or F) of the permit the applicant is eligible with regard to protection of federally listed endangered and threatened species, and designated critical habitat. See Part 1.3.C.6 and Appendix C of the permit. If you select criterion F, provide the permit tracking number of the operator under which you are certifying eligibility. The permit tracking number is the number assigned to the operator by the Storm Water Notice Processing Center after EPA acceptance of a complete NOI.

Section VII. Certification Information

All applications, including NOIs, must be signed as follows:

For a corporation: By a responsible corporate officer. For the purpose of this Section, a responsible corporate officer means: (i) a president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy- or decision-making functions for the corporation, or (ii) the manager of one or more manufacturing, production, or operating facilities, provided, the manager is authorized to make management decisions which govern the operation of the regulated facility including having the explicit or implicit duty of making major capital investment recommendations, and initiating and directing other comprehensive measures to assure long-term environmental compliance with environmental laws and regulations; the manager can ensure that the necessary systems are established or actions taken to gather complete and accurate information for permit application requirements; and where authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures.

For a partnership or sole proprietorship: By a general partner or the proprietor, respectively; or

For a municipality, state, federal, or other public agency: By either a principal executive officer or ranking elected official. For purposes of this Part, a principal executive officer of a federal agency includes (i) the chief executive officer of the agency, or (ii) a senior executive officer having responsibility for the overall operations of a principal geographic unit of the agency (e.g., Regional Administrator of EPA).

Include the name and title of the person signing the form and the date of signing. An unsigned or undated NOI form will not be considered eligible for permit coverage.

Paperwork Reduction Act Notice

Public reporting burden for this application is estimated to average 3.7 hours. This estimate includes time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number. Send comments regarding the burden estimate, any other aspect of the collection of information, or suggestions for improving this form, including any suggestions which may increase or reduce this burden to: Chief, Information Policy Branch 2136, U.S. Environmental Protection, Agency, 1200 Pennsylvania Avenue, NW, Washington, D.C. 20460. Include the OMB control number on any correspondence. Do not send the completed form to this address.

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APPENDIX U

RAIN ZONES OF THE UNITED STATES

Figure U-1

Rain Zones of the United States

Table U-1

Typical Values of Annual Storm Event Statistics for Rain Zones

Rain Zone	Annual Statistics				Independent Storm Event Statistics							
	No. of Storms		Precip		Duration		Intensity		Volume		DELTA	
	Avg	COV	Avg	COV	Avg	COV	Avg	COV	Avg	COV	Avg	COV
			(in)		(hrs)		(in/hr)		(in)		(hr)	
North East	70	0.13	34.6	0.18	11.2	0.81	0.067	1.23	0.50	0.95	126	0.94
North East-Coastal	63	0.12	41.4	0.21	11.7	0.77	0.071	1.05	0.65	1.03	140	0.87
Midatlantic	62	0.13	39.5	0.18	10.1	0.84	0.082	1.20	0.64	1.01	143	0.97
Central	66	0.14	41.9	0.19	9.2	0.85	0.097	1.09	0.62	1.00	133	0.99
North Central	55	0.16	29.8	0.22	9.5	0.83	0.067	1.20	0.55	1.01	167	1.17
Southeast	65	0.15	49.0	0.20	8.7	0.92	0.122	1.09	0.75	1.10	136	1.03
East Gulf	68	0.17	53.7	0.23	6.4	1.05	0.176	1.03	0.80	1.19	130	1.25
East Texas	41	0.22	31.2	0.29	8.0	0.97	0.137	1.08	0.76	1.16	213	1.26
West Texas	30	0.27	17.3	0.33	7.4	0.98	0.121	1.13	0.57	1.07	302	1.53
Southwest	20	0.30	7.4	0.37	7.6	0.88	0.079	1.16	0.37	0.88	473	1.46
West Inland	14	0.38	4.9	0.43	9.4	0.75	0.055	1.06	0.36	0.87	766	1.54
Pacific South	19	0.36	10.2	0.42	11.6	0.76	0.054	0.76	0.54	0.96	476	2.09
Northwest Inland	31	0.23	11.5	0.29	10.4	0.82	0.057	1.20	0.37	0.83	304	1.43
Pacific Central	32	0.25	18.4	0.33	13.7	0.80	0.048	0.85	0.58	1.05	265	2.00
Pacific Northwest	71	0.15	56.7	0.19	15.9	0.80	0.035	0.73	0.50	1.09	123	1.50

COV - Coefficient of Variation - Standard Deviation / Mean DELTA - Interval between storm midpoints

A011144

APPENDIX V

TYPICAL "c" COEFFICIENTS

TYPICAL "c" COEFFICIENTS FOR 5- TO 10-YEAR FREQUENCY DESIGN STORMS

Description of Area	Runoff Coefficients
Business	
• Downtown areas	0.70-0.95
• Neighborhood areas	0.50-0.70
Residential	
• Single-family areas	0.30-0.50
• Multi-units (detached)	0.40-0.60
• Multi-units (attached)	0.60-0.75
Residential (suburban)	0.25-0.40
Apartment dwelling areas	0.50-0.70
Industrial	
• Light areas	0.50-0.80
• Heavy areas	0.60-0.90
Parks and cemeteries	0.10-0.25
Playgrounds	0.20-0.35
Railroad yard areas	0.20-0.40
Unimproved areas	0.10-0.30
Streets	
• Asphalt	0.70-0.95
• Concrete	0.80-0.95
• Brick	0.70-0.85
Drives and walks	0.75-0.85
Roofs	0.75-0.95
Lawns—course textured soil (greater than 85 percent sand)	
• Slope: Flat (2 percent)	0.05-0.10
Average (2-7 percent)	0.10-0.15
Steep (7 percent)	0.15-0.20
Lawns—fine textured soil (greater than 40 percent clay)	
• Slope: Flat (2 percent)	0.13-0.17
Average (2-7 percent)	0.18-0.22
Steep (7 percent)	0.25-0.35

Source: *Design and Construction of Sanitary and Storm Sewers*, with permission from the publisher, American Society of Civil Engineers, *Manual of Practice*, page 37, New York, 1960.

A011146

APPENDIX W

NOTICE OF TERMINATION FOR STORMWATER

A011147

THIS FORM REPLACES FORM 3517-7 (8-98)
Refer to the Following Page for Instructions

Form Approved OMB Nos. 2040-0086 and 2040-0211

NPDES FORM

United States Environmental Protection Agency
Washington, DC 20460

Notice of Termination (NOT) of Coverage Under an NPDES General Permit for Storm Water Discharges Associated with Construction Activity

Submission of this Notice of Termination constitutes notice that the party identified in Section II of this form is no longer authorized to discharge storm water associated with construction activity under the NPDES program from the site identified in Section III of this form. All necessary information must be included on this form. Refer to the instructions at the end of this form.

I. Permit Information

NPDES Storm Water General Permit Tracking Number:

Reason for Termination (Check only one):

- ☐ Final stabilization has been achieved on all portions of the site for which you are responsible.
- ☐ Another operator has assumed control, according to Appendix G, Section 11.C of the CGP, over all areas of the site that have not been finally stabilized.
- ☐ Coverage under an alternative NPDES permit has been obtained.
- ☐ For residential construction only, temporary stabilization has been completed and the residence has been transferred to the homeowner.

II. Operator Information

Name:

IRS Employer Identification Number (EIN): -

Mailing Address:

Street:

City: State: Zip Code: -

Phone: - - Fax (optional): - -

E-mail (optional):

III. Project/Site Information

Project/Site Name:

Project Street/Location:

City: State: Zip Code: -

County or similar government subdivision: _____

IV. Certification Information

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Print Name: _____

Print Title: _____

Signature: _____

Date: _____

AB11148

Instructions for Completing EPA Form 3510-13
Notice of Termination (NOT) of Coverage Under an NPDES General Permit for Storm Water Discharges Associated with Construction Activity

NPDES Form | This Form Replaces Form 3517-7 (8-98) | Form Approved OMB Nos. 2040-0086 and 2040-0211

Who May File an NOT Form
Permittees who are presently covered under the EPA-issued National Pollutant Discharge Elimination System (NPDES) General Permit for Storm Water Discharges Associated with Construction Activity may submit an NOT form when final stabilization has been achieved on all portions of the site for which you are responsible; another operator has assumed control in accordance with Appendix G, Section 11.C of the General Permit over all areas of the site that have not been finally stabilized; coverage under an alternative NPDES permit has been obtained; or for residential construction only, temporary stabilization has been completed and the residence has been transferred to the homeowner.

"Final stabilization" means that all soil disturbing activities at the site have been completed and that a uniform perennial vegetative cover with a density of at least 70% of the native background vegetative cover for the area has been established on all unpaved areas and areas not covered by permanent structures, or equivalent permanent stabilization measures (such as the use of riprap, gabions, or geotextiles) have been employed. See "final stabilization" definition in Appendix A of the Construction General Permit for further guidance where background native vegetation covers less than 100 percent of the ground, in arid or semi-arid areas, for individual lots in residential construction, and for construction projects on land used for agricultural purposes.

Completing the Form
Type or print, using uppercase letters, in the appropriate areas only. Please place each character between the marks. Abbreviate if necessary to stay within the number of characters allowed for each item. Use only one space for breaks between words, but not for punctuation marks unless they are needed to clarify your response. If you have any questions about this form, refer to *www.epa.gov/npdes/stormwater/cgp* or telephone the Storm Water Notice Processing Center at (866) 352-7755. Please submit original document with signature in ink - do not send a photocopied signature.

Section I. Permit Number
Enter the existing NPDES Storm Water General Permit Tracking Number assigned to the project by EPA's Storm Water Notice Processing Center. If you do not know the permit tracking number, refer to *www.epa.gov/npdes/stormwater/cgp* or contact the Storm Water Notice Processing Center at (866) 352-7755.

Indicate your reason for submitting this Notice of Termination by checking the appropriate box. Check only one:

Final stabilization has been achieved on all portions of the site for which you are responsible.

Another operator has assumed control according to Appendix G, Section 11.C over all areas of the site that have not been finally stabilized.

Coverage under an alternative NPDES permit has been obtained.

For residential construction only, if temporary stabilization has been completed and the residence has been transferred to the homeowner.

Section II. Operator Information
Provide the legal name of the person, firm, public organization, or any other entity that operates the project described in this application and is covered by the permit tracking number identified in Section I. The operator of the project is the legal entity that controls the site operation, rather than the site manager. Provide the employer identification number (EIN from the Internal Revenue Service; IRS). If the applicant does not have an EIN enter "NA" in the space provided. Enter the complete mailing address and telephone number of the operator. *Optional:* enter the fax number and e-mail address of the operator.

Section III. Project/Site Information
Enter the official or legal name and complete street address, including city, state, zip code, and county or similar government subdivision of the project or site. If the project or site lacks a street address, indicate the general location of the site (e.g., Intersection of State Highways 61 and 34). Complete site information must be provided for termination of permit coverage to be valid.

Section IV. Certification Information
All applications, including NOIs, must be signed as follows:
For a corporation: By a responsible corporate officer. For the purpose of this Part, a responsible corporate officer means: (i) a president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy- or decision-making functions for the corporation, or (ii) the manager of one or more manufacturing, production, or operating facilities, provided, the manager is authorized to make management decisions which govern the operation of the regulated facility including having the explicit or implicit duty of making major capital investment recommendations, and initiating and directing other comprehensive measures to assure long-term environmental compliance with environmental laws and regulations; the manager can ensure that the necessary systems are established or actions taken to gather complete and accurate information for permit application requirements; and where authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures.

For a partnership or sole proprietorship: By a general partner or the proprietor, respectively; or

For a municipality, state, federal, or other public agency: By either a principal executive officer or ranking elected official. For purposes of this Part, a principal executive officer of a federal agency includes (i) the chief executive officer of the agency, or (ii) a senior executive officer having responsibility for the overall operations of a principal geographic unit of the agency (e.g., Regional Administrator of EPA).

Include the name and title of the person signing the form and the date of signing. An unsigned or undated NOT form will not be considered valid termination of permit coverage.

Paperwork Reduction Act Notice
Public reporting burden for this application is estimated to average 0.5 hours per notice, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number. Send comments regarding the burden estimate, any other aspect of the collection of information, or suggestions for improving this form including any suggestions which may increase or reduce this burden to: Chief, Information Policy Branch, 2136, U.S. Environmental Protection Agency, 1200 Pennsylvania Avenue, NW, Washington, DC 20460. Include the OMB number on any correspondence. Do not sent the completed form to this address.

A011149

APPENDIX X

NO EXPOSURE CERTIFICATION FORM

NPDES FORM 3510-11

United States Environmental Protection Agency
Washington, DC 20460

Form Approved
OMB No. 2040-0211

NO EXPOSURE CERTIFICATION for Exclusion from NPDES Storm Water Permitting

Submission of this No Exposure Certification constitutes notice that the entity identified in Section A does not require permit authorization for its storm water discharges associated with industrial activity in the State identified in Section B under EPA's Storm Water Multi-Sector General Permit due to the existence of a condition of no exposure.

A condition of no exposure exists at an industrial facility when all industrial materials and activities are protected by a storm resistant shelter to prevent exposure to rain, snow, snowmelt, and/or runoff. Industrial materials or activities include, but are not limited to, material handling equipment or activities, industrial machinery, raw materials, intermediate products, by-products, final products, or waste products. Material handling activities include the storage, loading and unloading, transportation, or conveyance of any raw material, intermediate product, final product or waste product. A storm resistant shelter is not required for the following industrial materials and activities:

- drums, barrels, tanks, and similar containers that are tightly sealed, provided those containers are not deteriorated and do not leak. "Sealed" means banded or otherwise secured and without operational taps or valves;
- adequately maintained vehicles used in material handling; and
- final products, other than products that would be mobilized in storm water discharges (e.g., rock salt).

A No Exposure Certification must be provided for each facility qualifying for the no exposure exclusion. In addition, the exclusion from NPDES permitting is available on a facility-wide basis only, not for individual outfalls. If any industrial activities or materials are or will be exposed to precipitation, the facility is not eligible for the no exposure exclusion.

By signing and submitting this No Exposure Certification form, the entity in Section A is certifying that a condition of no exposure exists at its facility or site, and is obligated to comply with the terms and conditions of 40 CFR 122.26(g).

ALL INFORMATION MUST BE PROVIDED ON THIS FORM.

Detailed instructions for completing this form and obtaining the no exposure exclusion are provided on pages 3 and 4.

A. Facility Operator Information

1. Name: _____ 2. Phone: _____
3. Mailing Address: a. Street: _____
   b. City: _____ c. State: ____ d. Zip Code: _____

B. Facility/Site Location Information

1. Facility Name: _____
2. a. Street Address: _____
   b. City: _____ c. County: _____
   d. State: ____ e. Zip Code: _____
3. Is the facility located on Indian Lands? Yes ☐ No ☐
4. Is this a Federal facility? Yes ☐ No ☐
5. a. Latitude: ____ ° ____ ' ____ " b. Longitude: ____ ° ____ ' ____ "
6. a. Was the facility or site previously covered under an NPDES storm water permit? Yes ☐ No ☐
   b. If yes, enter NPDES permit number: _____
7. SIC/Activity Codes: Primary: ____ Secondary (if applicable): ____
8. Total size of site associated with industrial activity: _____ acres
9. a. Have you paved or roofed over a formerly exposed, pervious area in order to qualify for the no exposure exclusion? Yes ☐ No ☐
   b. If yes, please indicate approximately how much area was paved or roofed over. Completing this question does not disqualify you for the no exposure exclusion. However, your permitting authority may use this information in considering whether storm water discharges from your site are likely to have an adverse impact on water quality, in which case you could be required to obtain permit coverage.

   Less than one acre ☐ One to five acres ☐ More than five acres ☐

A011151

C. Exposure Checklist

Are any of the following materials or activities exposed to precipitation, now or in the foreseeable future? (Please check either "Yes" or "No" in the appropriate box.) **If you answer "Yes" to any of these questions (1) through (11), you are not eligible for the no exposure exclusion.**

	Yes	No
1. Using, storing or cleaning industrial machinery or equipment, and areas where residuals from using, storing or cleaning industrial machinery or equipment remain and are exposed to storm water	☐	☐
2. Materials or residuals on the ground or in storm water inlets from spills/leaks	☐	☐
3. Materials or products from past industrial activity	☐	☐
4. Material handling equipment (except adequately maintained vehicles)	☐	☐
5. Materials or products during loading/unloading or transporting activities	☐	☐
6. Materials or products stored outdoors (except final products intended for outside use [e.g., new cars] where exposure to storm water does not result in the discharge of pollutants)	☐	☐
7. Materials contained in open, deteriorated or leaking storage drums, barrels, tanks, and similar containers	☐	☐
8. Materials or products handled/stored on roads or railways owned or maintained by the discharger	☐	☐
9. Waste material (except waste in covered, non-leaking containers [e.g., dumpsters])	☐	☐
10. Application or disposal of process wastewater (unless otherwise permitted)	☐	☐
11. Particulate matter or visible deposits of residuals from roof stacks and/or vents not otherwise regulated (i.e., under an air quality control permit) and evident in the storm water outflow	☐	☐

D. Certification Statement

I certify under penalty of law that I have read and understand the eligibility requirements for claiming a condition of "no exposure" and obtaining an exclusion from NPDES storm water permitting.

I certify under penalty of law that there are no discharges of storm water contaminated by exposure to industrial activities or materials from the industrial facility or site identified in this document (except as allowed under 40 CFR 122.26(g)(2)).

I understand that I am obligated to submit a no exposure certification form once every five years to the NPDES permitting authority and, if requested, to the operator of the local municipal separate storm sewer system (MS4) into which the facility discharges (where applicable). I understand that I must allow the NPDES permitting authority, or MS4 operator where the discharge is into the local MS4, to perform inspections to confirm the condition of no exposure and to make such inspection reports publicly available upon request. I understand that I must obtain coverage under an NPDES permit prior to any point source discharge of storm water from the facility.

Additionally, I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is to the best of my knowledge and belief true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Print Name: |_|_|_|

NPDES FORM 3510-11

Instructions for the NO EXPOSURE CERTIFICATION for Exclusion from NPDES Storm Water Permitting

Form Approved OMB No. 2040-0211

Who May File a No Exposure Certification

Federal law at 40 CFR Part 122.26 prohibits point source discharges of storm water associated with industrial activity to waters of the U.S. without a National Pollutant Discharge Elimination System (NPDES) permit. However, NPDES permit coverage is not required for discharges of storm water associated with industrial activities identified at 40 CFR 122.26(b)(14)(i)-(ix) and (xi) if the discharger can certify that a condition of "no exposure" exists at the industrial facility or site.

Storm water discharges from construction activities identified in 40 CFR 122.26(b)(14)(x) and (b)(15) are not eligible for the no exposure exclusion.

Obtaining and Maintaining the No Exposure Exclusion

This form is used to certify that a condition of no exposure exists at the industrial facility or site described herein. This certification is only applicable in jurisdictions where EPA is the NPDES permitting authority and must be re-submitted at least once every five years.

The industrial facility operator must maintain a condition of no exposure at its facility or site in order for the no exposure exclusion to remain applicable. If conditions change resulting in the exposure of materials and activities to storm water, the facility operator must obtain coverage under an NPDES storm water permit immediately.

Where to File the No Exposure Certification Form

No Exposure Forms sent regular mail:

SW No Exposure Certification (4203M)
USEPA
1200 Pennsylvania Avenue, NW
Washington, D.C. 20460

Forms sent overnight/express:

SW No Exposure Certification
US EPA East Building, Rm. 7329
1201 Constitution Avenue, NW
Washington, D.C. 20004
(202) 564-9537

Completing the Form

You must type or print, using uppercase letters, in appropriate areas only. Enter only one character per space (i.e., between the marks). Abbreviate if necessary to stay within the number of characters allowed for each item. Use one space for breaks between words. One form must be completed for each facility or site for which you are seeking to certify a condition of no exposure. Additional guidance on completing this form can be accessed through EPA's web site at www.epa.gov/owm/sw. Please make sure you have addressed all applicable questions and have made a photocopy for your records before sending the completed form to the above address.

Section A. Facility Operator Information

1. Provide the legal name of the person, firm, public organization, or any other entity that operates the facility or site described in this certification. The name of the operator may or may not be the same as the name of the facility. The operator is the legal entity that controls the facility's operation, rather than the plant or site manager.
2. Provide the telephone number of the facility operator.
3. Provide the mailing address of the operator (P.O. Box numbers may be used). Include the city, state, and zip code. All correspondence will be sent to this address.

Section B. Facility/Site Location Information

1. Enter the official or legal name of the facility or site.
2. Enter the complete street address (if no street address exists, provide a geographic description [e.g., Intersection of Routes 9 and 55]), city, county, state, and zip code. Do not use a P.O. Box number.
3. Indicate whether the facility is located on Indian Lands.
4. Indicate whether the industrial facility is operated by a department or agency of the Federal Government (see also Section 313 of the Clean Water Act).
5. Enter the latitude and longitude of the approximate center of the facility or site in degrees/minutes/seconds. Latitude and longitude can be obtained from United States Geological Survey (USGS) quadrangle or topographic maps, by calling 1-(888) ASK-USGS, or by accessing EPA's web site at http://www.epa.gov/owm/sw/industry/index.htm and selecting Latitude and Longitude Finders under the Resources/Permit section.

   Latitude and longitude for a facility in decimal form must be converted to degrees (°), minutes (′), and seconds (″) for proper entry on the certification form. To convert decimal latitude or longitude to degrees/minutes/seconds, follow the steps in the following example.

   Example: Convert decimal latitude 45.1234567 to degrees (°), minutes (′), and seconds (″).

   a) The numbers to the left of the decimal point are the degrees: 45°.

   b) To obtain minutes, multiply the first four numbers to the right of the decimal point by 0.006: 1234 x 0.006 = 7.404.

   c) The numbers to the left of the decimal point in the result obtained in (b) are the minutes: 7′.

   d) To obtain seconds, multiply the remaining three numbers to the right of the decimal from the result obtained in (b) by 0.06: 404 x 0.06 = 24.24. Since the numbers to the right of the decimal point are not used, the result is 24″.

   e) The conversion for 45.1234567 = 45° 7′ 24″.

6. Indicate whether the facility was previously covered under an NPDES storm water permit. If so, include the permit number.
7. Enter the 4-digit SIC code which identifies the facility's primary activity, and second 4-digit SIC code identifying the facility's secondary activity, if applicable. SIC codes can be obtained from the Standard Industrial Classification Manual, 1987.
8. Enter the total size of the site associated with industrial activity in acres. Acreage may be determined by dividing square footage by 43,560, as demonstrated in the following example.

   Example: Convert 54,450 ft^2 to acres

   Divide 54,450 ft^2 by 43,560 square feet per acre:
   54,450 ft^2 ÷ 43,560 ft^2/acre = 1.25 acres.

9. Check "Yes" or "No" as appropriate to indicate whether you have paved or roofed over a formerly exposed, pervious area (i.e., lawn, meadow, dirt or gravel road/parking lot) in order to qualify for no exposure. If yes, also indicate approximately how much area was paved or roofed over and is now impervious area.

A011153

Instructions for the NO EXPOSURE CERTIFICATION for Exclusion from NPDES Storm Water Permitting

Form Approved OMB No. 2040-0211

Section C. Exposure Checklist

Check "Yes" or "No" as appropriate to describe the exposure conditions at your facility. If you answer "Yes" to **ANY** of the questions (1) through (11) in this section, a potential for exposure exists at your site and you cannot certify to a condition of no exposure. You must obtain (or already have) coverage under an NPDES storm water permit. After obtaining permit coverage, you can institute modifications to eliminate the potential for a discharge of storm water exposed to industrial activity, and then certify to a condition of no exposure.

Section D. Certification Statement

Federal statutes provide for severe penalties for submitting false information on this application form. Federal regulations require this application to be signed as follows:

For a corporation: by a responsible corporate officer, which means:

(i) president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy or decision making functions for the corporation, or

(ii) the manager of one or more manufacturing, production, or operating facilities, provided the manager is authorized to make management decisions which govern the operation of the regulated facility including having the explicit or implicit duty of making major capital investment recommendations, and initiating and directing other comprehensive measures to assure long term environmental compliance with environmental laws and regulations; the manager can ensure that the necessary systems are established or actions taken to gather complete and accurate information for permit application requirements; and where authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures;

For a partnership or sole proprietorship: by a general partner or the proprietor; or

For a municipal, State, Federal, or other public facility: by either a principal executive or ranking elected official.

Paperwork Reduction Act Notice

Public reporting burden for this certification is estimated to average 1.0 hour per certification, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Burden means the total time, effort, or financial resources expended by persons to generate, maintain, retain, or disclose to provide information to or for a Federal agency. This includes the time needed to review instructions; develop, acquire, install, and utilize technology and systems for the purposes of collecting, validating, and verifying information, processing and maintaining information, and disclosing and providing information; adjust the existing ways to comply with any previously applicable instructions and requirements; train personnel to be able to respond to a collection of information; search data sources; complete and review the collection of information; and transmit or otherwise disclose the information. An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number. Send comments regarding the burden estimate, any other aspect of the collection of information, or suggestions for improving this form, including any suggestions which may increase or reduce this burden to: Director, OPPE Regulatory Information Division (2137), USEPA, 401 M Street, SW, Washington, D.C. 20460. Include the OMB control number of this form on any correspondence. Do not send the completed No Exposure Certification form to this address.

A011154

APPENDIX Y

MEDIA-SPECIFIC INSPECTION COMPONENTS

EXCERPTED (AND UPDATED) FROM EPA'S *MULTIMEDIA INVESTIGATION MANUAL*

The information in this appendix was excerpted from NEIC's *Multimedia Investigation Manual*

The information presented in this appendix includes many significant tasks for several media-specific inspection areas. Media discussed include hazardous waste, air, drinking water, toxic substances, and pesticides; emergency planning/community right-to-know and the Superfund program are also discussed.

A011156

A. Resource Conservation and Recovery Act (RCRA)

Subtitle C Hazardous Wastes

Evaluating Compliance

Under RCRA Subtitle C, hazardous wastes are subject to extensive regulations on generation, transportation, storage, treatment, and disposal. A manifest system tracks shipments of hazardous wastes from the generator through ultimate disposal. This "cradle to grave" management is implemented through regulations and permits.

In determining the facility status under RCRA, the investigator must decide whether the facility is a generator, transporter, and/or Treatment, Storage, and Disposal Facility (TSDF), and whether the facility is permitted or has interim status. Generally, EPA Regional and State offices maintain files for the facility to be inspected. Information may include:

- A list of wastes that are treated, stored, and disposed and how each is managed (for TSDFs)
- A list of hazardous wastes generated, their origins, and accumulation areas (for generators)
- Biennial, annual, or other reports required by RCRA and submitted to the regulatory agencies; these include any required monitoring reports
- A detailed map or plot plan showing the facility layout and location(s) of waste management areas
- The facility RCRA Notification Form (Form 8700-12)
- The RCRA Part A Permit Application (for TSDFs)
- The RCRA Part B Permit application (for TSDFs, if applicable)
- The RCRA permit (for TSDFs, if applicable)
- Notifications and/or certifications for land disposal restrictions (for generators).

Generators

Hazardous waste generators are regulated under 40 *CFR* Parts 262 and 268. These regulations contain requirements for:

- Obtaining an Environmental Protection Agency (EPA) Identification Number
- Determining whether a waste is hazardous
- Managing wastes before shipment
- Accumulating and storing hazardous wastes

A011157

- Manifesting waste shipments
- Recordkeeping and reporting
- Restricting wastes from land disposal (also regulated under Part 268).

The generator regulations vary, depending upon the volume of hazardous wastes generated with fewer requirements for smaller generators. Large Quantity Generators (LQGs) generate greater than 1000 kg of hazardous waste/month, Small Quantity Generators (SQGs) generate less than 1000kg/month but more than 100 kg/month, while Conditionally Exempt Small Quantity Generators (CESQGs) generate less than 100 kg/month. The investigator must determine which regulations apply. Additionally, the investigator should do the following:

- Verify that the generator has an EPA Identification Number that is used on all required documentation (e.g., reports, manifests, etc.).

- Confirm that the volume of hazardous wastes generated is consistent with reported volumes. Examine the processes generating the wastes to assure that all generated hazardous wastes have been identified. Look for improper mixing or dilution.

- Ascertain how the generator determines/documents that a waste is hazardous. Check to see wastes are properly classified. Collect samples, if necessary.

- Determine whether pre-transport requirements are satisfied, including those for packaging, container condition, labeling and marking, and placarding.

- Determine the length of time that hazardous wastes are being stored or accumulated. Storage or accumulation for more than 90 days requires a permit (facilities that generate less than 1000 kg/month of hazardous waste are allowed to store/accumulate for up to 180 days without a permit). Generators storing for less than 90 days must comply with requirements outlined in 40 *CFR* 262.34.

- Verify RCRA reports and supporting documentation for accuracy, including inspection logs, biennial reports, exception reports, and manifests (with land disposal restriction notifications and/or certifications).

- Watch for accumulation areas which are in use but have not been identified by the generator. Note: Some authorized State regulations do not have provisions for "satellite storage" accumulation areas.

- Determine whether a generator has the required contingency plan and emergency procedures, whether the plan is complete, and if the generator follows the plan/ procedures.

- Determine whether hazardous waste storage areas comply with applicable requirements.

- Facilities with their own vehicle maintenance garage should be evaluated to assure that wastes such as used oil, anti-freeze, solvents, and paints are disposed of properly.

Transporters Hazardous waste transporters (e.g., by truck, ship, or rail) are regulated under 40 *CFR* Part 263, which contains requirements for:

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- Obtaining an EPA Identification Number
- Manifesting hazardous waste shipments
- Recordkeeping and reporting
- Sending bulk shipments (by water, rail).

Storage regulations apply if accumulation times at transfer stations are exceeded. Transporters importing hazardous wastes, or mixing hazardous wastes of different Department of Transportation (DOT) shipping descriptions in the same container, are classified as generators and must comply with 40 *CFR* Parts 262 and 268. Investigators evaluating transporter compliance should do the following:

- Verify that the transporter has an EPA identification number that is used on all required documentation (e.g., manifests).

- Determine whether hazardous waste containers stored at a transfer facility meet DOT pre-transport requirements.

- Verify whether the transporter is maintaining recordkeeping and reporting documents, including manifests, shipping papers (as required), and discharge reports. All required documents should be both present and complete.

Treatment, Storage, and Disposal Facilities

Permitted and interim status TSDFs are regulated under 40 *CFR* Parts 264 and 265, respectively. (40 *CFR* Part 264 applies only if the facility has a RCRA permit (i.e., a permitted facility); 40 *CFR* Part 265 applies if the facility does not have a RCRA permit (i.e., an interim status facility). These requirements include three categories of regulations consisting of administrative requirements, general standards, and specific standards. The investigator should do the following activities to determine compliance with Subparts A through E:

- Verify that the TSDF has an EPA Identification Number that is used on all required documentation.

- Determine what hazardous wastes are accepted at the facility, how they are verified, and how they are managed.

- Compare wastes managed at the facility with those listed in the Hazardous Waste Activity Notification (Form 8700-12), the Parts A and B permit applications, and the permit.

- Verify that the TSDF has and is following a waste analysis plan kept at the facility; inspect the plan contents.

- Identify and inspect security measures and equipment.

- Review inspection logs to ensure they are present and complete. Note problems and corrective measures.

- Review training documentation to ascertain that required training has been given to employees.

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- Inspect waste management areas to determine whether reactive, ignitable, and incompatible wastes are handled pursuant to requirements.
- Review preparedness and prevention practices and inspect related equipment.
- Review contingency plans; examine emergency equipment and documented arrangements with local authorities.
- Examine the waste tracking system and associated recordkeeping/reporting systems. Required documentation includes manifests and biennial reports, and may include unmanifested waste reports and spill/release reports. Relevant documents may include on-site waste tracking forms.
- Verify that the operating record is complete according to 40 *CFR* 264.73 or 265.73.

The investigator can determine compliance with standards in Subparts F through H by doing the following:

- For permitted facilities, verify compliance with permit standards with respect to ground water monitoring, releases from solid waste management units, closure/post-closure, and financial requirements.
- For interim status facilities required to monitor ground water, determine what kind of monitoring program applies.
- Depending on the type of investigation, examine the following items to determine compliance:
  - Characterization of site hydrogeology
  - Sampling and analytical records
  - Statistical methods used to compare analytical data
  - Analytical methods
  - Compliance with reporting requirements and schedules
  - Sampling and analysis plan (for content, completeness, and if it is being followed)
  - Conditions, maintenance, and operation of monitoring equipment, including wellheads, field instruments, and sampling materials
  - Construction/design of monitoring system
  - Assessment monitoring outline and/or plan
  - Corrective action plan for permitted facilities and for interim status facilities under 3008(h) enforcement actions.
- For waste management units undergoing closure, review the closure plan (including amendments and modifications), plan approval, closure schedule, and facility and

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regulatory certification. Examine response actions to any release of hazardous waste constituents from a closed or closing regulated unit.

- For waste management units in post closure care, inspect security measures, ground water monitoring and reporting, and the maintenance and monitoring of waste containment systems.

- Verify that the owner/operator has demonstrated financial assurance regarding closure.

Specific Hazardous Waste Management Units

The technical standards in 40 *CFR* Part 264 (Subparts I through O and Subpart X) and 40 *CFR* Part 265 (Subparts I through R) govern specific hazardous waste management units used for storage, disposal, or treatment (e.g., tanks, landfills, incinerators). Standards for chemical, physical, and biological treatment at permitted facilities under 40 *CFR* Part 264 have been incorporated under Miscellaneous Units, Subpart X. The investigator should do the following:

- Identify all hazardous waste management areas and the activity in each area; compare the areas identified in the field with those listed the permit or permit application, as appropriate. Investigate inconsistencies between actual practice and the information submitted to regulatory agencies.

- Verify that the owner/operator is complying with applicable design, installation, and integrity standards; field-check the design, condition, and operation of waste management areas and equipment.

- Determine how incompatible wastes and ignitable or reactive wastes are managed.

- Verify that the owner/operator is conducting self-inspections where and when required; determine what the inspections include.

- Identify and inspect required containment facilities for condition and capacity; identify lead detection facilities.

- Determine whether hazardous waste releases have occurred and how the owner/operator responds to leaks and spills.

- Verify that the owner/operator is complying with additional waste analysis and trial test requirements, where applicable.

- Check the closure/post-closure procedures for specific waste management units (surface impoundments, waste piles, etc.) for regulatory compliance.

- For landfills, determine how the owner/operator manages bulk and contained liquids.

- Field-check security and access to waste management units.

- Determine the facility monitoring requirements (for air emissions, ground water, leak detection, instrumentation, equipment, etc.) and inspect monitoring facilities and records.

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Land Treatment Facilities

When inspecting land treatment facilities, the investigator should also review the following items:

- Soil monitoring methods and analytical data.
- Comparisons between soil monitoring data and background concentrations of constituents in untreated soils to detect migration of hazardous wastes.
- Waste analyses done to determine toxicity, the concentrations of hazardous waste constituents, and, if food-chain crops are grown on the land, the concentrations of arsenic, cadmium, lead, and mercury in the waste(s). The concentrations must be such that hazardous waste constituents can be degraded, transformed, or immobilized by treatment.
- Runon and runoff management systems.

Incinerators

When evaluating compliance of interim status incinerators, the investigator also should review and/or inspect the following items:

- Waste analyses done to enable the owner/operator to establish steady-state operating conditions and to determine the pollutants that might be emitted.
- General procedures for operating the incinerator during start-up and shut-down.
- Operation of equipment used for monitoring combustion and emissions control, monitoring schedules, and data output.
- The incinerator and associated equipment.

For permitted incinerators, the investigator must evaluate the incinerator operation against specific permit requirements for waste analysis, performance standards, operating requirements, monitoring, and inspections. The investigator also should do the following:

- Verify that the incinerator burns only wastes specified in the permit
- Verify methods to control fugitive emissions
- Determine waste management practices for burn residue and ash.

Thermal Treatment Facilities

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The investigator evaluating compliance of thermal treatment facilities in interim status also should review the following items:

- General operating requirements, to verify whether steady-state operating conditions are achieved, as required.
- Waste analysis records, to ensure that (a) the wastes are suitable for thermal treatment and (b) the required analyses in 40 *CFR* Part 265.375 have been performed.

Thermal treatment facilities permitted under 40 *CFR* Part 264 Subpart X will have specific permit requirements.

Biological Treatment Facilities

The investigator evaluating compliance of chemical, physical, and biological treatment facilities in interim status also should do the following:

- Determine the general operating procedures.
- Review the waste analysis records and methods to determine whether the procedures are sufficient to comply with 40 *CFR* 265.13.
- Review trial treatment test methods and records to determine whether the selected treatment method is appropriate for the particular waste.
- Examine procedures for treating ignitable, reactive, and incompatible wastes for compliance with Subpart Q requirements.

Chemical, physical, and biological treatment facilities permitted under Subpart X will have specific permit requirements.

Air Emission Standards

Owners/operators of TSDFs and generators with 90-day unites must comply with air emission standards contained in Subparts AA, BB, and CC of 40 *CFR* Parts 264 and 265. Subparts AA and BB establish standards for equipment containing or contacting hazardous wastes with organic concentrations of at least 10 percent. This equipment includes:

- Process vents
- Pumps in light liquid service
- Compressors
- Sampling connecting systems
- Open-ended valves or lines
- Valves in gas/vapor service or in light liquid service
- Pumps and valves in heavy liquid service, pressure relief devices in light liquid or heavy liquid service, and flanges and other connections.

Total organic emissions from process vents must be reduced below 1.4 kg/hr and 2.8 mg/yr. The other equipment types above must be marked and monitored routinely to detect leaks. Repairs must be initiated within 15 days of discovering the leak.

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Subpart CC establishes standards for units managing hazardous wastes with organic concentrations of greater than 500 ppmw at the point of waste origination. The following types of units must be controlled:

- Tanks
- Containers
- Surface impoundments
- Miscellaneous Subpart X units

The facility operating record should contain information documenting compliance with the air emission standards. A complete list of required information is in 40 *CFR* Parts 264.1035, 264.1064, 265.1035, and 265.1064. Permitted facilities must submit semiannual reports to the Regional Administrator outlining which valves and compressors were not fixed during the preceding 6 months. The investigator can do the following things:

- Visually inspect the equipment for marking.
- Review documentation in the operating record and cross-check this information with that submitted to the Regional Administrator in semiannual reports.

Land Disposal Restrictions

Land Disposal Restrictions (LDR) in 40 *CFR* Part 268 prohibit land disposal of hazardous wastes unless the waste meets applicable treatment standards as listed in 40 *CFR* 268.40-43. The treatment standards are expressed as (1) contaminant concentrations in the extract or total waste or (2) specified technologies.

Notifications and certifications comprise the majority of required LDR documentation. Notifications tell the treatment or storage facility the appropriate treatment standards and any prohibition levels that apply to the waste. Certifications are signed statements telling the treatment or storage facility that the waste already meets the applicable treatment standards and prohibition levels.

Investigators evaluating hazardous waste generators for LDR compliance should do the following:

- Determine whether the generator produces restricted wastes; review how/if the generator determines a waste is restricted.
- Review documentation/data used to support the determination that a waste is restricted, based solely on knowledge.
- Determine how/if a generator determines the waste treatment standards and/or disposal technologies.
- Verify whether the generator satisfies documentation, recordkeeping, notification, certification, packaging, and manifesting requirements.
- Ascertain whether the generator is, or might become, a TSDF and subject to additional requirements.

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- Determine who completes and signs LDR notifications and certifications and where these documents are kept.
- Review the waste analysis plan if the generator is treating a prohibited waste in tanks or containers.

Investigators evaluating TSDFs should do the following:

- Ensure the TSDF is complying with generator recordkeeping requirements when residues generated from treating restricted wastes are manifested offsite.
- Verify whether the treatment standards have been achieved for particular wastes prior to disposal.
- Review documentation required for storage, treatment, and land disposal; documentation may include waste analyses and results, waste analysis plans, and generator and treatment facility notifications and certifications.

Subtitle I—Underground Storage Tanks (USTs)

Evaluating Compliance

Because the tanks are located underground, visual/field observations have limited application in determining compliance for USTs. The UST program relies heavily on the use of documents to track the status and condition of any particular tank.

Interviews with facility personnel are important when determining compliance with any environmental regulation. Questions regarding how the facility is handling its UST program will give the inspector insight into the types of violations that may be found. Topics to be covered in the interview include:

- Age, quantity, and type of product stored for each onsite tank.
- How and when tanks have been closed.
- Type of release detection used on each tank (if any); some facilities may have release detection on tanks where it is not required.
- Type of corrosion protection and frequency of inspections.
- Which tanks have pressurized piping associated with them.

Visual/field observations are used to determine if any spills or overfills have occurred that have not been immediately cleaned up. The presence of product around the fill pipe indicates a spill or overfill. Proper release detection methods can also be verified with field observations. During the interviews, ask the facility if monthly inventory control along with annual tightness testing is used. If monthly inventory control is used, check the measuring stick for divisions of 1/8 inch. A field check of the entire facility can also be done to determine if any tanks may have gone unreported. Fillports and vent lines can indicate the existence of a UST.

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Documents take up the largest portion of time during a UST inspection. Documents that should be reviewed include:

- Notifications for all UST systems
- Reports of releases including suspected releases, spills and overfills, and confirmed releases
- Initial site characterization and corrective action plans
- Notifications before permanent closure
- Corrosion expert's analysis if corrosion protection is not used
- Documentation of operation of corrosion protection equipment
- Recent compliance with release detection requirements, including daily inventory sheets with the monthly reconciliation
- Results of site investigation conducted at the time of permanent closure.

Document retention rules also apply, so be sure to get all of the documents a facility may be required to keep. To determine if the implementing agency has been notified of all tanks, compare the notifications to general UST lists from the facility. Usually, the facility will keep a list of tanks separate from the notifications and tanks may appear on that list that do not appear on a notification form. Also, compare the notifications to tank lists required in other documents, like the Spill Prevention Control and Countermeasures Plan.

RCRA Non-Notifiers

Anytime an investigator is conducting an inspection, they should be aware of the possibility of a "non-notifier" under RCRA. A non-notifier is a facility who has either not notified the EPA or the delegated state of their hazardous waste activity or is managing hazardous waste in an unpermitted unit. The failure to notify may be intentional or the facility may not be aware that the unit should be regulated.

Two specific circumstances for an investigator to be aware of are as follows:

- a facility that is generating a hazardous waste and failed to notify of their generator status and obtain a RCRA I.D. Number.
- a facility that is disposing of hazardous waste in an on-site surface impoundment or landfill that has been determined by the facility to be either a non-hazardous solid waste management unit or an exempt wastewater treatment unit. (When inspecting the wastewater treatment plant, investigators should be aware that the RCRA exemption applies to tanks only. If wastewater meeting the definition of a hazardous waste is discharged into a surface impoundment, this unit is required to have a RCRA permit.)

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B. Clean Air Act (CAA)

The Clean Air Act (CAA) is the legislative basis for air pollution control regulations. It was first enacted in 1955 and later in 1963, 1965, 1970, 1977, and 1990. The 1955 and the 1963 Amendments called for the abatement of air pollution through voluntary measures. The 1965 amendments gave Federal regulators the authority to establish automobile emission standards.

Basic Program

The CAA Amendments of 1970 significantly broadened the scope of the Act, forming the basis for Federal and State air pollution control regulations. Section 109 of the 1970 Amendments called for the attainment of National Ambient Air Quality Standards (NAAQS, 40 *CFR* Part 50) to protect public health and welfare from the known or anticipated adverse effects of six air pollutants (as of 1990 the standards were for small particulates, sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, and lead). The States were required to develop and submit to EPA implementation plans that were designed to achieve the NAAQS. These State Implementation Plans (SIPs) contained regulations that limited air emissions from stationary and mobile sources. They were developed and submitted to EPA on a continuing basis and became federally enforceable when approved.

Section 111 of the 1970 Amendments directed EPA to develop standards of performance for new stationary sources. These regulations, known as New Source Performance Standards (NSPS, 40 *CFR* Part 60), limited air emissions from subject new sources. The standards are pollutant and source specific.

Section 112 of the 1970 amendments directed EPA to develop standards for hazardous air pollutants. These regulations, known as the National Emission Standards for Hazardous Air Pollutants (NESHAPs, 40 *CFR* Part 61), limited hazardous air emissions from both new and existing sources.

The CAA Amendments of 1977 addressed the failure of the 1970 amendments to achieve the NAAQS by requiring permits for major new sources. The permit requirements were based on whether the source was located in an area that did not meet the NAAQS (non-attainment areas). The permit program for sources in attainment areas was referred to as the Prevention of Significant Deterioration (PSD) program.

The CAA Amendments of 1990 significantly expanded the scope of the Act. Section 112 amendments have amended the NESHAP program with the new provisions called "Title III - Hazardous Air Pollutants." Title III listed 189 hazardous air pollutants (Appendix O) and required EPA to start setting standards for categories of sources that emit these pollutants within 2 years (1992) and finish setting all standards within 10 years. It also contains provisions for a prevention-of-accidental-releases program.

Section 211 of the CAA regulates any fuel or fuel additive for use in motor vehicles if the resulting emission would cause or contribute to air pollution that may reasonably be anticipated to endanger public health or welfare, or if the emission products would significantly impair any emission control device or system in general use. There are several provisions under CAA section 211 which regulate fuels such as gasoline, diesel fuel, and fuel additives.

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The Federal tampering prohibition is contained in Section 203(a)(3) of the CAA, 42 U.S.C. 7522(a)(3). Section 203(a)(3)(A) of the Act prohibits any person from removing or rendering inoperative any emission control device or element of design installed on or in a motor vehicle or motor vehicle engine prior to its sale and delivery to an ultimate purchaser. Section 203(a)(3)(A) also prohibits any person from knowingly removing or rendering inoperative any such device or element of design after such sale and delivery and the causing thereof.

Section 203(a)(3)(B) of the Act prohibits any person from manufacturing, selling, offering for sale, or installing any part or component intended for use with, or as part of, any motor vehicle or motor vehicle engine where a principal effect of the part or component is to bypass, defeat, or render inoperative any device or element of design installed on or in a motor vehicle or motor vehicle engine in compliance with regulations under this title, and where the person knows or should know that such part or component is being offered for sale or is being installed for such use.

Section 609 of the CAA Amendments of 1990 requires facilities that perform service on vehicle air conditioners to have recycling or recovery equipment and the technicians who use the equipment to be certified by an EPA-approved §609 program.

Evaluating Compliance

The following procedures are used to evaluate compliance with the Clean Air Act.

Before an onsite inspection, the documents listed below should be obtained from State or EPA files and reviewed to determine what regulations apply and what compliance problems may exist.

- The State air pollution control regulations contained in the SIP (State regulations and permits form the basis for the air compliance inspection and will vary from State to State).
- Title V operating permit/application; the State operating and construction permits.
- The most current emissions inventory (check for sources subject to SIP, NSPS, and NESHAPs requirements).
- The Volatile Organic Compound (VOC) and Hazardous Air Pollutant emissions inventory. (The VOC inventory may not be included in the emissions inventory, but reported separately under SARA Title III Form R submittal. More information on the former submittal is found in the Emergency Planning and Community Right-to-Know section.).
- The consent decrees/orders/agreements still in effect and related correspondence.
- The most recent inspection reports.
- The most recent monthly or quarterly Continuous Emission Monitoring/Continuous Opacity Monitoring (CEM/COM) reports.
- AIRS Facility Subsystem (AFS) reports.

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- Process descriptions, flow diagrams, and control equipment for air emission sources.
- Facility plot plan that identifies and locates the air pollution emission points.

The onsite inspection should include a review of the records and documents listed below:

- Process operating and monitoring records to determine if permit requirements are being followed.
- Fuel analysis reports (including fuel sampling and analysis methods) to determine if sulfur dioxide emission limits and/or other fuel requirements are being met.
- Reports of process/control equipment malfunctions causing reportable excess emissions (refer to SIP to determine reportable malfunctions and report requirements).
- Source test reports to determine if NSPS, NESHAPs, MACTs, and/or major sources have demonstrated compliance with emission standards.
- CEM reports to determine if NSPS and SIP reporting requirements are being met (reported emissions should be checked against raw data for accuracy, and reported corrective actions should be checked for implementation).
- CEMS/COMS certification tests (relative accuracy and calibration drift) to verify that performance specifications at 40 *CFR* Part 60, Appendix B, are met.
- Records and reports specified in SIP regulations, NSPS, NESHAP, and MACT subparts, and applicable permits.

The onsite inspection should also include the following:

- Visible Emission Observations (VEOs), by inspectors certified to read smoke within the last 6 months, to determine compliance with SIP, NSPS, or NESHAPs opacity limits (document non-compliance with EPA Method 9, 40 *CFR* Part 60, Appendix A).
- A check of real time CEM measurements to determine compliance SIP, NSPS, or NESHAPs limits (opacity CEM measurements can be compared against VEOs).
- A review of CEM/COM calibration procedures and frequency to determine if the zero/span check requirements and analyzer adjustment requirements of 40 *CFR* Part 60 are being met.
- Observations of process and control equipment operating conditions to determine compliance with permit conditions (if no permit conditions apply, control equipment operating conditions can be compared to baseline conditions from stack tests or manufacturer's specifications for proper operation).
- Observation of control equipment operating conditions and review of equipment maintenance practices and records to determine proper operation of control equipment.
- When inspecting a fuel refinery or terminal and when time permits, the investigator should review records to assess compliance with fuel regulations under CAA section 211. Things to look for include compliance with the new reformulated gasoline

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requirements including Reid vapor pressure levels (during summer months only) and oxygenate levels of outgoing gasoline, the sulfur content of outgoing diesel fuel, and the lead level of unleaded gasoline leaving the refinery.

- When inspecting a facility with its own fleet of vehicles or garage, maintenance records for the vehicles should be reviewed to determine compliance with Section 203 of the CAA. A review of air conditioning repair/maintenance records should also be conducted to determine compliance with Section 609 of the CAA.

- A review of all sources to determine if existing, new, modified, or reconstructed sources have construction and operating permits required by SIP (note other process changes that may not require a permit but could affect emissions). For example:

  - Are there any boilers, stationary diesel engines (emergency generators, lift pumps), or waste gas boilers of any size? What are their capacities, when installed or altered?

  - Are there any incinerators for sludge, grease, grit, screenings, etc.? When were they installed or altered?

  - Are there any storage tanks storing any liquid except water? What are their capacities, when installed or altered?

  - Are there any solvent or gasoline tanks? What are their capacities, when installed or altered?

  - Are there any storage silos for storing solid particles (e.g., lime)? What are their capacities, when installed or altered?

  - Are there any air pollution control devices of the following types? When where they installed or altered?

    - Odor control equipment (carbon adsorbers, scrubbers) on such equipment as sludge handling/storage tanks, pump stations, wet-wells, metering stations, grit screening, headworks building?

    - Waste gas burners such as digester flares, boilers, etc.?

    - Scrubbers on pH adjustment process or pretreatment equipment (usually HCl control)?

  - Is there any shop equipment of the following types? When was it installed or altered?

    - Paint spray booths
    - Shotblast booths, controlled (any size) or uncontrolled
    - Solvent degreasers

  - Is there any wastewater or water treatment equipment designed to reduce Volatile Organic Compounds (VOCs), which may emit air contaminants, such as aeration basins, surface impoundments, air strippers, roughing filters, trickling filters, or oil/water separators? When was the equipment installed or altered?

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- At industrial/commercial wastewater and pretreatment facilities, are there any aeration basins, lagoons, or settling basins? When were they installed or altered?

- At industrial/commercial treatment works, is there equipment used to dispense odor reducing/masking agents? When was it installed or altered?

- At industrial/commercial treatment works, is there equipment used directly to manufacture fertilizers (including mixers, blenders, conveyors, etc.)? When was it installed or altered?

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C. Safe Drinking Water Act (SDWA)

Basic Program

Public drinking water supply systems (i.e., that serve at least 25 people or have 15 service connections for at least 60 days per year) are regulated by the Safe Drinking Water Act (SDWA) Amendments of 1986. Public water systems are divided into two categories designated as community and noncommunity systems. A community system serves people year-round, whereas a noncommunity system serves people only for a portion of the time (e.g. hotels and campgrounds). Different requirements apply to each type of system. Different requirements also apply depending on whether the water supply source is surface water or groundwater. EPA sets standards [known as Maximum Contaminant Levels (MCLs)] for the quality of water that can be served by public water systems. Public systems must sample their water periodically and report findings to the State (or EPA, if the State has not been delegated the authority to enforce the SDWA). The systems must notify consumers if they do not meet the standards or have failed to monitor or report. EPA is on a statutory schedule for promulgating a large number of new MCLs.

The Underground Injection Control (UIC) program was developed pursuant to the SDWA (Public Law 93-523), Part C—Protection of Underground Sources of Drinking Water (40 *CFR* Parts 124 and 144 through 148). The scope of the UIC program is the determination of the soundness of construction and operation of injection wells as they relate to the protection of all underground sources of drinking water. The UIC program regulates five classes of injection wells, summarized as follows:

Class I Industrial, municipal, or hazardous waste disposal beneath the lowermost underground source of drinking water (USDW)

Class II Oil and gas-related wells used for produced fluid disposal, enhanced recovery, hydrocarbon storage, etc.

Class III Mineral extraction wells

Class IV Hazardous or radioactive waste disposal above or into a USDW

Class V Injection wells not included in Classes I through IV.

Evaluating Compliance

Monitoring requirements for water supply systems and whether the system can be reasonably expected to routinely provide safe potable water should be determined. Many facilities purchase their potable water supply from a nearby municipality. If no further treatment is provided (e.g., chlorination by the facility), the facility remains a "consumer" rather than becoming a "supplier," and consequently does not have the monitoring or reporting requirements that a supplier would have. Nevertheless, the facility does have a responsibility to ensure that their actions do not result in contamination of the municipal water supply (e.g., through cross-connection). The audit team should be alert to these possibilities.

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Inspectors should:

- Verify public water system records of monitoring and reports of exceedences of MCLs
- Interview water system personnel to identify potential operations and maintenance problems
- Check for appropriate treatment systems, such as adequate disinfection
- Check for cross-connections to the water supply and distribution system
- Obtain water source, treatment, and service area information
- Verify that sample locations are appropriate and representative for each contaminant (i.e. sample collected in distribution system versus entry to distribution system)
- Verify that sampling techniques and procedures are appropriate

For UIC inspections, the following should be reviewed:

- Current status of wells (active, abandoned, under construction repairs)
- Types of wastes discharged to wells
- UIC permit and permit conditions, if applicable
- Injection well construction
- Potential pathways of endangerment to Underground Sources of Drinking Water (USDWs)
- Protection of USDWs from endangerment
- Frequency and type of Mechanical Integrity Testing (MIT)
- Annular pressure
- Annular pressure monitoring
- Radioactive tracer surveys
- Installation methods for well plugging
- Remedial operation
- Applicability of land disposal restrictions to injection well operations
- Recordkeeping and evidence documentation
- Outlets for floor drains
- Connection to "dry" wells

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- Evidence of surface ponding
- Presence of septic systems and/or leach fields

Several States and industries have requested approval of alternative mechanical integrity testing methods or variances to accommodate special local hydrogeological conditions, historical practices, or industry interests. Inspectors and field investigators should be cautioned to keep current with special permit conditions and the status of any pending approvals/denials of alternative mechanical integrity testing procedures and variances.

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D. Toxic Substances Control Act (TSCA)

This section describes those specific aspects of toxic substances control that are addressed by the Toxic Substances Control Act (TSCA) and its associated rules and regulations (40 *CFR* Parts 702 through 799).

Basic Program

The regulation of toxins under TSCA is divided into two components for Agency enforcement program management purposes.

1. "Chemical control" covers enforcement aspects related to specific chemicals regulated under Section 6 of TSCA, such as Polychlorinated Biphenyls (PCBs), Chlorofluorocarbons (CFCs), and asbestos.

2. "Hazard evaluation" refers to the various recordkeeping, reporting, and submittal requirements specified in Sections 5, 8, 12, and 13 of TSCA; although, some elements of what might be termed "chemical control" are also addressed in these sections. Sections 12 and 13 of TSCA, which pertain to chemical exports and imports, respectively, will not be covered in this manual because of their special nature and unique requirements.

Prior to discussing TSCA activities at a facility, the investigator must present appropriate facility personnel with copies of two TSCA inspection forms:

1. Notice of Inspection—Shows purpose, nature, and extent of TSCA inspection.

2. TSCA Inspection Confidentiality Notice—Explains a facility's rights to claim information at the facility as TSCA Confidential Business Information.

Before leaving the site, two additional forms must be completed, as appropriate:

1. Receipt for Samples and Documents—Itemizes all documents, photos, and samples received by the investigator during the inspection.

2. Declaration of Confidential Business Information—Itemizes the information that the facility claims to be TSCA Confidential Business Information.

Evaluating Compliance

Chemical Control

Although the controlled substances most frequently encountered during multi-media investigations are PCBs, the investigator should determine if other regulated toxic substances are present at the facility. Currently these include metal working fluids (Part 747), fully halogenated chlorofluoroalkanes (40 *CFR* Part 762), and asbestos (40 *CFR* Part 763); additional toxic substances may be regulated in the future. Because the probability of finding

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PCBs and PCB-items at the facility is greater than finding other TSCA-regulated substances, the following discussion is directed toward an evaluation of compliance with proper PCB and PCB-item handling procedures. If other TSCA-regulated substances are found, the investigator should consult the regulations for appropriate requirements.

Management of PCBs/PCB-items is regulated under 40 *CFR* Part 761. In general, these regulations address recordkeeping, marking and labeling, inspections, storage, and disposal.

Facilities that store and/or dispose of PCBs and PCB-items should have EPA-issued letters of approval that contain facility operating and recordkeeping requirements in addition to those specified in 40 *CFR* Part 761. The investigator must obtain a copy of these approvals and any subsequent notifications to evaluate facility compliance. The inspector should review Part 761.30 to identify uses of PCB transformers which are prohibited beginning October 1, 1990, but with effective dates extending to October 1, 1993. The inspector should also review the requirements found in Part 761.30 that allow the installation of PCB transformers for emergency use.

In general, the compliance evaluation includes obtaining and reviewing information from Federal, State, and local regulatory agency files; interviewing facility personnel regarding material handling activity; examining facility records and inspecting materials handling units. Specific investigation tasks include:

-
  - Inspect all in-service electrical equipment, known or suspected of containing PCBs, for leaks or lack of proper marking. A similar inspection should also be made of any equipment that the facility is storing for reuse. Make certain that any remedial actions were quick and effective in the case of leaks, spills, etc.

- If the above equipment includes any PCB transformers or capacitors, make certain that all relevant prohibitions are being met, such as those involving enhanced electrical protection, as well as other requirements in the Use Authorization section of the PCB Rule. Make certain that any hydraulic or heat transfer systems suspected of containing PCB fluids have been properly tested.

- Determine whether the facility is involved with servicing PCB items or using/collecting/ producing PCBs in any manner. If so, make certain that the appropriate requirements of the PCB Rule are being met.

- Determine whether the facility is involved with either the storage or disposal of PCBs/PCB-items. Inspect all storage for disposal facilities for proper containment, leaking items, proper marking, dates/time limits, location, protection from elements, and other necessary requirements. If the facility disposes of PCBs, make certain that proper methods are being employed and that design and operation of disposal units is in accordance with regulatory requirements.

- Determine whether storage/disposal facilities are complying with the notification and manifesting requirements contained in Subpart K of the PCB Rule.

- Thoroughly review, for purposes of adequacy and regulatory compliance, all records and reports required by the PCB Rule including the following:

  - Annual documents

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- Inspection logs
- PCB transformer registration letters
- Manifests/certificates of destruction
- Test data
- Spill cleanup reports
- EPA-issued permits or letters of approval
- SPCC plan, if one is necessary
- Operating records
- Notification of PCB activity.

Hazard Evaluation

Establishing compliance with the various hazard evaluation aspects of TSCA is best accomplished through review and evaluation of the recordkeeping, reporting, and submittal data required by the various regulatory components of Sections 5 and 8. In general, Section 5 addresses new chemicals (i.e., those not on the TSCA Chemical Substances Inventory) and Section 8 addresses existing chemicals (i.e., those chemicals that are on the TSCA Chemical Substances Inventory).

Much of the information obtained and reviewed under these two sections of TSCA will be declared "TSCA Confidential Business Information" by company officials, and thus special security procedures must be followed during review and storage of the documents.

40 *CFR* Parts 703 through 723 should be consulted for an explanation of TSCA terms and definitions. The following list summarizes the different objectives for inspections of the key TSCA Sections 5 and 8 components.

1. Premanufacture Notification (PMN)

   a. Verify that all commercially manufactured or imported chemicals are on the TSCA Chemical Substances Inventory, are covered by an exemption, or are not subject to TSCA.

   b. Verify that commercial manufacture or import of new chemicals did not begin prior to the end of the 90-day review date, and not more than 30 days before the Notice of Commencement (NOC) date. If commercial manufacture or import has not begun, verify that no NOC has been submitted.

   c. Verify the accuracy and documentation of the contents of the PMN itself.

2. Research and Development (R&D) Exemption

   a. Verify that the recordkeeping and notification requirements are being met for all R&D chemicals.

   b. Verify that "Prudent Laboratory Practices" and hazardous data searches are adequately documented.

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3. Test Marketing Exemption (TME)

   a. Verify that the conditions spelled out in the TME application are being met, particularly with respect to dates of production, quantity manufactured or imported, number of customers and use(s).

   b. Verify that the TME recordkeeping requirements are being met.

4. Low Volume Exemption (LVE) and Polymer Exemption (PE)

   a. Verify that specific conditions of the exemption application are being met, and that all test data have been submitted.

   b. For an LVE, verify that the 1,000-kg limit per 12-month period has not been exceeded. For a PE, ensure that the chemical structure and monomer composition(s) are accurate.

   c. Verify that recordkeeping requirements for both LVEs and PEs are being met.

5. 5(e)/5(f) Order, Rule, or Injunction

   a. Verify that all conditions of the order, rule, or injunction are being followed, including use of protective equipment, glove testing, training, and recordkeeping.

   b. If a testing trigger is specified, verify production volume and status of testing activity.

6. Significant New Use Rule (SNUR)

   a. Verify that no commercial production has occurred prior to the 90-day review date.

   b. Verify that SNUR notices (i.e., Significant New Use Notices [SNUNs]) have been submitted for all applicable manufactured, imported, or processed chemicals.

   c. Verify technical accuracy of SNUN and completeness of required recordkeeping.

7. Bona Fide Submittals

   Determine the commercial production (or import) status and R&D history of those bona fide chemicals not found on the confidential 8(b) inventory. Verify findings against applicable PMN, TME, and other exemption.

8. Section 8(a) Level A PAIR and CAIR Report

   a. Determine if Preliminary Assessment Information Rule (PAIR) and Comprehensive Assessment Information Rule (CAIR) reports have been submitted for all 8(a) Level A listed chemicals manufactured or imported by the facility.

   b. Verify the accuracy of submitted PAIR information, particularly the reported figures for total production volume and worker exposure levels.

   c. Verify the accuracy of submitted CAIR information and if the report meets the date specified in the regulation.

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9. Section 8(b) Inventory Update Rule (IUR)

   a. Verify the accuracy of the information submitted in response to the IUR.

   b. Determine that required information was submitted by the deadline for all chemicals subject to IUR.

10. Section 8(c) Recordkeeping

   a. Determine if the facility has a Section 8(c) file and that allegations of significant health and environmental harm on record are properly filed and recorded.

   b. Determine that all applicable allegations have been recorded and filed.

   c. Determine if the facility has a written Section 8(c) policy and if the policy includes outreach to the employees.

11. Section 8(d) Reporting

   Determine if copies (or lists) of all unpublished health effects studies have been submitted by manufacturers, importers, and processors for any Section 8(d) listed chemical.

12. Section 8(e) Reporting

   a. Verify that all Section 8(e) substantial risk reports to the Agency were accurate and submitted within the required time frames.

   b. Verify that all substantial risk incidents and/or test results have been reported to EPA.

   c. Determine that the company has an adequate written policy addressing Section 8(e), and that it relieves employees of individual liability.

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E. Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

Basic Program

Pesticides are regulated by FIFRA and regulations promulgated pursuant to FIFRA. Under FIFRA, pesticide products must be registered by EPA before they are sold or distributed in commerce. EPA registers pesticides on the basis of data adequate to show that, when used according to label directions, they should not cause unreasonable adverse effects on human health or the environment. States have primary enforcement responsibility for FIFRA.

To ensure that previously registered pesticides meet current scientific and regulatory standards, in 1972 Congress amended FIFRA to require the "reregistration" of all existing pesticides.

Evaluating Compliance

The following list is used in conjunction with specific storage/use/disposal requirements found on pesticide labels. FIFRA requires a written Notice of Inspection and written Receipt for Samples collected.

- Determine types and registration status of all pesticides produced, sold, stored, and used at the facility, particularly if any are restricted or experimental use pesticides.
- Determine use(s) of each pesticide.
- Determine certification status of facility/handlers.
  - Verify who certifies facility/pesticide handlers (EPA, State, Department of Defense).
  - Determine if commercial or private applicator.
  - If restricted-use pesticides are used, check if pesticide applicators are authorized to use these pesticides.
  - Check expiration dates on licenses/certificates.
- Review applicable records.
  - Check previous inspection records and complaints.
  - Check application records.
  - Check restricted-use pesticides records (must be kept at least 2 years). Document suspected violations accordingly.
  - Check inventory records.

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- Check training records.

- Inspect storage, mixing/loading, and container disposal areas
  - Check bulk storage areas for compliance with Federal/State rules.
  - Check location, ventilation, segregation, shelter, and housekeeping of pesticide storage handling areas. Check security, fire protection, and warning signs, as may be required by State regulations.
  - Check mixing equipment/procedures for reducing handlers' exposures to pesticides.
  - Check for safety equipment/procedures/use.
  - Check container cleanup and disposal procedures.
- Pesticide waste disposal
  - Check to see that pesticides are disposed of in accordance with applicable label and RCRA requirements.
- Determine measures taken to ensure farm worker safety.
  - Check pesticide use records for re-entry time limit notation.
  - Check pesticide use records for informing farmer(s) or warning workers and/or posting fields.
- Observe actual pesticide application.
  - Observe mixing/loading and check calculations for proper use dilution.
  - Observe when spray is turned on/off with respect to ends of field.
  - Watch for drift or pesticide mist dispersal pattern.
  - Note direction of spraying pattern and trimming techniques.
  - Record wind speed and direction, air temperature, and relative humidity.
  - Observe application with respect to field workers, houses, cars, power lines, and other obstacles.
  - Determine if applicator and assisting personnel are wearing safety gear required by the label.

A011184

F. Emergency Planning and Community Right-to-Know Act (EPCRA)

Basic Program

The Emergency Planning and Community Right-To-Know Act of 1986 is a free-standing law contained within the Superfund Amendments and Reauthorization Act (SARA) of 1986. EPCRA is also commonly known as SARA Title III. EPCRA requires dissemination of information to State and community groups and health professionals on chemicals handled at regulated facilities.

An EPCRA inspection verifies that the facility owner/operator has notified State and local agencies of regulated activities; has submitted information to specific State and local agencies; and has prepared and submitted all other required reports.

Evaluating Compliance

Emergency Planning (Sections 301 through 303)

EPA promulgated regulations that identify extremely hazardous substances and the levels to be regulated under EPCRA. The inspector should determine whether the facility is subject to EPCRA regulation. If the facility does meet the requirements, the inspector should verify whether the facility owner/operator:

- Notified the State emergency response agency and the local emergency planning committee that the facility is regulated under EPCRA.
- Designated a facility emergency coordinator to assist the local emergency planning committee in the planning process.
- Notified the local emergency planning committee of the emergency coordinator's identity.

Emergency Notification (Section 304)

The owner/operator of a facility subject to EPCRA must immediately report releases of hazardous substances above the reportable quantity. Substances subject to this requirement are the extremely hazardous substances listed in 40 *CFR* Part 355 and hazardous listed in 40 CFR Part 302. The inspector should verify whether an immediate notification (within 15 minutes) was made to the:

- State emergency response commission
- Local emergency planning committee
- National Response Center

Community Right-to-Know Requirements (Sections 311 through 312)

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Manufacturing facilities subject to the Occupational Safety and Health Act (OSHA) Hazardous Communication regulation (29 *CFR* Part 1910) are required to prepare Material Safety Data Sheets (MSDS) for each hazardous chemical handled at the facility. OSHA revised its Hazardous Communication Regulation, effective September 23, 1987, to require that MSDSs be prepared by nonmanufacturing facilities. The inspector should verify that the facility owner/operator has sent the following to the State emergency response commission, the local emergency planning committee, and the local fire department:

- MSDSs or a list of chemicals covered by MSDSs found at the facility above the threshold planning quantity (40 CFR Part 370 Subpart B)

- An annual inventory (Tier 11 Form) of hazardous chemicals found at the facility above the threshold planning quantity (40 CFR Part 370 Subpart D).

Toxic Chemical Release Reporting (Section 313)

Covered facilities (40 *CFR* 372.22) that manufacture, process, or otherwise use certain chemicals above specified amounts must annually report releases to the environment. The inspector should determine whether the facility owner/operator is required to submit this annual report (Form R). The following criteria are applied to determine if the facility is required to report:

- The facility has the equivalent of 10 or more full-time employees.

- The facility is in SIC codes:
  - 10 (except 1011, 1081, and 1094)
  - 12 (except 1241)
  - 20 through 39
  - 4911, 4931, or 4939 (limited to facilities generating power for consumer use by combusting coal and/or oil)
  - 4953 (limited to RCRA Subtitle C facilities)
  - 5169 and 5171
  - 7389 (limited to facilities engaged in solvent recovery services)

- The facility manufactured or processed in excess of 25,000 pounds or used in any other manner 10,000 pounds or more of the chemicals listed on the Toxic Release Inventory (TRI). The list of TRI chemicals can be found in the current year's reporting instructions.

A011186

G. Pollution Prevention

Basic Program

EPA is developing an Agency-wide policy for pollution prevention. Present authorities were established in the 1984 Hazardous and Solid Waste Amendments to RCRA (Section 3002). The October 1990 Pollution Prevention Act established pollution prevention as a national priority. The September 16, 1998, Executive Order 13101, Section 403, Federal Facility Compliance.

Evaluating Compliance

EPA has developed a policy regarding the role of inspectors in promoting waste minimization (OSWER directory number 9938.10). As stated in the policy, to evaluate compliance, the Inspector should:

- Check hazardous waste manifests for a correctly worded and signed waste minimization certification.
- Determine whether this certification was manually signed by the generator or authorized representative.
- Confirm that a waste minimization program is in place by requesting to see a written waste minimization plan, or requesting that the plan be described orally, or requesting that evidence of a waste minimization program be demonstrated. The inspector can, and should, visually check for evidence of a "program in place" onsite.
- Check the Biennial Report and/or Operating record of generators and TSDFs, as appropriate. These documents should contain descriptions of waste minimization progress and a certification statements. If known omissions, falsifications, or misrepresentations on any report or certification are suspected, criminal penalties may apply and the case should be referred for criminal investigation.
- Check any waste minimization language included in the facility's permits, any enforcement order, and settlement agreements. Verify that waste minimization requirements are being satisfied.

The policy also states that the inspector should promote waste minimization by:

- Being familiar with, recommending, and distributing waste minimization literature.
- Referring the facility to the appropriate technical assistance program for more specific or technical information.
- Providing limited, basic advice to the facility of obvious ways they can minimize their waste. This advice should be issued in an informal manner with the caveat that it is not binding in any way and is not related to regulatory compliance.

A011187

The multi-media inspection team can also document cross-media transfers of waste streams, that can result in false claims of waste minimization. For example, a facility could treat a solvent wastewater stream in an air stripper that has no air pollution control devices. On paper, the amount of solvent discharged to a land disposal unit or sewer system could show a reduction, but the pollutants are going into the air, possibly without a permit. Another example would be a facility claiming a reduction in hazardous waste generated because the waste steam was delisted.

A011188

APPENDIX Z

NATIONAL MULTI MEDIA SCREENING INSPECTION WORKSHEET

GENERAL INFORMATION

1. Inspector(s) Name _____ 2. Date _____

3. Facility Name/Address

_____

_____

4. Facility Contact(s)/Title(s)

_____

_____

5. Description of Facility Operations

SIC Code _____

Number of Employees _____

Operating Schedule _____

_____

Major Products/Production Capacity

_____

_____

_____

_____

A011190

RCRA

Observations

1. Does the facility generate anything that looks like waste material that might contain hazardous constituents?

2. If so, describe what the facility says regarding the RCRA regulatory status of the waste material and their rational for such determination. (e.g., have they made a RCRA waste identification and what was that determination? Have they determined the waste to be exempt from regulation and why?

3. Describe the process that generates the waste material.

4. Do you see any containers of hazardous waste, land disposal units, lagoons, treatment units? Approximately how many?

5. Were any of the units that contain or handle hazardous wastes (containers, berms, dikes, tanks, piping, impoundments, etc.) in poor condition, unmarked, opened, leaking, cracked, corroded, or in a condition that would allow the release or potential release of hazardous wastes? If yes, describe unit(s). Any actual or evidence of past releases observed? If so, describe waste (i.e., liquid, sludge, etc.) unit(s), and location.

6. Does the facility operate a boiler or industrial furnace which burns hazardous wastes? Was there any incineration of hazardous waste on site?

7. Was there any evidence of spills, leaks, or discharges of hazardous wastes? If so, provide location and description.

A011191

Interview Questions/Records Review

1. If the facility is a generator of hazardous waste was there a notification of hazardous waste activity? What is the quantity (kilograms/month) of hazardous wastes produced? How are they produced?

2. What is the EPA Identification Number? _____

3. What was the basis (i.e. test, knowledge of process and waste) for determining if the facility did or did not produce or handle hazardous wastes? Who made the determination?

A011192

UST

Observations

1. Are there any underground storage tanks? _____

2. Approximately how many? What are the contents? (Wastes, virgin petroleum, or chemicals) _____

3. What type of leak detection is used? When was it last used?

4. Is there any evidence of leaks, spills, broken piping, broken fill/vent lines, or leaking pump joints or valves? Provide location and description.

Interview Questions/Records Review

1. If the tanks are for virgin petroleum or chemicals (not wastes), are they registered with the state? Date of registration? Date of tank(s) installation?

A011193

SPCC

Observations

1. Does the facility have the capacity to store oil either in above or below ground tanks? How many gallons? Does any tank have a capacity of more than 660 gallons in a single tank or does the facility have a capacity of more than 1320 gallons in a number of tanks or a capacity of more than 42,000 gallons below the ground?

2. What type of secondary containment is used at the facility? Were there any deficiencies in the secondary containment (cracks, broken, dikes left open)? Is it adequate to contain the entire contents of the largest tank?

Interview Questions/Records Review

1. Does the facility have a certified (signed by a P.E.) plan? When was it last updated?

2. Has there been any major changes to oil storage at the facility since the last modification of the plan?

A0111194

WETLANDS

Observations

1. Are there any wet areas near the facility with wetland-type vegetation (cattails, rushes, sedges) that have been disturbed by waste disposal, ditching, or filling?

Interview Questions/Records Review

1. Does the facility have a federal section 404 permit or any state or local permit authorizing the fill?

A011195

FIFRA

Observations

1. Does the facility produce pesticides? _____
2. Is the facility applying pesticides? _____
3. Where are the pesticides stored?

_____

Interview Questions/Records Review

1. If the facility produces pesticides what is the establishment's registration number?
   _____
2. If the facility is applying pesticides what is the registration number of the pesticides?
   _____
3. If the facility is applying pesticides what is the method of application?
   _____

A011196

AIR

Observations

1. Is there any asbestos on site? _____

2. Is the facility undergoing or has the facility undergone any renovations or demolitions during the last 18 months which involve the removal or disturbance of asbestos-containing materials? Approximately how much asbestos (square feet or linear feet) was removed?

_____
_____

3. Does the facility have any coating or printing operations? Does the facility use any paints or organic solvents? What, if any, type of air pollution control is used? Was it operating?

_____
_____
_____

4. Were there any odors? What process was the source of the odors? Describe the odors.

_____
_____
_____
_____

5. Were there any visible (opaque smoke) emissions? What process was the source? Were their any fugitive (not from a stack) emissions? Was the air pollution control equipment, if any, operating? Describe source.

_____
_____
_____
_____

Interview Questions/Records Review

1. If asbestos was removed was notification provide to the State and EPA?

_____

2. If the facility has coating or printing operations are they water based or organic solvent based?

_____

3. Does the facility handle/emit any of the National Emission Standards for Hazardous Air Pollutants (NESHAP) chemicals other than asbestos (mercury, beryllium, vinyl chloride, benzene, arsenic, radio nuclides)? Describe process.

_____
_____
_____

4. Has the facility added new or expanded existing processes in the last two years? Was it permitted by EPA of the State?

A011197

A011198

TSCA-PCBs

Observations

1. Did the facility have or does it have any PCB electrical equipment? What equipment (type and quantity) is on-site?

2. Does the facility have a PCB equipment storage area for disposal or reuse? Describe the storage area (i.e. concrete pad, walls, roof, curbs).

3. Are there any labels/markings on the PCB equipment?

4. Is there any leaking PCB electrical equipment? Describe.

5. Does the facility have any hydraulic systems? Any leaking?

A011199

Interview Questions/Records Review

1. If the facility has PCB electrical equipment was it tested? What were the test results?

_____

_____

2. If the facility has any hydraulic systems when were they tested for PCBs? What were the test results?

_____

_____

A011200

WATER-NPDES

Observations

1. Does the facility use water in it's manufacturing process?

2. Does the facility discharge to a stream, municipal sewer, or use subsurface disposal?

3. What process(es) generate wastewater? Is the wastewater treated? Is the effluent clear? Does the treatment plant appear to be maintained (look for rust, dry basins, abandoned equipment, etc.)?

4. Where does the storm water drain to?

5. Where do floor drains discharge?

A011201

Interview Questions/Records Review

1. How is the treatment plant's sludge disposed? How is it tested?

A011202

EPCRA

Interview Questions/Records Review

1. Were there any chemical releases in excess of the reportable Superfund quantities (see below)? Who was provided the notification? Was it oral or written?

2. Does the facility manufacture, process, or use any toxic chemicals in a quantity greater than 10,000 lbs/yr? Identity them. Are any of them section 313 chemicals[1]?

3. If the answer to question 2 is yes, has the facility submitted the toxic chemical release form (R)?

4. Does the facility have the Material Safety Data Sheets on site and were they submitted to the State Emergency Response Commission (SERC) and/or the Local Emergency Planning Committee (LEPC)?

5. Has the facility submitted the Emergency and Hazardous Chemical Inventory forms to the LEPC and SERC?

SDWA-UIC

Observations

1. Are there any discharges other than sanitary waste (i.e. industrial wastes) into or onto (including drain fields) the ground? Is an on-site septic disposal system used? Describe the discharges and disposal system.

Interview Questions/Records Review

[1] The chemicals subject to these requirements can be found in EPA publication number 560/4-92-011, January 1992, "Title III, List of Lists".

A011203

1. Does the facility have or has it had any wells (dug, drilled or driven), dry wells, leachfields, or septic systems? Did they receive(d) commercial or industrial waste (liquid and/or solid), cooling water, or drainage from roof drains, floor drains, or parking lots? If yes, give a description.

_____

_____

_____

2. Does the facility have a permit? _____

3. What is the current status of wells (active, abandoned, under construction, repairs)?

_____

_____

4. If the wells are inactive what was the date they were last used? _____

A011204

SDWA-PWS

Interview Questions/Records Review

1. What is the facility's source of drinking water? Does the facility have a private well? How many people does it serve?

2. Is the water sampled and analyzed for contaminants? Are the results reported to the state or EPA?

A011205

ENVIRONMENTAL ASSESSMENT

1. Is there any evidence of environmental impacts that haven't been addressed? Possible examples include:

- additional evidence of spills, leaks
- vegetation damage in the surrounding area
- odors in the surrounding neighborhood
- neighborhood covered with "dusts"
- poor water quality in streams near the facility.

2. Were there situations of possible excessive occupational exposure that should be referred to OSHA?

A011206

APPENDIX AA

BIO-SECURITY GUIDANCE (Final)

December 10, 2001

MEMORANDUM

SUBJECT: Routine Biosecurity Procedures for EPA Personnel Visiting Farms, Ranches, Slaughterhouses and other Facilities with Livestock and Poultry

FROM: Michael M. Stahl, Director /s/
Office of Compliance

TO: Acting and Current Regional Administrators and Deputy Regional Administrators

Attached is the final biosecurity guidance for EPA personnel visiting livestock or poultry facilities, including ranches, dairies, feed yards, sale yards, swine premises, slaughterhouses, and other facilities where there are animals or unprocessed animal tissues that may transmit diseases. The guidance was prompted by heightened national concern about the spread of animal diseases. Failing to take appropriate steps to prevent disease transmission could result in severe financial impacts on farmers and the destruction of potentially many of thousands of animals.

While EPA had already incorporated biosecurity discussions into basic CAFO Inspector Training, it was clear that EPA needed to formalize and to reinforce biosecurity measures. Also, while CAFO inspections could be one avenue for possible disease transmission by EPA personnel, guidelines were needed for all EPA field activities that could affect livestock.

The guidance was developed in coordination with USDA's Natural Resources Conservation Service and Animal and Plant Health Inspection Service (APHIS) and the Food and Drug Administration. We circulated drafts for comment to these organizations, EPA headquarters offices, regions, states, and academic and industry contacts. The final guidance relies heavily on and incorporates much of guidance developed by APHIS for USDA employees on June 21, 2001. My thanks to all who contributed to the development of this guidance.

A011208

If you have any questions about this guidance, please contact me or Carol Galloway, National Agriculture Compliance Assistance Center, at 913-551-5008.

Attachment:

Routine Biosecurity Procedures for EPA Personnel Visiting Farms, Ranches, Slaughterhouses, and Other Facilities with Livestock and Poultry

cc: Sylvia Lowrance, OECA, AAA (w/o attachments)
Rick Colbert, OC/AgD (w/o attachments)
Regional Enforcement Coordinators, Regions 1-10 (electronic only)
National Agriculture Sector Contacts (electronic only)
Eric Schaeffer, Director, ORE
James Makris, Director, CEPPO
Marcia Mulkey, Director, OPP
Michael Cook, Director, OWM
John Seitz, Director, OAQPS
John Chamberlin, OARM, OA
Ty Vannieuwenhoven, USDA, APHIS
Tom Christensen, USDA, NRCS
Julius Jimeno, OARM, OA, SHEMD
Jeff Davidson, OARM, OA, SHEMD
Judy Nelson, OPPTS
Jean-Mari Peltier, OA
Ray Mars, FDA

A011209

ROUTINE BIOSECURITY PROCEDURES FOR EPA PERSONNEL VISITING FARMS, RANCHES, SLAUGHTERHOUSES AND OTHER FACILITIES WITH LIVESTOCK AND POULTRY

This guidance establishes routine procedures to minimize the risk of EPA personnel transmitting animal diseases from livestock or poultry facilities, including farms, ranches, dairies, feed yards, sale yards, swine premises, slaughterhouses, and other facilities where there are animals or unprocessed animal tissues, secretions or excretions (including saliva, manure or urine, soiled feed, bedding, water or dirt, milk) to livestock or poultry. Often, owners/producers have adopted more stringent biosecurity measures than these procedures. More stringent measures might include specific directions on site entry (e.g., showering, changing clothes to come onto or leave the premises, vehicle washing), or vehicle travel on the site, and other measures. EPA should discuss appropriate biosecurity measures with the operator prior to entering animal areas, and are encouraged to follow the more stringent measures.

Separate emergency procedures will be applicable in cases of actual outbreaks of contagious animal diseases. In such a case, EPA generally will avoid visiting affected areas and will coordinate with USDA's Animal and Plant Health Inspection Service (APHIS) and local emergency control authorities concerning activities in these areas. Periodically, EPA will contact the offices of the appropriate APHIS Area Veterinarians in Charge and the offices of the state veterinarians to identify any areas with existing emergency animal disease events. The addresses and telephone numbers of these offices are attached.

EPA personnel should be aware of personal health and safety issues when visiting livestock facilities and consult with EPA's Health and Safety staff with questions about proper procedures. Livestock facilities may include OSHA-defined "confined spaces," e.g., manure pits. If staff need to enter such areas, all appropriate safety precautions must be followed. In addition, some animal diseases can be spread to humans, such as brucellosis (bacteria) and echinococcus (parasite).[1] Fortunately, the U.S. largely has eliminated major risk of disease transmission from animals to humans by a combination of veterinary medicine and state regulation.

The following procedures are consistent with written procedures developed by APHIS for use by USDA personnel (June 12, 2001).

Biosecurity Procedures

- Individuals should not make on-site visits to livestock operations if they have visited a foreign country and were exposed to or had contact with farm animals (with or without a known contagious disease) within 5 days prior to the site visit. Also, clothing and shoes worn on foreign farm visits should be cleaned before use on U.S. facilities.
- Thoroughly wash hands with soap and water or antibacterial wipes or gel before entering and

[1]Brucellosis is transmitted through contaminated and untreated milk and milk products and by direct contact with infected animals (cattle, sheep, goats, pigs, camels, buffaloes, and wild ruminants) or animal carcasses. It is extremely variable in humans. The acute form (less than 8 weeks from illness onset) may result in nonspecific and "flu-like" symptoms including fever, sweats, malaise, anorexia, headache, myalgia, and back pain. Echinococcus granulosus lives on dogs and livestock, and infects humans through contact with these animals. Allergic reactions and damage to various organs from cyst formation are the most common forms of disease in humans.

A011210

after leaving any animal facility. Disposable latex gloves also may be used but not as a substitute for proper hand washing.

- Park your vehicle on paved or concrete areas, away from farm production sites, to avoid contact with dirt, mud or manure. If not possible, be certain that tires are free of dirt and debris by hosing the tires and wheel wells before leaving the premises. If this does not clean the tires adequately, take the vehicle to a nearby pressure car wash. Including dates and types of vehicle washing in the vehicle log book is recommended.
- Consider using a vehicle supplied by the facility operator for on site travel if available.
- Prior to entering the site, put on disinfected rubber boots or other footwear that has been cleaned and disinfected, or wear new disposable boot covers. The operator may have its own coveralls and boots for you to wear. However, if visiting only low-risk areas, such as offices that are located away from animal areas, clean street shoes or boots are acceptable (hand washing is still needed). [Note: Boot covers may not provide sufficient traction to safely navigate slopes surrounding lagoons and pits. Personnel may want to use tape to secure the boot cover to prevent slippage].
- On entering a facility, acknowledge any and all other livestock facilities visited within the previous 48 hours including whether or not EPA entered any animal confinement or waste storage areas.
- Inform the operator of where the EPA staff wants to go on the site, determine what biosecurity procedures, if any, the owner/operator has for the on-site locations to be visited, and determine which biosecurity procedures will be followed for the areas to be visited.
- EPA should only enter animal production buildings if it is essential to complete the goals of the visit, and should avoid contact with livestock, poultry or other animals (wild or domestic) on any facility. If close contact with animals is expected, including walking through narrowly confined pens or lots where animals are within reach, wearing coveralls is recommended.
- Designate the interior of your vehicle as a "clean area" and keep clean supplies in this area.
- Designate a "dirty area" of your vehicle, such as the trunk of the car or a specified enclosed area of a truck bed for double bagged clothes or dirty equipment to be taken off site.

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- Before leaving the site, clean and disinfect boots or tightly bag boots for later cleaning. Scrub boot bottom and sides to remove all dirt and debris, then wash with disinfectant solution. Disinfectants are not effective on dirt, manure or other organic matter.
- Clean and disinfect equipment if contaminated.
- Use disinfectants that have been registered (or exempted) by EPA for the intended use (see below). Keep a copy of the label and the Material Safety Data Sheet (MSDS) for any registered disinfectant used and make both available to the facility upon its request. Follow all label safety precautions and dispose of empty containers, unused disinfectant solution, and used disinfectant in accordance with label instructions.
- If non-disposable clothing is soiled with manure, blood, milk, or other animal secretions or there has been close contact with livestock (actual handling or walking where animals were within reach), before leaving the site, double bag clothing for later cleaning.
- Dispose of soiled boot covers, and disposable clothing on-site if acceptable to the owner/operator. Where on-site disposal is not possible, double bag and tightly seal all contaminated clothing and gear in disposable bags.
- Inform the owner/operator of the areas of the site that were visited, and the biosecurity procedures taken. This can be done at an inspection closing conference.

Supplies:

- clean boots or new disposable boot covers
- clean change of clothing or coveralls
- appropriate registered or exempted disinfectant (see below)
- water (at least minimum required for hand washing and disinfection)
- a bucket or tray to contain disinfectant
- long handled brush
- clean bags for trash disposal or storage of items to be cleaned
- liquid and/or gel antibacterial soap or wipes
- first aid kit including an eye wash
- phone numbers of the state veterinarian or other local officials available in case you suspect animal diseases are present. Share any such observations with the owner/operator as soon as possible

Disinfectants for Routine Biosecurity

The following products are currently registered by EPA as being effective against a broad range of disease-causing organisms, including Foot and Mouth Disease; they are not effective against all disease-causing organisms. Consult the label information and, if other diseases are a concern, consult the state veterinarian or state department of agriculture.

Virkon S (EPA Reg. No. 62432-1, label and MSDS)
Oxonia Active (EPA Reg. No. 1677-129, label and MSDS)

There are also two household chemicals subject to EPA Section 18 "quarantine exemptions" (i.e., they are exempted from FIFRA pesticide registration requirements) for use as Foot and Mouth Disease disinfectants. They are issued to APHIS but designed so that the general public can make treatments themselves using these chemicals. One permits vinegar (acetic acid) to be applied as a 4% solution, and the other permits bleach (sodium hypochlorite) to be used in a solution of 3 parts bleach to 2 parts water. Information on these Section 18 actions is attached.

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Attachments:

1. APHIS Veterinary Series Area Offices and State Veterinarians
2. Copies of EPA-approved labels for Virkon S (April 26, 2001) and Oxonia Active (May 11, 2001) and associated Material Safety Data Sheets
3. Section 18s for Acetic Acid and Sodium Hypochlorite (Bleach)

Disclaimer

The discussion in this document is intended solely as guidance. This document is not a regulation. It does not impose legally binding requirements on EPA, states, or the regulated community. This guidance does not confer legal rights or impose legal obligations upon any member of the public. The general description provided here may not apply to a particular situation based on the circumstances. Interested parties are free to raise questions and objections about the substance of this guidance and the appropriateness of the application of this guidance to a particular situation. EPA retains the discretion to adopt approaches on a case-by-case basis that differ from those described in this guidance where appropriate. This document may be revised periodically without public notice. EPA welcomes public input on this document at any time.

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Appendix BB

NPDES CAFO Permit NMP Nine Minimum Standards Review Checklist

NPDES CAFO Permit NMP Nine Minimum Standards Review Checklist

The checklist is composed of three parts which are to be completed as follows:

Part A **Summary Information**
Documents critical information concerning the operation.

Part B **Detailed Plan Review and On-Site Inspection Checklist**
To be completed when reviewing a plan or during an on-site inspection of the operation.

Part A - Summary Information

1. Plan Preparer Certification
   - Was the plan prepared by a certified nutrient management specialist? ☐ Yes ☐ No
   - Is the name and certification credentials of the plan preparer identified in the plan? ☐ Yes ☐ No
2. Type of Operation
   - Is the facility operated ☐ Year Round ☐ Seasonally

     Notes: _____
   - Is the operation ☐ Open lot ☐ Partially enclosed ☐ Fully enclosed.

     Notes: _____
   - Does the description of the facility in the plan reflect the description of the facility in the application/NOI/Fact Sheet/Permit? ☐ Yes ☐ No
3. Facility Maps
   - Does the plan include maps that identify topography, soil types, confinement areas, manure and wastewater storage, raw material storage, handling, and treatment facilities, and environmentally sensitive areas (sinkholes, wells, drinking water sources, field tile drain outlets) for the production area and all land application areas owned or under the ownership, rental, lease, other legal arrangement of the CAFO operator? ☐ Yes ☐ No ✗
   - Does the plan identify the watershed(s) in which the operation is located including latitude and longitude to the entrance of the production area? ☐ Yes ☐ No
   - Is this watershed listed on the States list of impaired watersheds? ☐ Yes ☐ No

     If yes, what impairments are identified? _____
   - Is this facility located in a state designated source water protection area? ☐ Yes ☐ No
   - Are there any other water quality problems in this watershed? ☐ Yes ☐ No

     Explain: _____

✗ = Questions where a "no" answer may indicate that the facility may be in violation of permit requirements. A "no" answer may also indicate that the NMP is deficient.

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4. Animals

- What type of animals are confined at the facility?

☐ Beef (slaughter/feeder) ☐ Chicken – Layer
☐ Dairy ☐ Chicken – Broiler
☐ Swine ☐ Sheep/lambs
☐ Turkey ☐ Horse
☐ Other _____ ☐ Duck

- What is the design capacity by animal type?

☐ Beef (slaughter/feeder) _____ ☐ Chicken – Layer _____
☐ Dairy _____ ☐ Chicken – Broiler _____
☐ Swine _____ ☐ Sheep/lambs _____
☐ Turkey _____ ☐ Horse _____
☐ Other _____ ☐ Duck _____

- Is the plan based upon the design capacity? ..... ☐ Yes ..... ☐ No

If no, what capacity is the plan based upon? _____

_____

_____

- Does the plan identify the size (acres) of the production area? ☐ Yes _____ acres ☐ No

5. Manure/Litter/Process Watewater Generation

- What are the manure generation rates for N, P, and K identified in the plan?

Animal Type 1 ..... N_____ lbs/Year ✗ P_____ lbs/Year ✗ K_____ lbs/Year
Animal Type 2 ..... N_____ lbs/Year ✗ P_____ lbs/Year ✗ K_____ lbs/Year
Animal Type 3 ..... N_____ lbs/Year ✗ P_____ lbs/Year ✗ K_____ lbs/Year

- What are the manure generation rates for N, P, and K rates based upon?

☐ Current year manure analysis from this operation
☐ Historical manure analysis from this operation [Note Year(s): _____]
☐ Book value [Note Source: _____]

- Are the generation rates for N, P, and K generally consistent with USDA's Agricultural Waste Management Field Handbook? ..... ☐ Yes ..... ☐ No

If no, are other practices in place that account for the rates included in the plan? ..... ☐ Yes ..... ☐ No

What are the practices identified in the plan? ..... ☐ Feed Management ..... ☐ Other

Explain: _____

_____

_____

If no, are atmospheric N losses used in the plan excessive? ..... ☐ Yes ..... ☐ No

✗ = Questions where a "no" answer may indicate that the facility may be in violation of permit requirements. A "no" answer may also indicate that the NMP is deficient.

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6. Manure Utilization Options

- What manure utilization options are identified in the plan? (*Note if more than one option is identified in the plan indicate the relative amount of the manure/wastewater utilized under this option*)

Land Application ..... ☐ Yes _____% ..... ☐ No

If yes: how many acres of land owned or under the control of the applicant are available for applying manure/wastewater generated by the CAFO? _____ acres.

Do the facility maps identify the fields or conservation management units (CMU) used to develop the plan? (Field boundaries, field number, acreage) ..... ☐ Yes ..... ☐ No ✗

Composting ..... ☐ Yes _____% ..... ☐ No

Incineration ..... ☐ Yes _____% ..... ☐ No

If yes, does the plan address what is done with the remaining ash _____

_____

_____

Other ..... ☐ Yes _____% ..... ☐ No

Describe *(as needed)* _____

_____

- Is manure generated at the CAFO sold/given away for use at another location not associated with the generating CAFO? ..... ☐ Yes ..... ☐ No

If yes, what is the estimated amount transferred annually? _____ tons

7. Crop Production

- Does the plan identify what crops are produced? ..... ☐ Yes ..... ☐ No ✗

What are they? _____

- Does the plan identify the crop rotations (if any)? ..... ☐ N/A .... ☐ Yes ..... ☐ No

What is the crop rotation? _____

_____

_____

- Does the plan identify cropping practices? ..... ☐ Yes ..... ☐ No

If yes, what are they? ☐ Ridge Till ☐ Conservation Tillage ☐ Other _____

- Does cropping system use irrigation? ..... ☐ Yes ..... ☐ No

If yes, what type: ☐ Flood ☐ Sprinkler ☐ Overland ☐ Center Pivot ☐ Ridge and furrow ☐ Traveling Gun

- Is crop/rotation information provided in the plan for each field/CMU? ..... ☐ Yes ..... ☐ No
- Are realistic crop yield goals identified in the plan? ..... ☐ Yes ..... ☐ No
- What source of information was used by to determine the realistic yield goals for this operation?

☐ Farm Records (*Circle One:* last year's crop and production, 3-year average, 5-year average)
☐ USDA ☐ State Databases (VALUES, MASCAP)
☐ County Averages ☐ Previous crop insurance records

- Is adequate justification provided to support the yield goal. ..... ☐ Yes ..... ☐ No

✗ = Questions where a "no" answer may indicate that the facility may be in violation of permit requirements. A "no" answer may also indicate that the NMP is deficient.

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8. Nutrient Application

- Does the plan identify the basis/rationale for determining an N-based or P-based application rate? ☐ Yes ☐ No ✗

  What is the basis? ☐ State Regulations/Nutrient Management Technical Standard ☐ NRCS Code 590

  ☐ Other _____

- Does the plan identify the application method? ☐ Yes ☐ No ✗

  If yes, what method is used: ☐ Surface applied ☐ Injected ☐ Incorporated

- Does the NMP reference the correct State Nutrient Management Technical Standard identified in the permit? ☐ Yes ☐ No ✗

- Does the plan include land application areas that are N-based and others that are P-based? ☐ Yes ☐ No

9. 25-Year, 24-Hour Storm Information*

- Does the plan utilize the correct 25-Year, 24-Hour rainfall amount for the location of this operation to determine storage requirements?* ☐ Yes ☐ No ✗

  Note source of information _____

Additional Comments: _____

_____

_____

_____

_____

* Some facilities are required to design storage impoundments based on a 100-year, 24-hour storm.

Part B - Detailed Plan Review and On-Site Inspection Checklist

Minimum Standard #1 Ensure Adequate Storage Capacity

Plan Review

- Does the plan identify the volume and duration of storage required for the facility? ☐ Yes ☐ No ✗
- Does the storage volume in the plan account for manure and process wastewater in addition to the collection of runoff and the 25-year/24-hour storm event for the CAFO location? (Note: New source swine, poultry, and veal operations use a 100-year/24-hour storm) ☐ Yes ☐ No ✗
- Are storage structures constructed and operated in accordance with the ELG? ☐ Yes ☐ No ✗
- Does the plan include a schedule for cleaning out the storage structures or solids removal for liquid storage structures? ☐ Yes ☐ No ✗
- Does the plan require maintenance for all storage structures? ☐ Yes ☐ No ✗

On-Site Inspection

- Is a depth marker in place in all lagoons and other appropriate storage structures? ☐ Yes ☐ No ✗
- Is adequate lagoon storage volume being maintained? ☐ Yes ☐ No ✗
- Is the length of storage documented in on-site records consistent with storage practices identified in the plan? ☐ Yes ☐ No

✗ = Questions where a "no" answer may indicate that the facility may be in violation of permit requirements. A "no" answer may also indicate that the NMP is deficient.

A011218

Minimum Standard #2 Ensure Proper Management of Mortalities

Plan Review

- Is animal mortality addressed in the plan. ☐ Yes ☐ No ✗

  If yes, what methods are identified in the plan to address animal mortality?

  ☐ Rendering ☐ Incineration ☐ Composting ☐ Disposal pits

  ☐ Landfill ☐ Other _____

- Does the plan address mortality storage prior to final disposition? ☐ Yes ☐ No
- Is the mortality rate used in the plan consistent with USDA expected values for the animals confined at the operation? ☐ Yes ☐ No
- Does the animal mortality plan meet State requirements? ☐ N/A ☐ Yes ☐ No ✗

On-Site Inspection

- Are the animal mortality disposal methods and equipment identified in the plan in place and being properly implemented? ☐ Yes ☐ No ✗

Minimum Standard #3 Divert Clean Water From Production Area

Plan Review

- Does the plan include provisions that address the diversion of clean water from the production areas? ☐ Yes ☐ No

  If no why? _____

  _____

  If no, is the runoff being collected and is storage of runoff adequate? (See Minimum Standard No. 8) ☐ Yes ☐ No
- Does the plan require periodic visual inspection to verify proper and functional diversion? ☐ Yes ☐ No
- Does the plan address the maintenance of diversion structures? ☐ Yes ☐ No

On-Site Inspection

- Are the diversion provisions identified in the plan being properly implemented? ☐ Yes ☐ No
- Is the storage capacity sufficient for all non-diverted runoff? ☐ Yes ☐ No
- Are records of periodic inspections being maintained? ☐ Yes ☐ No
- How often are operator inspections being conducted? (*Circle one:* Daily Weekly Monthly)

Minimum Standard #4 - Prevent Direct Contact

Plan Review

- Does the facility or topo map identify any surface water in the production area? ☐ Yes ☐ No

  If yes, are measures in the plan to prevent direct contact? ☐ Yes ☐ No ✗

  What are the measures identified in the plan? ☐ Fences ☐ Other

On-Site Inspection

- Is there surface water in the production area? ☐ Yes ☐ No
- Are the measures identified in the plan being implemented and maintained to prevent direct contact? ☐ Yes ☐ No ✗
- Are there any animals in contact with surface water in the production area? ☐ Yes ☐ No

✗ = Questions where a "no" answer may indicate that the facility may be in violation of permit requirements. A "no" answer may also indicate that the NMP is deficient.

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Minimum Standard #5 Chemical Handling

Plan Review

- Has the facility incorporated measures (in accordance with applicable laws and regulations) to prevent the mishandling of pesticides, hazardous and toxic chemicals, and petroleum products/by-products from contaminating manure and wastewater? ..... ☐ Yes ..... ☐ No

  If no, explain: _____

On-Site Inspection

- Are the measures identified being implemented? ..... ☐ Yes ..... ☐ No
- Is there any evidence of mishandling of pesticides, hazardous and toxic chemicals, and petroleum products/by-products contaminating manure and wastewater storage. ..... ☐ Yes ..... ☐ No

Notes: _____

_____

Minimum Standard #6 Conservation Practices to Reduce Nutrient Loss

Plan Review

- Does the plan include the use of best management practices (BMPs) to control runoff from the:

  Production area ..... ☐ N/A .... ☐ Yes ..... ☐ No

  Land application area(s) ..... ☐ N/A .... ☐ Yes ..... ☐ No

- Do the plan and facility maps identify the specific areas that the BMPs are to be applied?

Land Application Areas	Production Area
☐ Vegetated Buffers (Type of vegetation _____)	☐ (Type of vegetation _____)
☐ Diversion	☐
☐ Grassed Waterway (Type of vegetation _____)	
☐ Strip Cropping	
☐ Residue Management	
☐ Terracing	
☐ Conservation Tillage	

- If any of these BMPs are being used does the plan specify how they are to be implemented? ..... ☐ Yes ..... ☐ No

  If yes, what does the plan require? _____

  _____

- What references are cited for the practices? ☐ USDA Practice Standards ☐ State Standards

  ☐ Other _____ *(Note: to be used to verify proper implementation)*

- Does the plan include O&M requirements for practices used to reduce nutrient loss? ..... ☐ Yes ..... ☐ No

On-Site Inspection

- Are the nutrient loss minimization practices in the plan being properly implemented? ..... ☐ Yes ..... ☐ No ✗
- If buffers are being used, are the widths in agreement with those identified in the plan? ..... ☐ Yes ..... ☐ No
- Is there any evidence of buffers being breached by waste or evidence of erosion? ..... ☐ Yes ..... ☐ No

✗ = Questions where a "no" answer may indicate that the facility may be in violation of permit requirements. A "no" answer may also indicate that the NMP is deficient.

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Minimum Standard #7 Protocols for Manure and Soil Testing

Plan Review

- Does the plan include specific protocols for the sampling and analysis of manure, wastewater and soil for determining nutrient content? ☐ Yes ☐ No ✗
- Are these protocols recognized by the State or identified in the State Nutrient Management Technical Standard? ☐ Yes ☐ No ✗
- Does the plan identify the sampling frequency for manure and soil sample analysis? ☐ Yes ☐ No ✗

  (At a minimum manure samples are to be taken annually and tested for nitrogen and phosphorous and soil samples taken and tested for phosphorous at least once every 5 years.)

On-Site Inspection

- Were the manure/wastewater and soil samples taken within 12 months of developing the site-specific NMP? ☐ Yes ☐ No
- Have manure and soil samples been collected at a frequency that is consistent with permit requirements? ☐ Yes ☐ No
- Are the sampling protocols consistent with permit requirements or those specified in the state nutrient management technical standard? ☐ Yes ☐ No

  (At a minimum manure samples are to be taken annually and tested for nitrogen and phosphorous and soil samples taken and tested for phosphorous at least once every 5 years.)
- Are the results of the sample analysis consistent with the content and analyses of the NMP? ☐ Yes ☐ No

Minimum Standard #8 - Protocols for Land Application of Manure and Wastewater

Plan Review

- What is the number of acres owned/acres leased or subject to an access agreement to be used for land application identified in the plan? _____acres owned _____acres leased _____acres applied
- Does the plan identify weather and soil conditions under which application activities will not be conducted (e.g., frozen ground)? ☐ Yes ☐ No
- Does the plan include a proper analysis to determine whether application rates are to be based upon N or P for each management unit? ☐ Yes ☐ No ✗
- Is the analysis consistent with the State Nutrient Management Technical Standard identified in the permit or approved by the Director of the permitting authority? ☐ Yes ☐ No ✗
- Does the plan take into account other sources of nutrients used at the operation? ☐ Yes ☐ No ✗

  If yes, what other sources of nutrients have been accounted for:

  ☐ Commercial Fertilizer ☐ Biosolids
  ☐ Bedding ☐ Legume Credits
  ☐ Wastewater ☐ Previous manure applications
  ☐ Other_____
- Does the plan include the application of wastewater to fields via an irrigation system? ☐ Yes ☐ No

  If yes:
  - → Does the plan identify the type of irrigation system? ☐ Yes ☐ No
  - → Are the nutrients contributed by the irrigation system accounted for in the nutrient budget for the operation? ☐ Yes ☐ No
  - → Does the plan include provisions to minimize ponding or puddling of wastewater on land application fields? ☐ Yes ☐ No
  - → Does the plan address the management of drainage water to prevent surface or ground water contamination? ☐ Yes ☐ No

✗ = Questions where a "no" answer may indicate that the facility may be in violation of permit requirements. A "no" answer may also indicate that the NMP is deficient.

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- Does the plan identify the crop rotation system, crop nutrient requirements based on soil testing, realistic yield goals*, and crop nutrient removal? ☐ Yes ☐ No X
- Does the plan include restrictions or adequate management practices to prevent water pollution from the application of manure/wastewater to flooded, saturated, frozen, or snow covered ground? ☐ Yes ☐ No
- Does the plan address specific pumping and clean out schedules for all liquid storage structures? ☐ Yes ☐ No
- Does the plan require records to be maintained that document the date, location, weather, and application rate of manure and wastewater that is land applied? ☐ Yes ☐ No X
- Is there sufficient land owned or under the control of the operator to properly utilize all manure and wastewater generated by the operation? ☐ Yes ☐ No

  If no:
  - → Does the plan identify the quantity of excess manure being generated? _____tons/year or gallons/year
  - → Does the plan identify how the excess manure is to be utilized? _____
  - → Is excess manure/wastewater to be transferred off-site? ☐ Yes ☐ No

  If yes:
  - → Does the plan include the necessary arrangements for this transfer? ☐ Yes ☐ No
  - → Does the plan identify the recipients? ☐ Yes ☐ No
- Does the plan address the maintenance of land application equipment? ☐ Yes ☐ No
- Does the plan identify the manure application method to be used? ☐ Yes ☐ No
- Does the plan require periodic calibration of manure application equipment. ☐ Yes ☐ No
- Are the application rates identified in the plan appropriate? ☐ Yes ☐ No

Notes: _____

_____

_____

On-Site Inspection

- Does the plan reflect the current operational characteristics (number of animals, cropping, etc.)? ☐ Yes ☐ No X
- Are the number of acres owned/acres leased consistent with those identified in the plan? ☐ Yes ☐ No X
- Is the crop rotation consistent with that identified in the plan used to determine application rates and timing? ☐ Yes ☐ No
- Is the application equipment being used consistent with the equipment identified in the plan? ☐ Yes ☐ No
- Is the land application equipment being used appropriate? ☐ Yes ☐ No
- Is the amount of manure/wastewater being transferred off-site consistent with the amount identified in the plan? ☐ Yes ☐ No
- Are records (name and address of recipient and amount) of off-site manure disposal being maintained (if required)? ☐ Yes ☐ No
- Is manure and wastewater being applied within a 100' setback or within a 35' vegetated buffer to any down gradient surface waters, open tile line intake structures, agricultural well heads or other conduits to surface waters? ☐ Yes ☐ No X

* or other documented recommendation from local extension or other source)

X = Questions where a "no" answer may indicate that the facility may be in violation of permit requirements. A "no" answer may also indicate that the NMP is deficient.

Minimum Standard #9 - Recordkeeping

Plan Review

- Identify the required records that the plan identifies are to be maintained at the facility.
  - ☐ Manure and wastewater sample nutrient analysis results
  - ☐ Soil sample analysis results that the plan was based upon for all land application areas (Dates of sample: ___/___/___, ___/___/___, ___/___/___, ___/___/___, ___/___/___)
  - ☐ Manure/wastewater storage - date of emptying, level before emptying, and level after emptying, or quantity removed (dry manure)
  - ☐ Storage facility level (weekly)
  - ☐ Inspection log (stormwater diversions, runoff control structures, water lines, surface impoundments, and manure application equipment)
  - ☐ Maintenance log of all equipment necessary to control discharge and meet permit requirements (e.g., maintenance of land application equipment)
  - ☐ Crop planting/harvest dates by field or CMU
  - ☐ Crop type and yield by field or CMU - bushels/acre (seasonally)
  - ☐ Total amount of N and P applied - date, time, and rate (lbs/acre, gallons/acre), weather condition, application method, and equipment used by field or CMU (daily)
  - ☐ On-site precipitation
  - ☐ Animal Inventory
  - ☐ Lease/Rental/Access Agreements for all land not owned by the operator
  - ☐ Name and address of recipients and quantity of manure transferred off-site
- Does the plan require any additional records be maintained at the facility? ..... ☐ Yes ..... ☐ No
  If yes, what are these records?_____
  _____
- Does the plan include an emergency action plan to address spills and catastrophic events? ..... ☐ Yes ..... ☐ No

On-Site Inspection

- Are all of the records identified in the plan being maintained and kept current? ..... ☐ Yes ..... ☐ No ✗
  If no, explain:_____
  _____
- Are records being maintained at the required frequency? ..... ☐ Yes ..... ☐ No
  If no, explain:_____
  _____
- Are records being maintained on-site for the period required by the permit? ..... ☐ Yes ..... ☐ No
  If no, explain:_____
  _____
- Do the records include the date, time and estimated volume of any overflows? ..... ☐ Yes ..... ☐ No

✗ = Questions where a "no" answer may indicate that the facility may be in violation of permit requirements. A "no" answer may also indicate that the NMP is deficient.

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Plan Adequacy/Discharge Potential

- Is the plan adequately addressing the storage, handling, and application of manure and wastewater to prevent the discharge of pollutants to waters of the US? ..... ☐ Yes ..... ☐ No ✗
- Is there evidence of a past discharge? ..... ☐ Yes ..... ☐ No

  If yes, what evidence was identified? _____

- Is there any evidence of discharges to waters of the US from other activities at the operation? .... ☐ Yes ..... ☐ No

  If yes, what evidence was identified? _____

- Is there a risk of a future violation of permit conditions? ..... ☐ Yes ..... ☐ No

  If yes, what is the basis for this determination? _____

- Does the plan require revision? ..... ☐ Yes ..... ☐ No

  If yes, what specific components of the plan require revision? _____

Additional Comments: _____

✗ = Questions where a "no" answer may indicate that the facility may be in violation of permit requirements. A "no" answer may also indicate that the NMP is deficient.

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APPENDIX CC

INTEGRATED COMPLIANCE INFORMATION SYSTEM (ICIS) SCREEN SHOTS

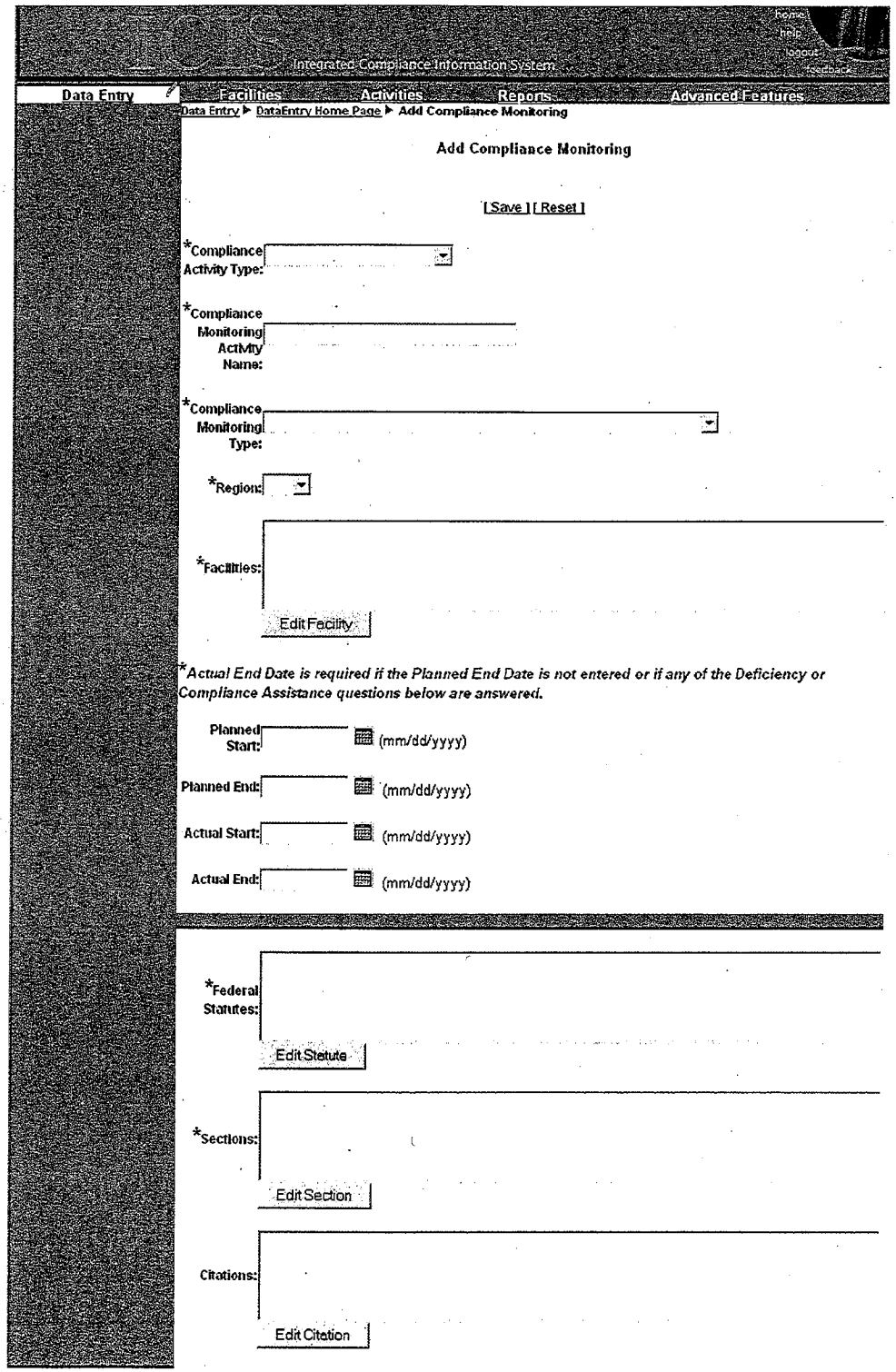
9.1.4 Compliance Monitoring

The Compliance Monitoring screens capture data on information requests, compliance inspections, compliance investigations, and off-site record reviews. These screens incorporate data elements from the Inspection Conclusion Data Sheet (ICDS) and Enforcement and Compliance data standards. All available information is initially entered through the Add Compliance Monitoring screen (Figure 9.1.4-1). When the user saves the data on the Add Compliance Monitoring screen, the Compliance Monitoring Detail (Figure 9.1.4-2) screen is displayed. Data can be added or updated as required via the Compliance Monitoring Detail screen. The Compliance Monitoring Detail screen is also displayed when the user clicks on a Compliance Monitoring link on the All Compliance Monitoring screen (Section 9.3.3) to edit a particular activity. Fields and button functionality for the Add Compliance Monitoring and Compliance Monitoring Detail screens are described in Table 9.1.4-1 and Table 9.1.4-2 respectively.

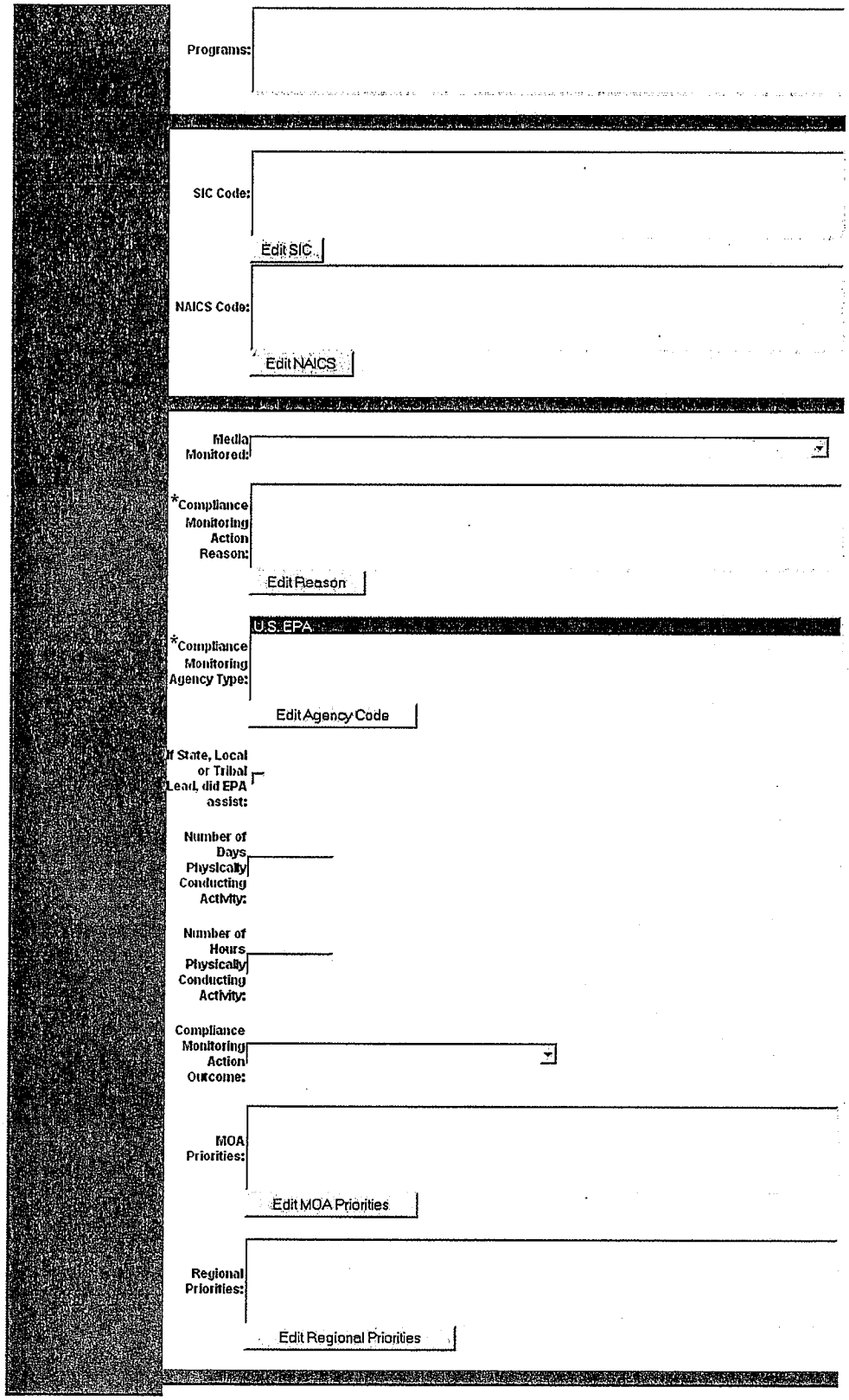
See Section 8 (i.e., Common Objects) for a discussion of left side menu topics (i.e., Sub Activities, Related Activities, Facility, Contacts, Regional Fields).

A011226

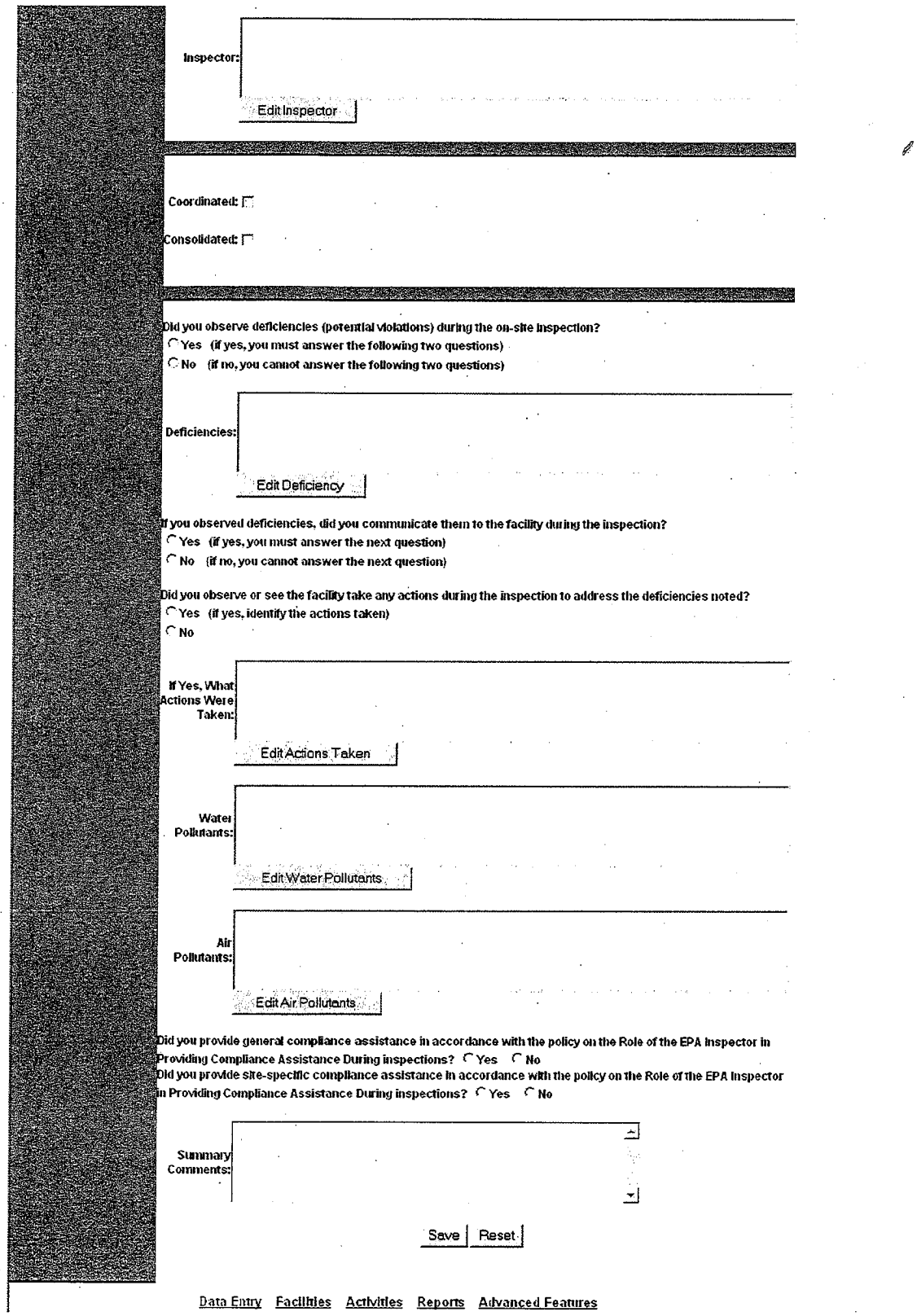
Figure 9.1.4-1: Add Compliance Monitoring Screen



A011227

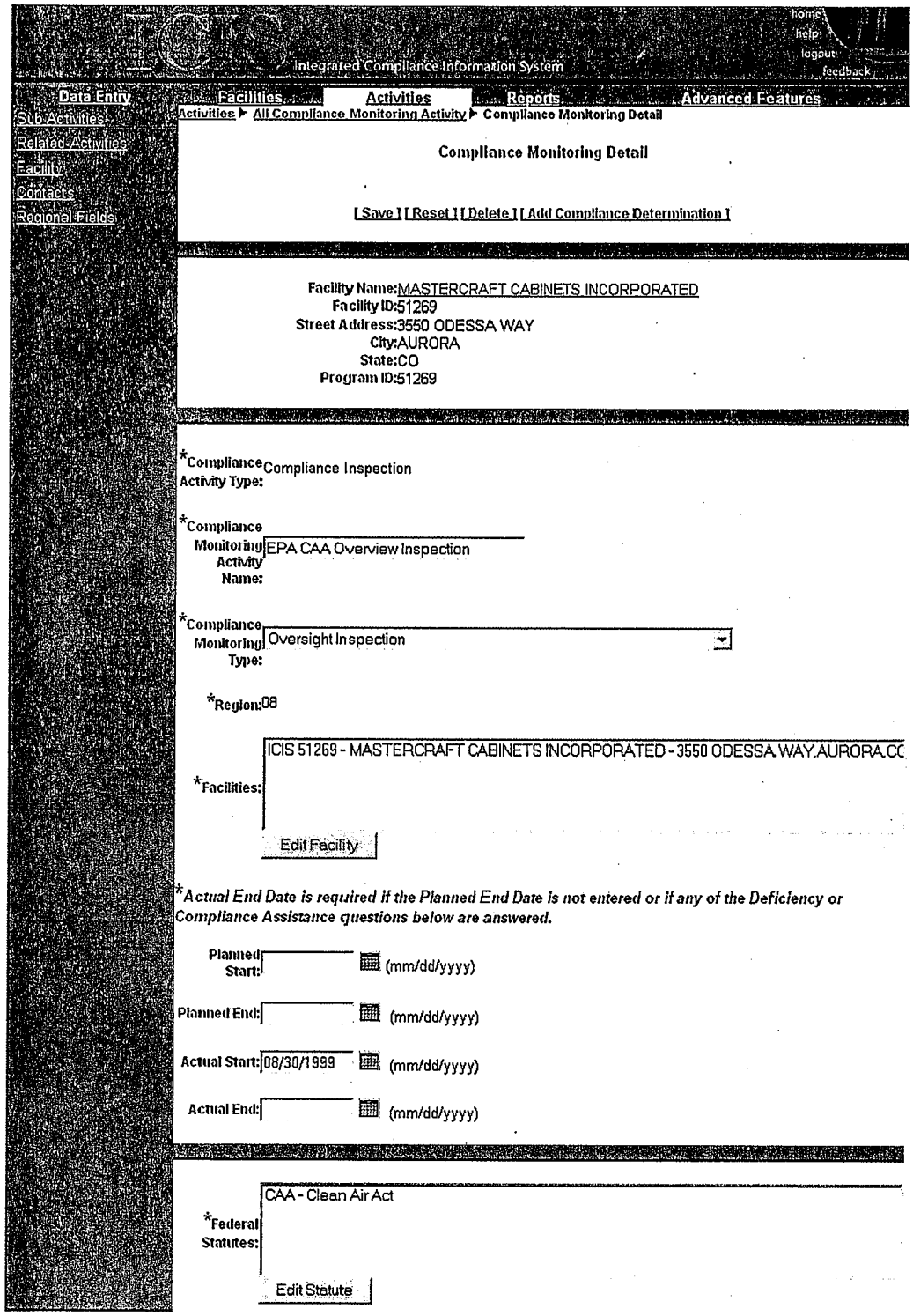

Programs:
SIC Code:
Edit SIC
NAICS Code:
Edit NAICS
Media Monitored:
*Compliance Monitoring Action Reason:
Edit Reason
U.S. EPA
*Compliance Monitoring Agency Type:
Edit Agency Code
If State, Local or Tribal Lead, did EPA assist:
Number of Days Physically Conducting Activity:
Number of Hours Physically Conducting Activity:
Compliance Monitoring Action Outcome:
MOA Priorities:
Edit MOA Priorities
Regional Priorities:
Edit Regional Priorities

A011228

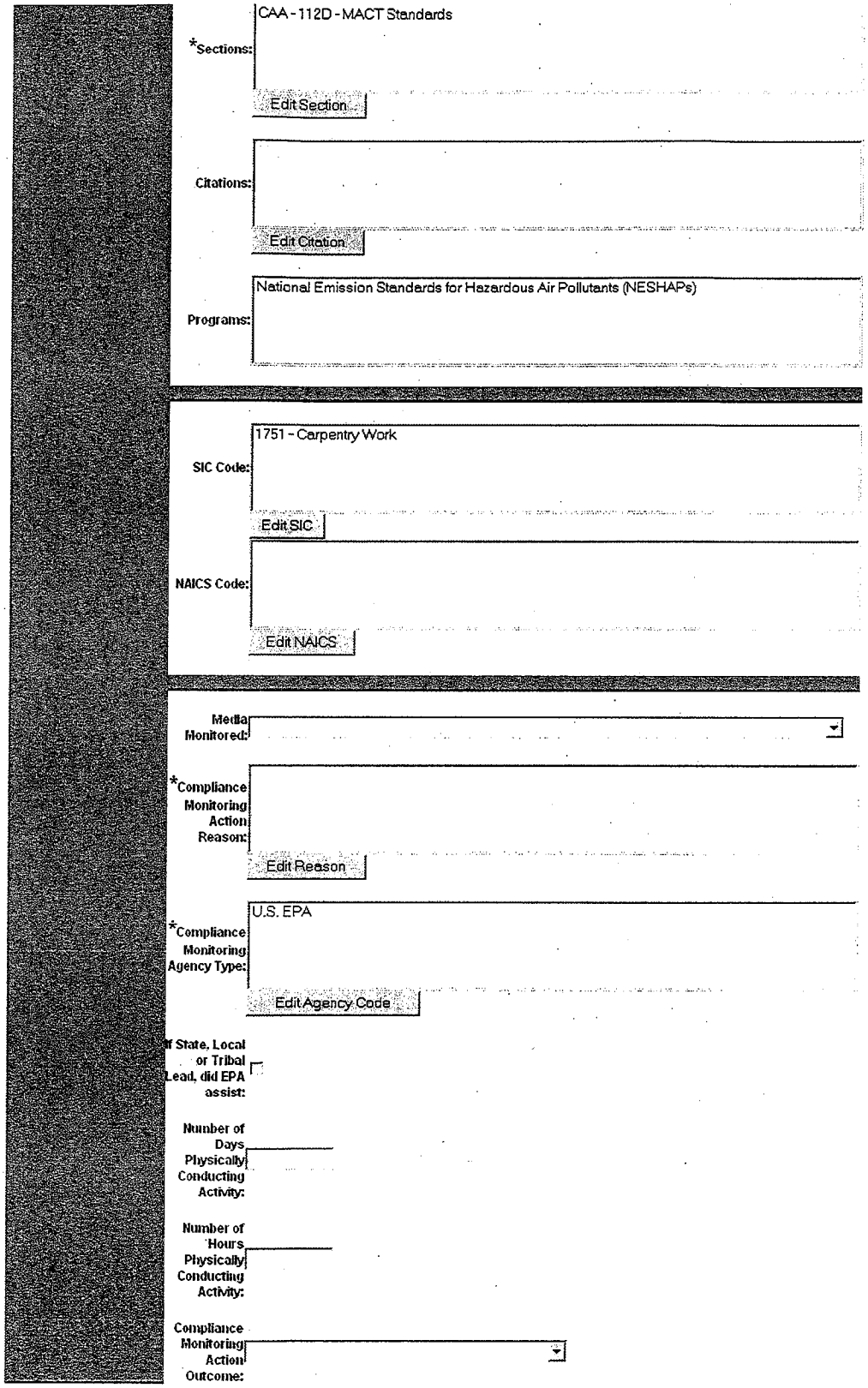

Inspector:
Edit Inspector
Coordinated:
Consolidated:
Did you observe deficiencies (potential violations) during the on-site inspection?
Yes (if yes, you must answer the following two questions)
No (if no, you cannot answer the following two questions)
Deficiencies:
Edit Deficiency
If you observed deficiencies, did you communicate them to the facility during the inspection?
Yes (if yes, you must answer the next question)
No (if no, you cannot answer the next question)
Did you observe or see the facility take any actions during the inspection to address the deficiencies noted?
Yes (if yes, identify the actions taken)
No
If Yes, What Actions Were Taken:
Edit Actions Taken
Water Pollutants:
Edit Water Pollutants
Air Pollutants:
Edit Air Pollutants
Did you provide general compliance assistance in accordance with the policy on the Role of the EPA Inspector in Providing Compliance Assistance During inspections? Yes No
Did you provide site-specific compliance assistance in accordance with the policy on the Role of the EPA Inspector in Providing Compliance Assistance During inspections? Yes No
Summary Comments:
Save
Reset
Data Entry Facilities Activities Reports Advanced Features

A011229

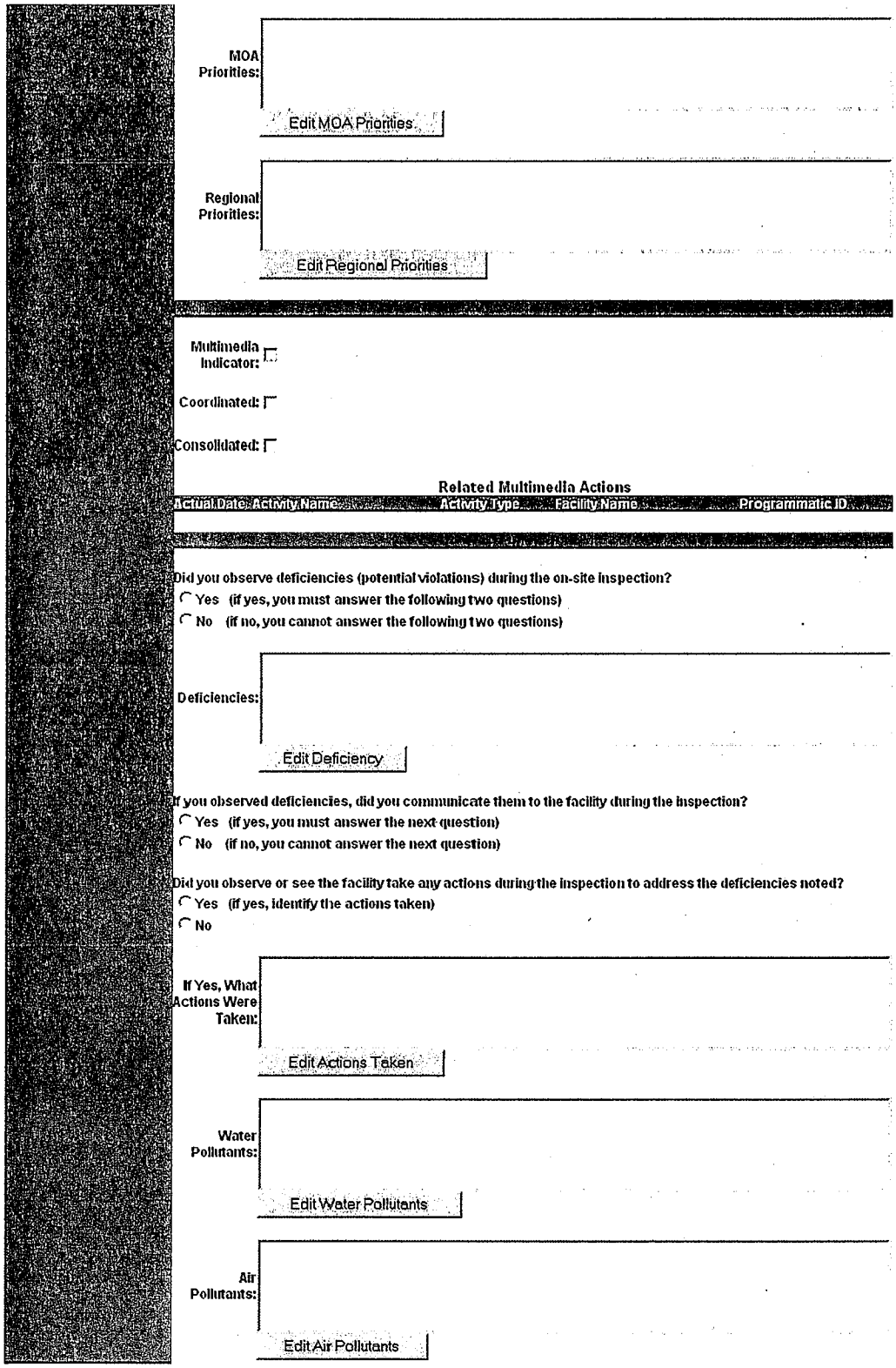
Figure 9.1.4-2: Compliance Monitoring Detail Screen



A011230


*Sections:
CAA - 112D - MACT Standards
Edit Section
Citations:
Edit Citation
Programs:
National Emission Standards for Hazardous Air Pollutants (NESHAPs)
SIC Code:
1751 - Carpentry Work
Edit SIC
NAICS Code:
Edit NAICS
Media Monitored:
*Compliance Monitoring Action Reason:
Edit Reason
*Compliance Monitoring Agency Type:
U.S. EPA
Edit Agency Code
If State, Local or Tribal Lead, did EPA assist:
Number of Days Physically Conducting Activity:
Number of Hours Physically Conducting Activity:
Compliance Monitoring Action Outcome:

A011231


MOA Priorities:
Edit MOA Priorities
Regional Priorities:
Edit Regional Priorities
Multimedia Indicator:
Coordinated:
Consolidated:
Related Multimedia Actions
Actual Date
Activity Name
Activity Type
Facility Name
Programmatic ID
Did you observe deficiencies (potential violations) during the on-site inspection?
Yes (if yes, you must answer the following two questions)
No (if no, you cannot answer the following two questions)
Deficiencies:
Edit Deficiency
If you observed deficiencies, did you communicate them to the facility during the inspection?
Yes (if yes, you must answer the next question)
No (if no, you cannot answer the next question)
Did you observe or see the facility take any actions during the inspection to address the deficiencies noted?
Yes (if yes, identify the actions taken)
No
If Yes, What Actions Were Taken:
Edit Actions Taken
Water Pollutants:
Edit Water Pollutants
Air Pollutants:
Edit Air Pollutants

A011232

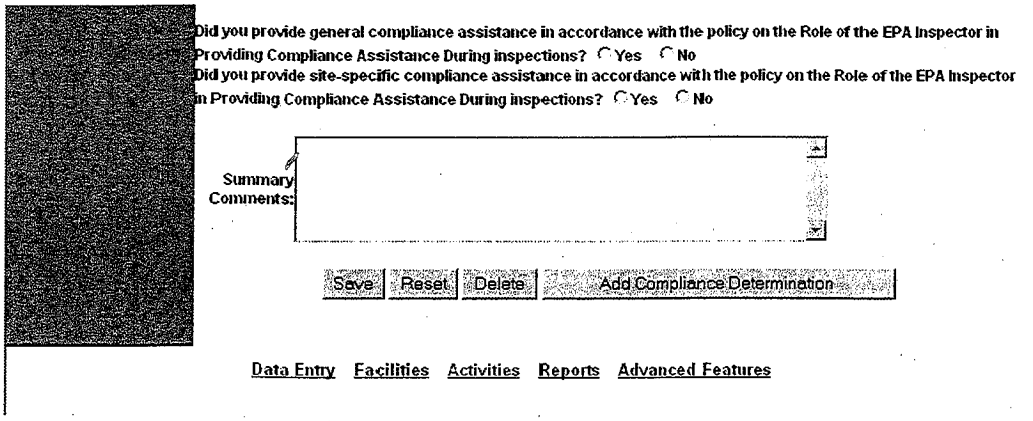


Table 9.1.4-1: Compliance Monitoring Fields

Field	Description	Business Rules/Instructions
• Facility Name • Facility ID • Street Address • City • State • Program ID.	These fields identify the facility site that is related to the compliance monitoring activity.	• Facility information is display only and only appears on the Detail screen. • These fields are blank when the screen is initially displayed after adding the activity through the Add Compliance Monitoring screen. They are populated as a result of the user linking a facility to the activity using the Facility side menu option. • If multiple facilities are linked to the activity, data for the first facility that was linked are displayed.

A011233

Field	Description	Business Rules/Instructions
Compliance Activity Type	This is the type of compliance monitoring action taken by a regulatory agency (i.e., Information Request, Off-site Review). A drop-down list of valid values is provided, which contains:* • Information Request - An enforceable, written request for information to a regulated entity or potentially regulated entity about a site, facility, or activity. Examples include issuance of a subpoena for the production of documents or testimony, or a requirement that a facility conduct testing or sampling (e.g., a stack test). • Compliance Inspection - A visit to a facility or site for the purpose of gathering information to determine compliance including direct observations of facility operations. Examples include inspections pursuant to a search warrant or an order in aid of access; inspections at a regulated entity's office location; and off-site observations of a facility or site. • Compliance Investigation - An extraordinary, detailed assessment of a regulated entity's compliance status. • Off-site Record Review - A review of records, conducted at the government agency's offices, for the purpose of reviewing information to determine compliance of a regulated entity. Examples include the review of the reports of facility-conducted testing or sampling tests submitted by the regulated entity; the review of self-reported information from regulated entities, including information required to be submitted (e.g., Discharge Monitoring Report [DMR] or CAA Title V self-certifications) and voluntarily submitted information. • Voluntary Disclosure – The voluntary submission of information regarding a potential violation. *Note: Definition of terms is not provided in the drop-down list.	• Compliance Activity Type only appears on the Add Compliance Monitoring screen. The user cannot modify Compliance Activity Type once the activity is saved. • Compliance Activity Type is required; the user must select a value from the drop-down list. • If the user selects Voluntary Disclosure, the alert, 'You have made a request that will take you to another Page. All changes on this page will be lost.', is displayed. The user then has the option of clicking OK to display the Voluntary Disclosure Detail screen or Cancel to return to the Add Compliance Monitoring screen.

A011234

Field	Description	Business Rules/Instructions
Compliance Monitoring Activity Name	This is the name given to the Compliance Monitoring activity to allow users to identify the Compliance Monitoring data. This field is a concatenation of the name that the user entered through the Add screen and the statute code that they selected.	Compliance Monitoring Activity Name is required. The user must enter a name in this field.
Compliance Monitoring Type	This is a description of the type of Compliance Monitoring activity taken by a regulatory Agency. Inspections to determine the compliance of a facility or regulated entity with the terms of a previously issued enforcement instrument are included here. A drop-down list of valid values is provided.	• Compliance Monitoring Type is a required field. The user must select a value from the drop-down list. • The contents of the drop-down list are filtered based on the value of Compliance Activity Type.
Region	This is the EPA region associated with the monitoring activity. A drop-down list of valid values is provided on the Add screen.	Region is required: • Add screen: – For regional users, Region defaults to the login user's region as determined through their roles. – Headquarters users or users affiliated with more than one region must select a region from the drop-down list. • Detail screen: Region is display only and defaults to the region that was entered/defaulted to on the Add screen.
Planned Start	This is the date that the Compliance Monitoring action is planned to begin.	The user may enter Planned Start by using the calendar icon to select a date from the calendar pop-up or by typing a date directly in the field. If entered, Planned Start: • Must be a valid date in mm/dd/yyyy format • Can be a past, current, or future date • Cannot be after the Planned Completion date.
Planned Completion	This is the date that the Compliance Monitoring action is planned to end.	The user may enter Planned Completion by using the calendar icon to select a date from the calendar pop-up or by typing a date directly in the field. If entered, Planned Completion: • Must be a valid date in mm/dd/yyyy format • Can be a past, current, or future date • Cannot be prior to the Planned Start Date.

A011235

Field	Description	Business Rules/Instructions
Actual Start	This is the date that the Compliance Monitoring action was performed or conducted (i.e., ICDS - Date of Inspection).	The user may enter Actual Start by using the calendar icon to select a date from the calendar pop-up or by typing a date directly in the field. If entered, Actual Start: • Must be a valid date in mm/dd/yyyy format • Can be a past or current date • Cannot be a future date • Cannot be greater than the Actual Completion date.
Actual End	This is the actual date on which the Compliance Monitoring activity was completed.	The user may enter Actual End by using the calendar icon to select a date from the calendar pop-up or by typing a date directly in the field. If entered, Actual End: • Must be a valid date in mm/dd/yyyy format • Can be a past or current date • Cannot be a future date • Date cannot be prior to the Actual Start date.
Federal Statutes	This is the law(s) that is permitting the Compliance Monitoring action.	• Federal Statutes is a required field. The user must click on the Edit Statutes button to select one or more statutes from the resulting multi-select pop-up window. • Statutes are filtered based on the Program(s) to which the user is affiliated through their role(s). • To create a multi-media activity, the user must select multiple statutes, as well as at least one corresponding section for each statute selected. • When multiple statutes are saved, individual compliance monitoring activities are created for each statute and are displayed on separate Compliance Monitoring Detail screens.
Sections	This is the section(s) of law(s) that is authorizing the Compliance Monitoring action.	• Sections is a required field. The user must click on the Edit Sections button to select one or more sections from the resulting multi-select pop-up window. • Sections are filtered based on both the Program(s) to which the user is affiliated through their role(s) as well as the selected statutes. • The user must select at least one section for a listed statute for that statute to be saved with the activity. • To create a multi-media activity, the user must select multiple statutes, as well as at least one corresponding section for each statute selected.

A011236

Field	Description	Business Rules/Instructions
Citations	This is the Code of Federal Regulations (CFRs) that permits the monitoring action. Citation is composed of three components: • Title • Part • Section.	Citations is an optional field; however, to add one or more citations to the activity, the user: • Must click on the Edit Citations button to display the Citations data entry pop-up window • Must enter data in each of the three components (Title on the first citation defaults to 40 CFR; however, the user may edit this value) • May enter up to five citations at a time. To add more than five citations, the user must once again click on the Edit Citations button.
Programs	This is the EPA program applicable to the monitoring activity.	Programs is display only and is automatically populated based on the Section(s) that the user selects.
SIC	This is the 4-digit Standard Industrial Classification (SIC) code that represents the economic activity of a company.	SIC is an optional field; however, to enter data in this list box, the user must click on the Edit SIC button to select one or more SICs from the resulting multi-select pop-up window.
NAICS	This is the 6-digit code that represents a subdivision of an industry that accommodates user needs in the United States.	NAICS is an optional field; however, to enter data in this list box, the user must click on the Edit NAICS button to select one or more NAICS from the resulting multi-select pop-up window.
Media Monitored	This is the description of the media associated with the EPA programs. A drop-down list of valid values is provided.	The user selects a value from a drop-down list.
Compliance Monitoring Action Reason	This is the reason for performing a Compliance Monitoring action.	• Compliance Monitoring Action Reason is a required field. To enter data in this list box, the user must click on the Edit Reason button to select one or more Reasons from the resulting multi-select pop-up window. • Reasons are dependent on the Compliance Activity Type. If on the Add screen the user changes the Compliance Activity Type after selecting reasons but before saving, an alert is generated informing them that because the reasons are dependent on Compliance Activity Type, the previously selected values may no longer be valid and are being cleared. The users must then select new reasons. (This is not an issue on the Detail screen because Compliance Activity Type does not appear on that screen.)

A011237

Field	Description	Business Rules/Instructions
Compliance Monitoring Agency Type	This is the type of agency performing or conducting the Compliance Monitoring action. A drop-down list of valid values is provided. The list includes:* • U.S. EPA - United States Environmental Protection Agency • Other Federal - Another agency of the United States • State - State agency • Interstate - Interstate agency • Local - Local agency • Tribal - Tribal government agency. *Note: Acronyms are not spelled out in the drop-down list.	Compliance Monitoring Agency Type is required. The user must select a value from the drop-down list.
If State, Local, or Tribal lead, did EPA assist	This is a check box that is used to indicate whether or not EPA was the lead agency.	The default for this box is unchecked. The user cannot check this box if Compliance Monitoring Agency Type is U.S. EPA.
Length of Activity in days	This is the length of the monitoring activity in days (i.e., number of days to perform the inspection).	This field is optional; however, when populating this field, the user must enter a whole number (i.e., zero or higher).
Number of hours spent on the activity	This is the total number of hours spent on the monitoring activity (i.e., hours spent on the investigation).	This field is optional; however, when populating this field, the user must enter a whole number (i.e., zero or higher).
Compliance Monitoring Activity Outcome.	This is the result of the Compliance Monitoring action. A drop-down list of valid values is provided.	Compliance Monitoring Activity Outcome is optional; however, to enter a value in this field, the user must select that value from the drop-down list.
MOA Priorities	This is the name of the Memorandum of Agreement (MOA) associated with the activity.	• MOA Priorities is an optional field; however, to enter data in this list box, the user must click on the Edit MOA Priorities button to select one or more priorities from the resulting multi-select pop-up window. • Only current fiscal year priorities where Region is HQ are available to the user for selection.

A011238

Field	Description	Business Rules/Instructions
Regional Priorities	The name of the regional priority associated with the activity.	• Regional Priorities is an optional field; however, to enter data in this list box, the user must click on the Edit Regional Priorities button to select one or more priorities from the resulting multi-select pop-up window. • Only current fiscal year priorities affiliated with the entered/defaulted Region are available to the user for selection. • If on the Add screen the user changes the Region code after selecting regional priorities but before saving, an alert is generated informing them that because the priorities are dependent on region, the previously selected values may no longer be valid and are being cleared. The users must then either select new regional priorities or leave the field blank. (This is not an issue on the Detail screen because Region is display only and cannot be changed.)
Multi-media Indicator	This is a check box used to indicate that the Compliance Monitoring Action is a multi-media activity (i.e., a Compliance Monitoring Action designed to verify compliance with two or more distinct environmental programs conducted within a short time frame).	• Multi-media Indicator only appears on the Compliance Monitoring Detail screen and then only when the current activity is a multi-media activity. • This indicator is display only and defaults to checked.
Coordinated	This is a check box used to indicate whether or not no more than three months may have elapsed between the inspection by one program and a subsequent inspection by another program.	The default for this box is unchecked. To indicate that no more than three months may have elapsed between the inspection by one program and a subsequent inspection by another program, the user must check this box.
Consolidated	This is a check box used to indicate whether or not a single inspection covered two or more programs under different statutes.	The default for this box is unchecked. To indicate that a single inspection covered two or more programs under different statutes, the user must check this box.
Related Multimedia Actions: • Actual Date • Activity Name • Facility Name • Programmatic ID.	This section identifies, in tabular format, those activities that are related to the current activity through a multi-media action. It is populated when the user selects multiple statute/law section combinations on either the Add or Detail screen, thereby creating individual compliance monitoring activities for each selected statute.	• This section is display only and only appears on the Detail screen. • The user may click on the Activity Name link of a listed activity to display the Compliance Monitoring Detail screen for that named multi-media activity. • Each listed activity is linked to each of the other listed activities and is also listed in the Related Multimedia Actions sections on those activities' Detail screens.

A011239

Field	Description	Business Rules/Instructions
If you observed deficiencies during inspection, did you communicate the deficiencies to the facility at that time?	These radio buttons are used to identify whether or not the facility was made aware of the observed deficiencies according to regional policies.	The user has three options concerning these radio buttons: • To indicate that deficiencies were observed and communicated to the facility, the user must click on the Yes radio button. • To indicate that deficiencies were observed but not communicated to the facility, the user must click on the No radio button. • To indicate that deficiencies were not observed, the user must not select either radio button. The user must select either of the two radio buttons when Deficiencies are selected. (See below.)
Deficiencies	These are the deficiencies that were observed during the inspection.	• To enter data in this list box, the user must click on the Edit Deficiencies button to select one or more deficiencies from the resulting multi-select pop-up window. • The user must enter one or more deficiencies when either the Yes or No radio button is selected in answer to the question,' If you observed deficiencies during inspection, did you communicate the deficiencies to the facility at that time?' • The user cannot enter any deficiencies when neither radio button is selected.
Did you observe or see the facility take any actions during the inspection to address the deficiencies noted?	These radio buttons are used to indicate whether or not any actions were taken by the facility to correct deficiencies.	The user must select one of these radio buttons if they select either Yes or No in answer to the question, ' If you observed deficiencies during inspection, did you communicate the deficiencies to the facility at that time?': • To indicate that the facility took actions or was observed to have taken actions to correct the noted deficiencies, the user must click on the Yes radio button. • To indicate that the facility did not take actions, or was not observed to have taken actions to correct the noted deficiencies, the user must click on the No radio button. If neither button was selected in answer to the question, ' If you observed deficiencies during inspection, did you communicate the deficiencies to the facility at that time?', then the user cannot select either Yes or No here.

A011240

Field	Description	Business Rules/Instructions
If Yes, Corrective Action Taken	This lists the corrective action(s) taken to address the noted deficiencies.	• To enter data in this list box, the user must click on the Edit Corrective Actions button to select one or more actions from the resulting multi-select pop-up window. • The user must select one or more corrective actions when the answer to the question, 'Did you observe or see the facility take any actions during the inspection to address the deficiencies noted?', is Yes. • The user cannot select any corrective actions when the answer to that question is No.
Water Pollutants	This lists the water pollutant(s) that were identified in the deficiency and had corrective action taken.	• Water pollutants is an optional field; however, the user must select at least one water pollutant when the selected corrective actions include Reduced Pollution (e.g., User Reduction, Indstrl Process Change, Emissions or Discharge Change) is selected. • To enter data in this list box, the user must click on the Edit Water Pollutants button to select one or more pollutants from the resulting multi-select pop-up window.
Air Pollutants	This lists the air pollutant(s) that were identified in the deficiency and had corrective action taken.	• Air Pollutants is an optional field; however, the user must select at least one air pollutant when the selected corrective actions include, Reduce(d) Pollution (e.g., Cease Excess Air Emissions). • To enter data in this list box, the user must click on the Edit Air Pollutants button to select one or more pollutants from the resulting multi-select pop-up window.
Did you provide compliance assistance during the inspection?	These radio buttons are used to indicate whether or not compliance assistance was given during the inspection.	• To indicate that compliance assistance was given during the inspection, the user must click on the Yes radio button. • To indicate that compliance assistance was not given during the inspection, the user must click on the No radio button.

A011241

Field	Description	Business Rules/Instructions
If yes, what type of assistance did you provide?	These radio buttons are used to indicate what kind of compliance assistance, if any, was provided during the inspection: • Tier 1- Distribution or sharing information on regulatory compliance, P2, or technical written assistance materials or websites and EPA, state, and local assistance programs. • Tier 2 - Assistance when they share information and insight into a facility's particular compliance problem and/or information on recognized industry practices to reduce or eliminate pollution at the facility. • Both – Both Tier 1 and Tier 2 assistance was provided during the inspection.	• The user must select one of these three radio buttons when the answer to the question, 'Did you provide compliance assistance during the inspection?' is Yes. • The user cannot select any of these three radio buttons when the question, 'Did you provide compliance assistance during the inspection?', is not answered (i.e., neither the Yes or No radio button is selected) or the answer is No.
Summary Comments	EPA inspectors may wish to provide a narrative description of actions taken by the facility or assistance to help the facility come into compliance.	

Table 9.1.4-2: Compliance Monitoring Buttons

Button Actions	
Button	**Action**
Save	The user clicks on this button to validate and save the compliance monitoring data. If required fields are left blank at the time of the save, an alert, 'The following fields are required:', listing the required fields is displayed. The user must enter each of the listed fields before attempting to save again. If a field fails the edit criteria, then an appropriate alert is displayed informing the user of the error and the user must correct the data before attempting to save again. Once the monitoring activity is successfully saved, the Compliance Monitoring Detail screen is automatically displayed, populated with the entered data. The message, '**Data has been successfully saved at <date, time>**' is displayed left aligned beneath the screen title.
Reset	The user clicks on Reset to revert the screen to its initial display values. Upon clicking on this button, the confirmation message, 'Do you want to reset this record's data?', is displayed. The user then has the option of clicking on OK to clear the entered data and revert to the screen defaults on the Add screen or to the last saved record on the Detail screen, or clicking on Cancel to leave the screen populated with the data that they have just entered and/or updated.
Delete	• The user clicks on this button to display a pop-up window that lists the number of dependencies linked to the current incident and prompts the user to confirm their intent to delete it (i.e., The Activity <compliance monitoring name> has the following dependencies. Do you want to delete it?). • This button is only available on the Compliance Monitoring Detail screen. • This button is only available for users with the rights to delete Compliance Monitoring activities.

A011242

Button Actions	
Button	**Action**
Release Data	• The user clicks on this button to display a pop-up window that lists the number of dependencies linked to the current Compliance Monitoring activity and prompts the user to confirm their intent to release it (i.e., The Activity <compliance monitoring name> has the following dependencies. Do you want to release it?). • This button is only available on the Compliance Monitoring Detail screen. • This button is only available for users with the rights to release Compliance Monitoring data from internal review for the program associated with the Compliance Monitoring activity. • See Section 4 for a description of the Internal Review functionality.
Add Compliance Determination	• The user clicks on this button to open the Add Compliance Determination screen from the Compliance Monitoring Detail screen. The user must click on Save to save any updates input on the Compliance Monitoring Detail screen; the Add Compliance Determination button will not save the monitoring data. • This button is only available on the Compliance Monitoring Detail screen.

A011243

California Regional Water Quality Control Board
General Industrial Activities Storm Water Permit, Order No. 97-03-DWQ
NPDES Permit No. CAS000001

Industrial Storm Water Inspection Report

GENERAL INSPECTION INFORMATION

WDID Number	Inspection Date	Arrival Time	Weather Conditions
4 56I001102	6/26/2007	10:30:00 AM	clear skies, no evidence of recent rain

Facility Name
Santa Paula Airport

Facility Address
8th St. and Santa Maria St.
Santa Paula, CA 93060

Facility Contacts Present During Inspection	Contact Phone Number
Rowena Mason and Bradley Ball	(805) 933-1155

SIC Code	Facility Size	% Impervious
45XX - Air Transportation Facilities That Have Vehicle Maintenance Shops, Material Handing Facilities, Equipment Cleaning Operations, or Airport and/or Aircraft Deicing/Anti-icing Operations	38 Acres	nd

Group Monitoring Plan Name (If Applicable)	NOI Filing Date	Name of Receiving Water
N/A	3/25/1992	Santa Clara River

Purpose of Inspection	
Type 1 (compliance)	Inspection Pre Announced? ☑ Photographs Taken? ☑ *Facility was inspected*

Storm Water Pollution Prevention Plan (SWPPP) Review

The SWPPP was reviewed at the facility.

The following required SWPPP components were deficient:

The SWPPP site map was incomplete (CAS000001 Attachment A.4.).

The site map did not identify storm water sampling locations.

Storm Water Monitoring Plan (SWMP) Review

The monitoring plan did not describe storm water sampling locations (CAS000001 Attachment B.7.).

The SWPPP did not identify sampling locations.

SWPPP Best Management Practices (BMPs) Implementation

Stains were noted on the pavement in front of the fuel farm (Photo 10).
A SWPPP citation was not acquired for this deficiency.

Annual Report Review

The inspector DID review the annual report for the previous reporting period. The annual report was determined to be complete unless noted below.

The following required monitoring and observation records were not available in the previous year's annual report or at the facility (if annual report was not available):

California Regional Water Quality Control Board
General Industrial Activities Storm Water Permit, Order No. 97-03-DWQ
NPDES Permit No. CAS000001

Industrial Storm Water Inspection Report

Only 1 sample collected on 4/10/06; second sample collected was mishandled/lost

Storm water samples were not collected from representative storm water discharge locations (CAS000001 Attachment B.7.).

Current sample locations do not characterize runoff from all industrial activities at the airport. The inspectors recommended discontinuing the collection of samples at the fuel station (sample point 2) and at the far west storm drain adjacent to the bioswale (sample point 1). The inspectors further recommended collecting future storm water samples at the storm drain behind Ray's Aviation (Photo 6) and at the storm drain east of the current sample location 1.

Storm Water Analytical Results for the Previous Reporting Period

The facility's SIC code requires storm water samples to be analyzed for pH, TSS, SC, and O&G or TOC, PLUS the additional Table D parameters of BOD; COD; NH3; pH.

General Description

Santa Paula Airport was inspected on 6/26/2007 to determine compliance with NPDES General Permit No. CAS000001. Santa Paula Airport is categorized under SIC code 45XX - Air Transportation Facilities That Have Vehicle Maintenance Shops, Material Handing Facilities, Equipment Cleaning Operations, or Airport and/or Aircraft Deicing/Anti-icing Operations. The inspector met with Rowena Mason and Bradley Ball to tour the facility and review relevant storm water paperwork. The inspection was conducted between 10:30:00 AM and 12:30:00 PM. Weather conditions at the time of the inspection were: clear skies, no evidence of recent rain.

Santa Paula Airport (facility) is a 38-acre non-towered, private airport run by a Board of Directors of which Ms. Mason is the President. The airport consists of approximately 300 aircraft, 117 hangars, 100 tie-downs, one Fixed Base Operation and one fuel farm with 100LL aircraft fuel (Photos 8 and 9).

No vehicle maintenance or washing and no aircraft washing activities occur at the facility. Two aircraft maintenance shops conduct maintenance indoors. Fluids, including herbicides used for facility maintenance, are stored indoors. Hangars are leased to small businesses and private aircraft owners and are periodically inspected by Mr. Ball and/or Ms. Mason (facility representatives).

The Santa Clara River parallels the airport to the south. Aside from this area, the majority of the facility gradually slopes in a westerly direction. A bioswale (West Bioswale) parallels the runway on the south side from midfield to the west (Photo 7). Runoff from the larger hangar area, fuel farm, restaurant, and transient aircraft parking flows to the West Bioswale. Storm water samples are collected at the fuel farm (Sample Point #2; Photos 8 and 9) and at an outfall slightly west of midfield (Sample Point #1; Photo 7).

The storm drain south of Ray's Aviation is surrounded by loose gravel and dirt; stabilization of this area was discussed with the facility representatives. Storm drains located in the bioswales are surrounded by vegetation. All other drains inspected on the property were surrounded by impervious surfaces and appeared to be maintained appropriately.

The airport experiences significant run-on from the town of Santa Paula down 10th Street and flows across a bioswale to a storm drain (Photos 2, 3, 4, and 5).

across a small dirt area, across the runway extension, to a recently created bioswale (East Bioswale - parallel to and south of the runway extension). From the East Bioswale, run-on enters a storm drain in the bioswale and discharges to the Santa Clara River (Photos 2, 3, 4, and 5).

Preliminary inspection results were discussed with the facility representative.

A011245

California Regional Water Quality Control Board
General Industrial Activities Storm Water Permit, Order No. 97-03-DWQ
NPDES Permit No. CAS000001

Industrial Storm Water Inspection Report

Tt Inspector(s) and Tt Reviewer

Power (Tt)	Scott Slamal (Tt)	7/3/2007
Tetra Tech Inspector Name	*Tetra Tech Reviewer*	*Report Date*

A011246

California Regional Water Quality Control Board
General Industrial Activities Storm Water Permit, Order No. 97-03-DWQ
NPDES Permit No. CAS000001

Industrial Storm Water Inspection Report

GENERAL INSPECTION INFORMATION

WDID Number	Inspection Date	Arrival Time	Weather Conditions
4 56I002775	6/26/2007	9:30:00 AM	clear skies, no evidence of recent rain

Facility Name
County of Ventura Camarillo Airport

Facility Address
555 Airport Way
Camarillo, CA 93010

Facility Contacts Present During Inspection	Contact Phone Number
Aaron Walsh, Erin Powers, and Todd McNamee	(805) 382-3024

SIC Code	Facility Size	% Impervious
45XX - Air Transportation Facilities That Have Vehicle Maintenance Shops, Material Handing Facilities, Equipment Cleaning Operations, or Airport and/or Aircraft Deicing/Anti-icing Operations	659 Acres	60 %

Group Monitoring Plan Name (If Applicable)	NOI Filing Date	Name of Receiving Water
AAAE/ARDF	4/2/1992	Mugu Lagoon

Purpose of Inspection	
Type 1 (compliance)	Inspection Pre Announced? ☑ Photographs Taken? ☑ *Facility was inspected*

Storm Water Pollution Prevention Plan (SWPPP) Review

The SWPPP was reviewed at the facility.

The SWPPP was determined to meet General Permit requirements.

Storm Water Monitoring Plan (SWMP) Review

The monitoring plan did not describe storm water sampling methods (CAS000001 Attachment B.10.).

SWPPP Best Management Practices (BMPs) Implementation

Section 6.5.2 of the facility's SWPPP states, "all chemicals are stored inside enclosed facilities or, if stored outside, stored under a roof or cover." Seven 55-gallon drums containing waste oil and an aircraft oil pan were identified outside of containment or cover near the Commemorative Aircraft hanger (Photos 9 and 10). Staining was also observed on the pavement in this area.

Section 4 of the facility's SWPPP identifies potential sources of pollutants. This section does not include a description of the facility's tie down areas. Three aircrafts were stored at the C and J Sales tie down area, near the storm water swales. Each was leaking hydraulic fluid (Photos 2, 3, and 4), a potential pollutant to storm water discharges.

Unauthorized Non-Storm Water Discharges Were Documented During the Inspection.

A011247

California Regional Water Quality Control Board
General Industrial Activities Storm Water Permit, Order No. 97-03-DWQ
NPDES Permit No. CAS000001

Industrial Storm Water Inspection Report

Section 6.3 of the SWPPP allows washing of aircraft outside of the wash rack only if wash water is not allowed to flow across paved parking or work areas and if wash water is not discharged to a storm drain. Two unauthorized, non-storm water discharges were identified during the inspection. Aircraft washing was identified outside of the wash rack area (Photo 1). Wash water was flowing across the tie down area of C and J Sales, into the storm water swale, and discharging to a storm drain (Photos 5 and 6). Wash water was entering the storm drain near the Sheriff's Department (Photo 8). Section 3.9.2 of the SWPPP discusses this as an allowed activity.

Annual Report Review

The inspector DID review the annual report for the previous reporting period. The annual report was determined to be complete unless noted below.

The following required monitoring and observation records were not available in the previous year's annual report or at the facility (if annual report was not available):

Storm water samples were not collected from representative storm water discharge locations (CAS000001 Attachment B.7.).

Three storm water outfalls receive runoff from the facility. The facility collects storm water samples from only one, Outfall 1. Outfall 1 is mainly influenced by the Camarillo Hills Drain and the west and southwest edge of the facility. Outfalls 2 and 3 are mainly influenced by the industrial activities of the airport and would be the appropriate outfalls to sample during storm events. The inspectors (Jacques [Tt] and Lee [RWQCB]) suggested that storm water samples be collected from these outfalls and not Outfall 1.

Records of an annual comprehensive site compliance investigation were not available (CAS000001 Attachment A.9.).

Storm Water Analytical Results for the Previous Reporting Period

The facility's SIC code requires storm water samples to be analyzed for pH, TSS, SC, and O&G or TOC, PLUS the additional Table D parameters of BOD; COD; NH3; pH.

Storm water sample results exceeded U.S. EPA/RWQCB benchmark values for the following parameters:

10/17/2005
Outfall 1: pH 9.5 s.u. (6-9 s.u.) and TSS 340 mg/L (100 mg/L)
Benchmark values are reported parenthetically. The facility is recommended to investigate the source(s) of these exceedences, review current BMPs, and consider additional BMPs to address potential sources.

General Description

County of Ventura Camarillo Airport was inspected on 6/26/2007 to determine compliance with NPDES General Permit No. CAS000001. County of Ventura Camarillo Airport is categorized under SIC code 45XX - Air Transportation Facilities That Have Vehicle Maintenance Shops, Material Handing Facilities, Equipment Cleaning Operations, or Airport and/or Aircraft Deicing/Anti-icing Operations. The inspector met with Aaron Walsh, Erin Powers, and Todd McNamee to tour the facility and review relevant storm water paperwork. The inspection was conducted between 9:30:00 AM and 12:30:00 PM. Weather conditions at the time of the inspection were: clear skies, no evidence of recent rain.

The County of Ventura Camarillo Airport (facility) consists of 658 acres, owned and operated by the County of Ventura. Airport related activities include the operation of 319 hangers, 204 aircraft tie downs, and 348,000 square feet of leased building space. Services include aircraft sales, fueling and maintenance activities, flight training, aircraft washing, and charter operations. Non-airport related activities include administrative and private commercial and office uses.

Potential pollutant sources include oil and grease, waste oil, aircraft and vehicle fuel, solvents, wash

A011248

water, suspended solids, herbicides, pesticides, fertilizers, and other chemicals stored on site. The facility provides waste oil storage for each Fixed Based Operator and tenant.

Runoff from the facility either flows from north to south or east to west. The airport is bounded on the north and west by the Camarillo Hills Drain (Photos 11 and 12) and to the south and east by the Pleasant Valley Drain. Wood Road Drain intersects and flows north to south through the center portion of the facility. A drainage ditch runs east to west through the agricultural infield area of the airport and discharges in the Wood Road Drain. Runoff from each drain eventually flows to the Revlon Slough Drain which discharges to the Mugu Lagoon.

Runoff from the southeast section of the airport flows to a series of catch basins and underground storm drains which discharge through Outfall 3 (Photo 15). The southeast section of the airport includes most industrial activities that are conducted on site. Runoff from the central, northeast, and most of the western portions of the runway, several hangers, and the control tower (located in the south-central portion of the facility) flow overland or through a series of catch basins and underground storm drains to Outfall 2 (Photo 14). Runoff from the western and southwestern edge of the facility flows overland to Outfall 1 (Photo 13).

The facility collects storm water samples from Outfall 1 only. The majority of industrial activities occur in Outfall 2 and 3 drainage areas. Therefore, samples collected from Outfall 1 are not representative of industrial activities that occur on site. The facility representatives and inspectors (Jacques [Tt] and Lee [RB]) discussed the need to collect samples from all representative outfalls, particularly Outfalls 2 and 3.

Preliminary inspection results were discussed with the facility representative.

Tt Inspector(s) and Tt Reviewer

Jacques (Tt)	Scott Slamal (Tt)	7/5/2007
Tetra Tech Inspector Name	*Tetra Tech Reviewer*	*Report Date*

A011249

California Regional Water Quality Control Board
General Industrial Activities Storm Water Permit, Order No. 97-03-DWQ
NPDES Permit No. CAS000001

Industrial Storm Water Inspection Report

GENERAL INSPECTION INFORMATION

WDID Number	Inspection Date	Arrival Time	Weather Conditions
4 56I002776	6/26/2007	2:00:00 PM	clear skies, no evidence of recent rain

Facility Name
Oxnard Airport

Facility Address
2889 5th
Oxnard, CA 93030

Facility Contacts Present During Inspection	Contact Phone Number
Erin Powers	(805) 388-4200

SIC Code	Facility Size	% Impervious
45XX - Air Transportation Facilities That Have Vehicle Maintenance Shops, Material Handing Facilities, Equipment Cleaning Operations, or Airport and/or Aircraft Deicing/Anti-icing Operations	216 Acres	95 %

Group Monitoring Plan Name (If Applicable)	NOI Filing Date	Name of Receiving Water
AAAE/ARDF	4/2/1992	City of Oxnard Storm Sewer System

Purpose of Inspection	
Type 1 (compliance)	Inspection Pre Announced? ☑ Photographs Taken? ☑ *Facility was inspected*

Storm Water Pollution Prevention Plan (SWPPP) Review

The SWPPP was reviewed at the facility.

The following required SWPPP components were deficient:

The SWPPP site map was incomplete (CAS000001 Attachment A.4.).

The site map does not identify the location of storm drains or direction of flow.

Storm Water Monitoring Plan (SWMP) Review

The monitoring plan did not describe sampling and analysis methodology (CAS000001 Attachment B.5.).

The monitoring plan did not describe storm water sampling locations (CAS000001 Attachment B.7.).

The monitoring plan did not describe storm water sampling methods (CAS000001 Attachment B.10.).

SWPPP Best Management Practices (BMPs) Implementation

Section 3.7.2, Aspen Helicopters, of the SWPPP states, "Absorbent material (Kleensweep) is kept on hand for the collection of small oil spills." Stains and spills were observed throughout the Aspen Midfield area including the water and fuel truck parking area (Photo 11), material storage area (Photo 15), helicopter tie downs (Photo 14), waste oil and lubricants disposal drum area (Photo 16), and at the Aspen Midfield storm drain and in the swale (Photo 19).

A01250

Section 5.1.1, Secondary Containment, of the SWPPP states, "the majority of the chemicals used on site are stored under roofed facilities often in specially designated areas." The facilities are completely isolated and not exposed to storm water runoff conditions." Used batteries, waste oil and lubricants disposal drums, and numerous totes and buckets containing fertilizers and mineral oil, were stored without containment outside of the Aspen Helicopter Inc. hangar (Photos 13, 15, 16 and 18).

Inspector Note: Section 3.7.2, Aspen Helicopters, of the SWPPP also states, "The concrete pad located in front of the shop is utilized for exterior washing of aircraft. The business has developed a special wash water containment system for cleaning helicopters after spraying pesticides over crops. The system consists of a 30'x 50' elevated steel wash pad developed to contain the wash water from helicopters used during crop spraying activities." The 30'x 50' elevated steel wash pad was not identified during the inspection. In addition, the inspectors did not inquire about the helicopter washing practices conducted by Aspen Helicopters.

Moreover, the SWPPP continues to state, "Aspen's non agriculture use aircraft are washed on ramp tie-downs in front of the facility. Steam Cleaning of aircraft engines is periodically performed outdoors in front of the enclosed maintenance area." The area noted appears to be the area in front of the Aspen Helicopter Inc. hangar (Aspen Midfield). Runoff from this area drains to the Aspen Midfield storm drain (Photo 19).

Annual Report Review

The inspector DID review the annual report for the previous reporting period. The annual report was determined to be complete unless noted below.

Storm water samples were not collected from representative storm water discharge locations (CAS000001 Attachment B.7.).

Currently the airport is collecting storm water samples from only one discharge location (Victoria outfall) that is not representative of all industrial runoff from the airport. Additional sample locations recommended by the inspectors (Scott Slamal [Tt] and Alex Alimohammadi [RWQCB]) include the following:

- Gate 4 storm drain (Photo 1); would represent runoff from the southeast portion of the airport (Photo 2).
- Aspen storm drain (Photo 3); would represent runoff from the Aspen maintenance shop (Photo 4).
- Fuel Farm storm drain (Photo 6); would represent runoff from the fuel farm and waste oil collection station (Photos 5 and 7).
- Aspen Midfield storm drain (Photo 19); would represent runoff from the material storage and helicopter landing zone areas noted in photos 13 through 18.

Storm Water Analytical Results for the Previous Reporting Period

The facility's SIC code requires storm water samples to be analyzed for pH, TSS, SC, and O&G or TOC, PLUS the additional Table D parameters of BOD; COD; NH3; pH.

Storm water sample results exceeded U.S. EPA/RWQCB benchmark values for the following parameters:

11/27/2006
Victoria Outfall: SC 1,500 umhos/cm (200 umhos/cm)

Benchmark values are reported parenthetically. The facility is recommended to investigate the source(s) of these exceedences, review current BMPs, and consider additional BMPs to address potential sources.

General Description

California Regional Water Quality Control Board
General Industrial Activities Storm Water Permit, Order No. 97-03-DWQ
NPDES Permit No. CAS000001

Industrial Storm Water Inspection Report

Oxnard Airport was inspected on 6/26/2007 to determine compliance with NPDES General Permit No. CAS000001. Oxnard Airport is categorized under SIC code 45XX - Air Transportation Facilities That Have Vehicle Maintenance Shops, Material Handing Facilities, Equipment Cleaning Operations, or Airport and/or Aircraft Deicing/Anti-icing Operations. The inspector met with Erin Powers to tour the facility and review relevant storm water paperwork. The inspection was conducted between 2:00:00 PM and 5:00:00 PM. Weather conditions at the time of the inspection were: clear skies, no evidence of recent rain.

The Oxnard Airport is small non-hub commercial service airport. The airport consists of one commercial airline (United), two aircraft maintenance shops, four rental car agencies, 56,210 square feet of hangar space, 140 aircraft tie downs, and other commercial businesses.

Industrial activities include fuel tank and truck loading, aircraft fueling and servicing, and aircraft washing. Potential pollutants include fuels, oil, lubricants, solvents, hydraulic fluid, pesticides, sediment and wash water.

A fuel farm owned by Aspen Helicopter Inc. and Golden West Air Terminals, Inc. provides fueling services via four fuel trucks to aircrafts. The fuel station is contained by slot drains which connect to an oil water separator which connects to a storm drain. In the case of a spill a valve can be closed at the storm drain to prevent fuel from entering the storm sewer system. The facility representatives stated that a berm will be constructed around the fueling pad to insure containment during a spill by the middle of August 2007.

General aircraft washing takes place at the wash pad (Photo 21) or by a private aircraft detailing business. The wash pad drain connects to an oil water separator which according to the facility representatives, connects to the city sanitary sewer system. Aircraft maintenance is not permitted by the airport at tie-downs and is required to be conducted at the aircraft maintenance shops. However, the airport's SWPPP states that occasionally, in the case of larger aircrafts, maintenance activities will occur on ramp areas outside of the hangar facilities. The SWPPP further describes BMPs to be used during these times.

Rental cars are washed at the rental car wash pad (Photo 22). Wash water appeared to be contained in the wash pad drain connecting to an oil water separator which according to the facility representatives, connects to the city sanitary sewer system, .

Airport vehicles are maintained off site.

Storm water from the airport generally flows east to west by sheet flow and is conveyed by swales and catch basins to the discharge sample location, Victoria outfall (Photo 9). Water was observed pooling in this area and according to the facility representatives, was due to salt water influx from the ocean. This could give reason for the elevated results of specific conductivity in storm water sample.

Currently the airport is collecting storm water samples from only one discharge location (Victoria outfall) that is not representative of all industrial runoff from the airport. Additional sample locations recommended by the inspectors (Scott Slamal [Tt] and Alex Alimohammadi [RWQCB]) include the following:

- Gate 4 storm drain (Photo 1); would represent runoff from the southeast portion of the airport (Photo 2).

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Industrial Storm Water Inspection Report

- Aspen storm drain (Photo 3); would represent runoff from the Aspen maintenance shop (Photo 4).
- Fuel Farm storm drain (Photo 6); would represent runoff from the fuel farm and waste oil collection station (Photos 5 and 7).
- Aspen Midfield storm drain (Photo 19); would represent runoff from the material storage and helicopter landing zone areas noted in photos 13 through 18.

Preliminary inspection results were discussed with the facility representative.

Tt Inspector(s) and Tt Reviewer		
Slamal (Tt)	Kelly Jacques (Tt)	7/9/2007
Tetra Tech Inspector Name	*Tetra Tech Reviewer*	*Report Date*

A011253

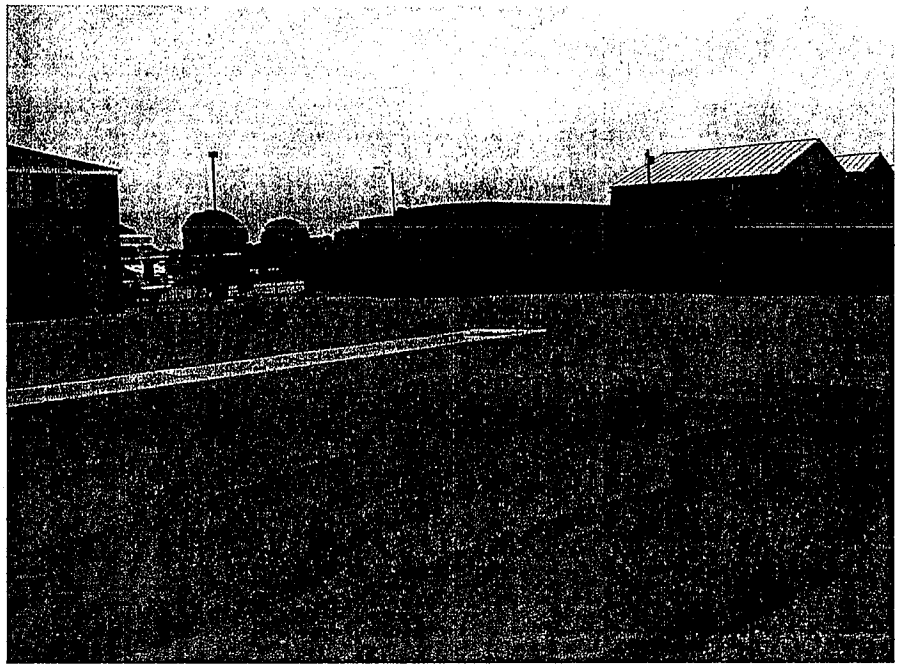

Photo 1: The Gate 4 storm drain.

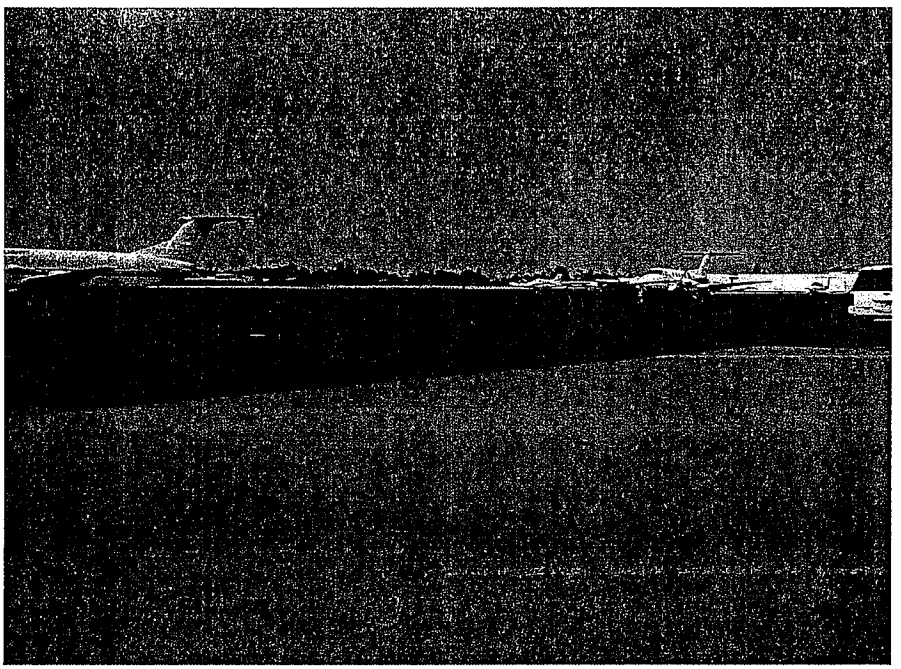

Photo 2: The southeast portion of the airport which drains to the Gate 4 storm drain.

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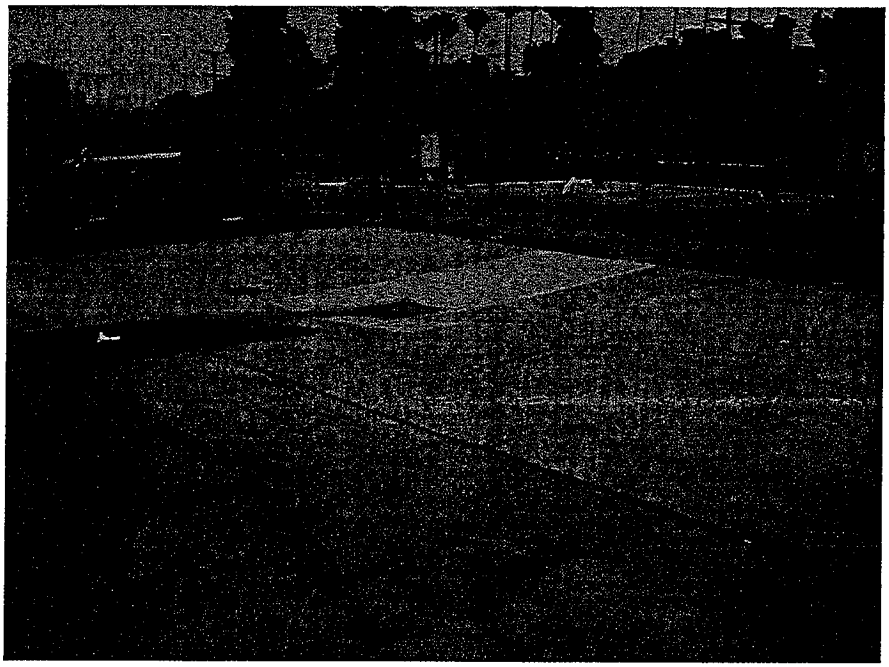

Photo 3: The Aspen storm drain at the northwest corner of hangar 3 which receives runoff from the Aspen maintenance shop.

Photo 4: The Aspen maintenance shop.

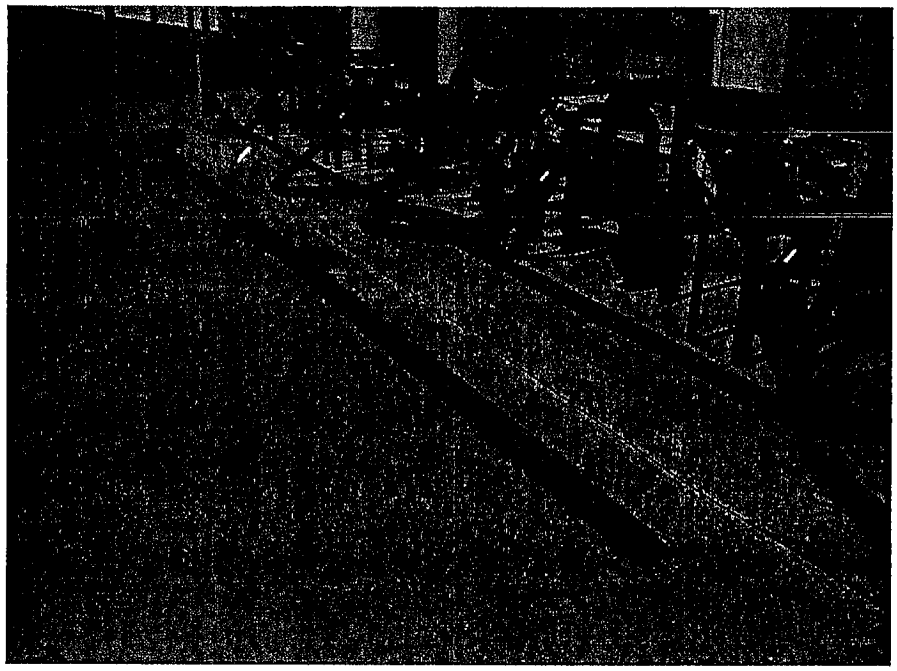

Photo 5: The Aspen Helicopter Inc. and Golden West fuel farm.

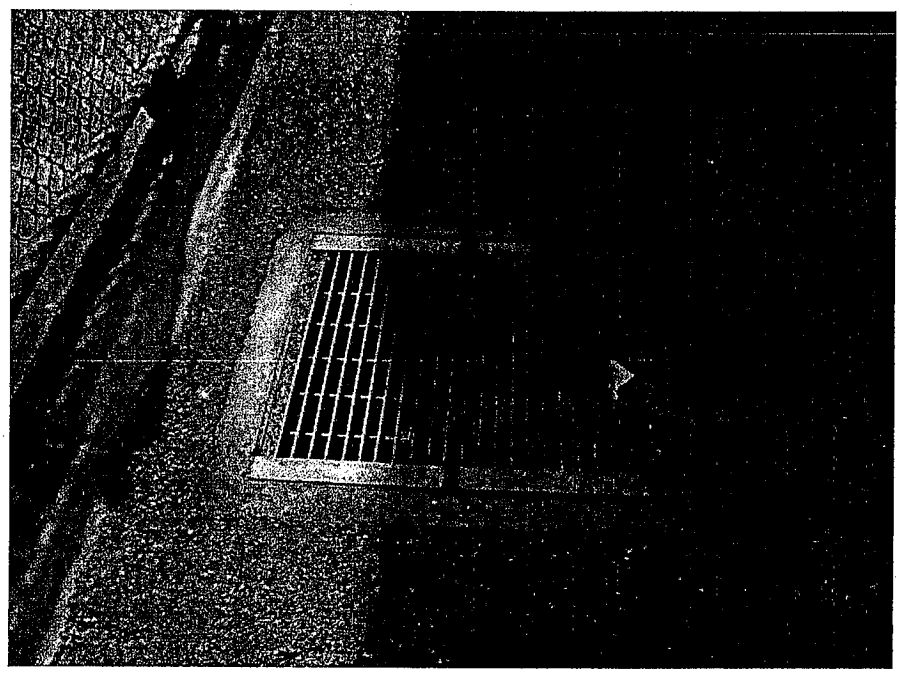

Photo 6: The Fuel Farm storm drain.

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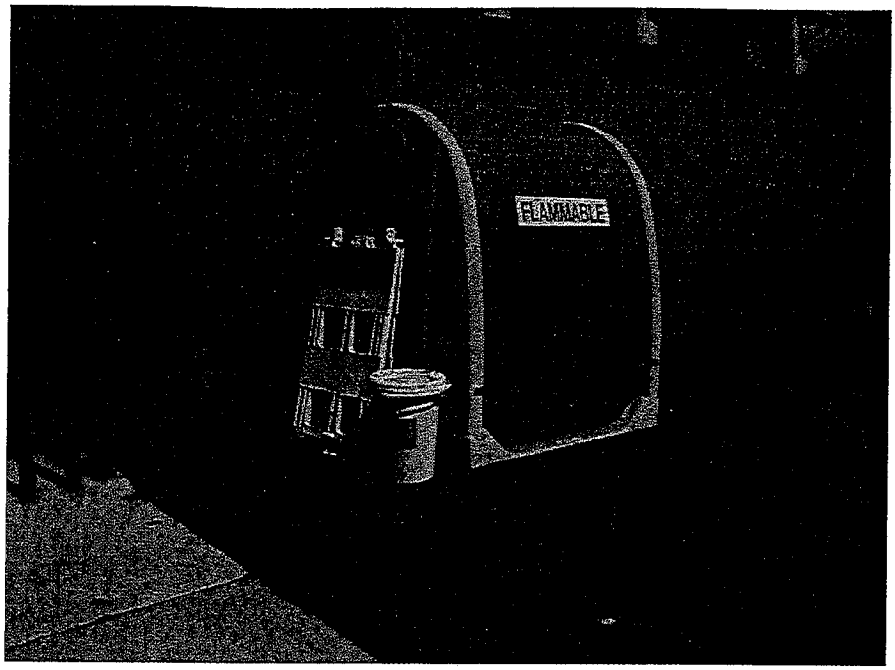

Photo 7: Waste oil collection station. Oil stains were observed on the pavement in front of the station.

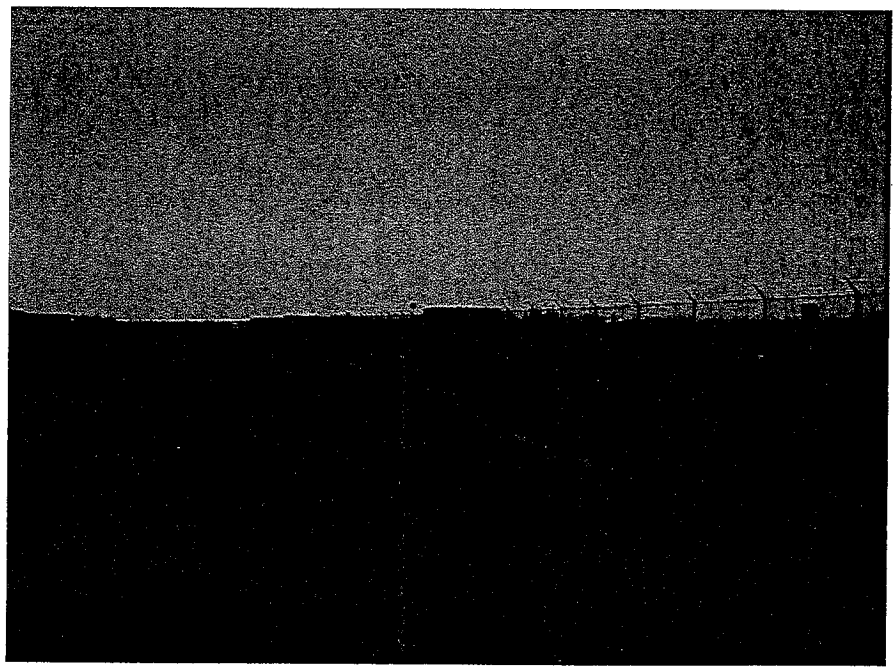

Photo 8: Drainage swale at the north boundary of the airport.

Photo 9: The Victoria outfall storm water sample location at the southwest corner of the airport.

Photo 10: The Aspen Helicopter water and fuel truck parking area. Stains were observed on the pavement throughout this area.

A011258

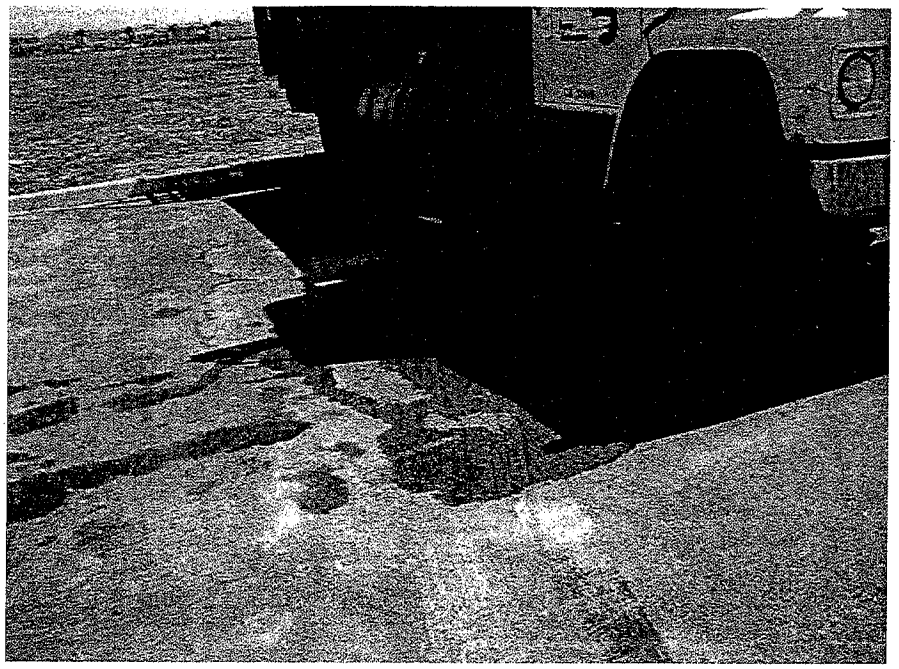

Photo 11: Close up of pavement stains at the water and fuel truck parking area.

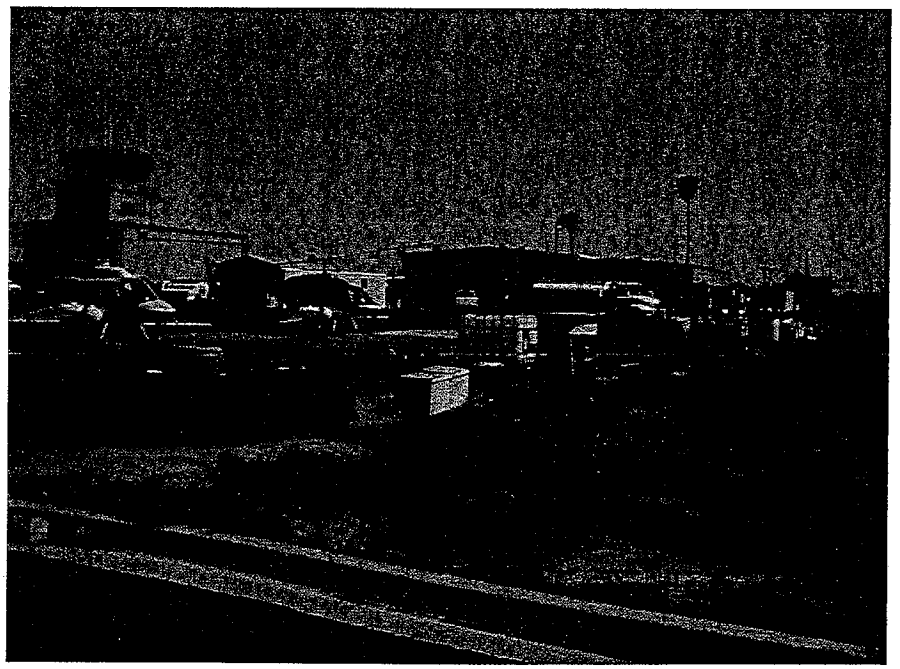

Photo 12: The Aspen Helicopter Inc. hangar and outside storage areas (Aspen Midfield).

A011259

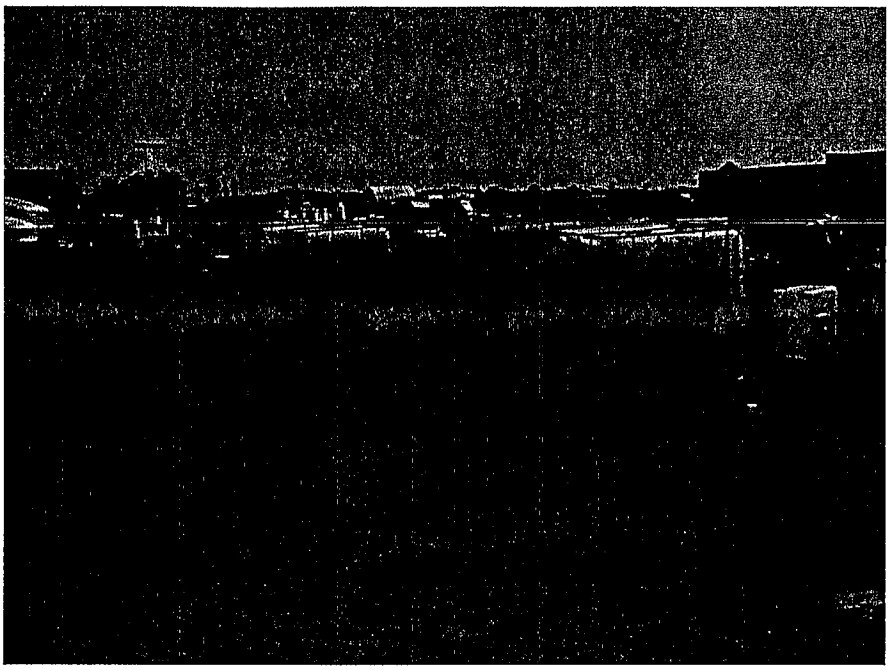

Photo 13: Numerous totes and buckets containing fertilizers and mineral oil were stored without secondary containment at Aspen Midfield. Stains were observed on the pavement throughout this area.

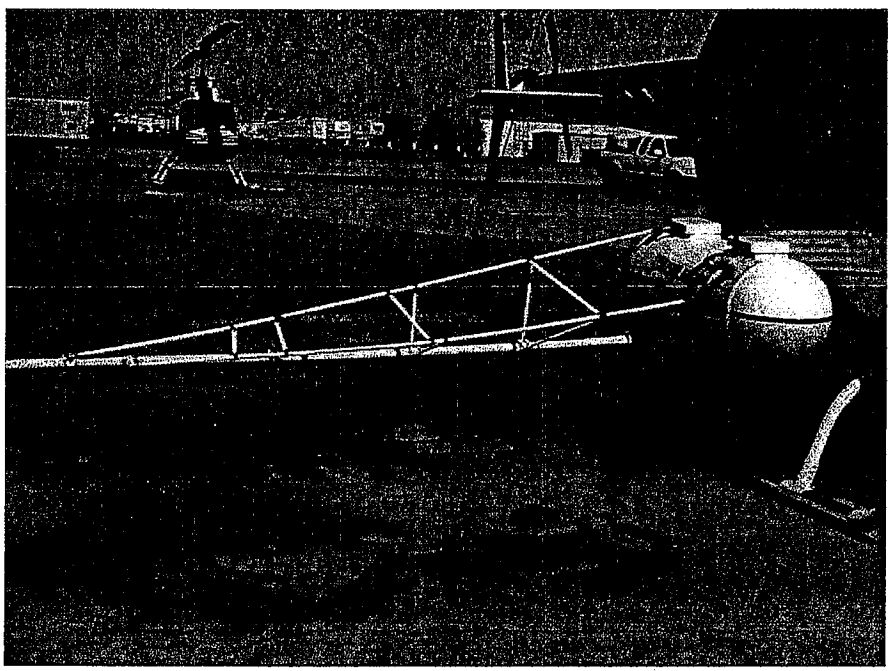

Photo 14: Stained pavement at the helicopter tie downs.

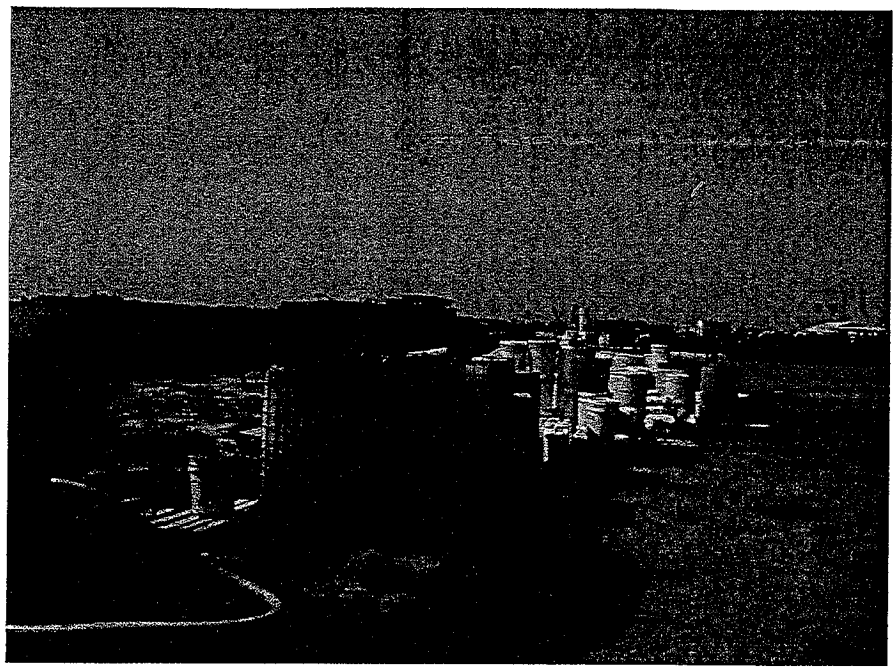

Photo 15: Stained pavement at the material storage area.

Photo 16: Waste oil and lubricant disposal drums adjacent to the Aspen Helicopter Inc. hangar store without cover or containment. Housekeeping was poor and the pavement was stained throughout this area.

A011261

Photo 17: Stained pavement outside of the Aspen Helicopter Inc. hangar.

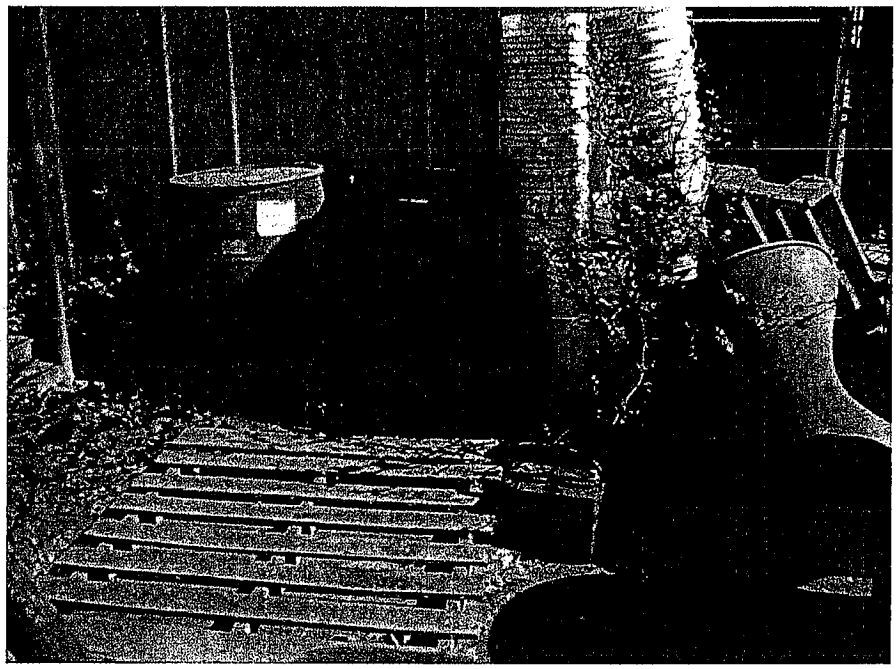

Photo 18: Used batteries, stored without cover or containment, outside of the Aspen Helicopter Inc. hangar.

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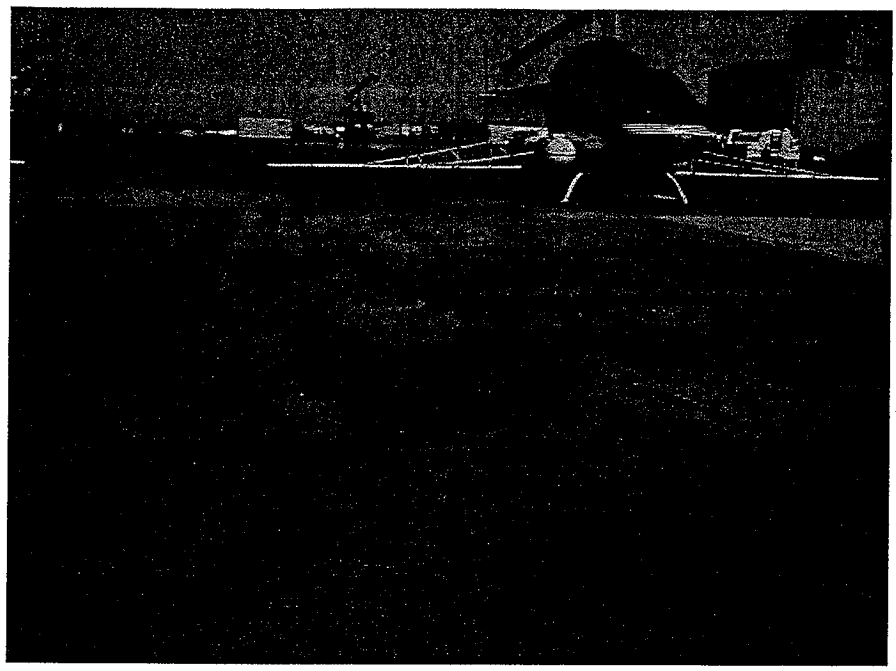

Photo 19: The Aspen Midfield storm drain. Note the stains at the storm drain and up-gradient in the swale. Runoff from the material storage areas noted in photos 13 through 18 drains to this storm drain.

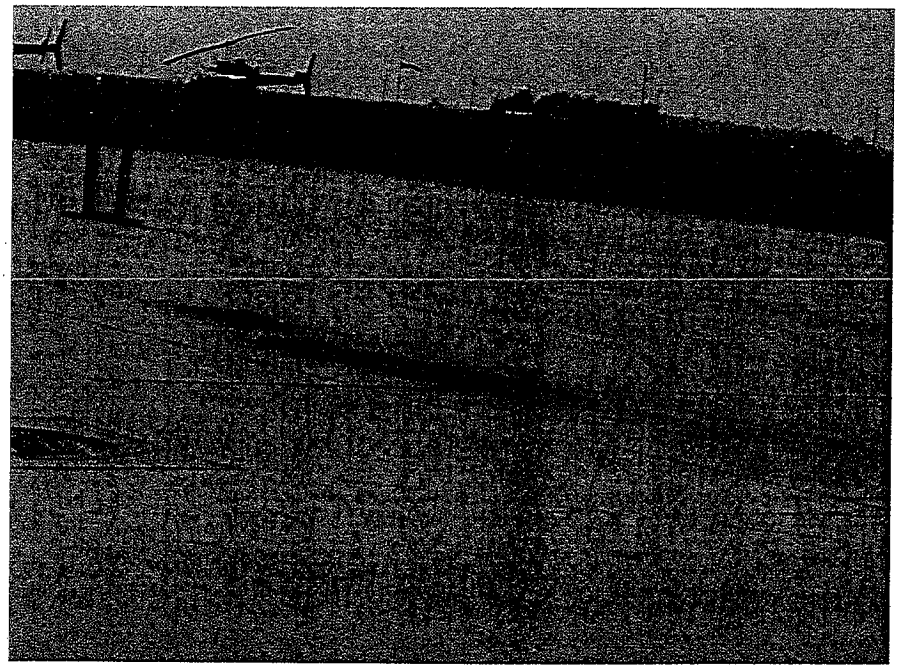

Photo 20: Pavement stains at the Skywest terminal ramp.

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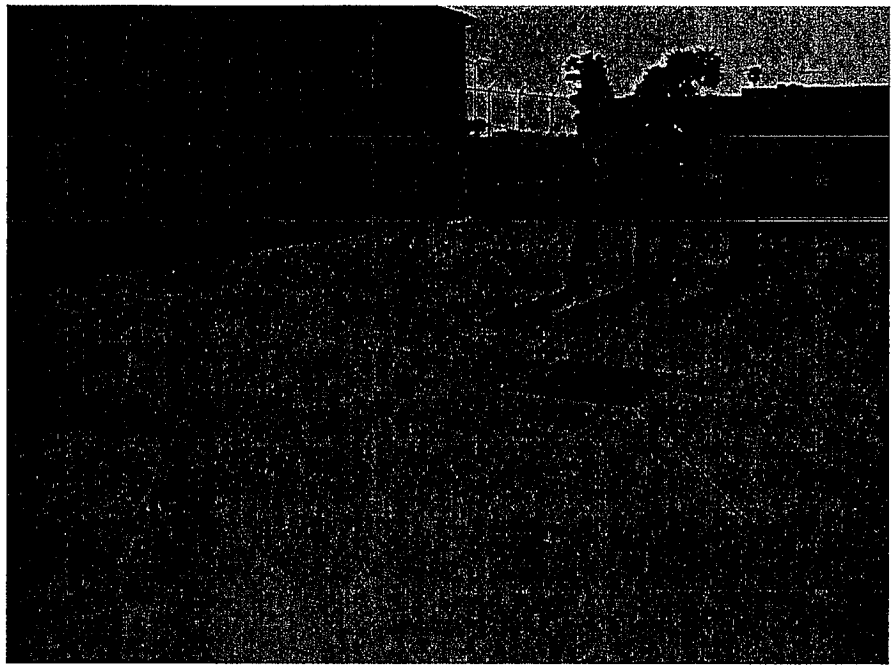

Photo 21: Aircraft wash pad which drains to an oil water separator connected to the sanitary sewer system.

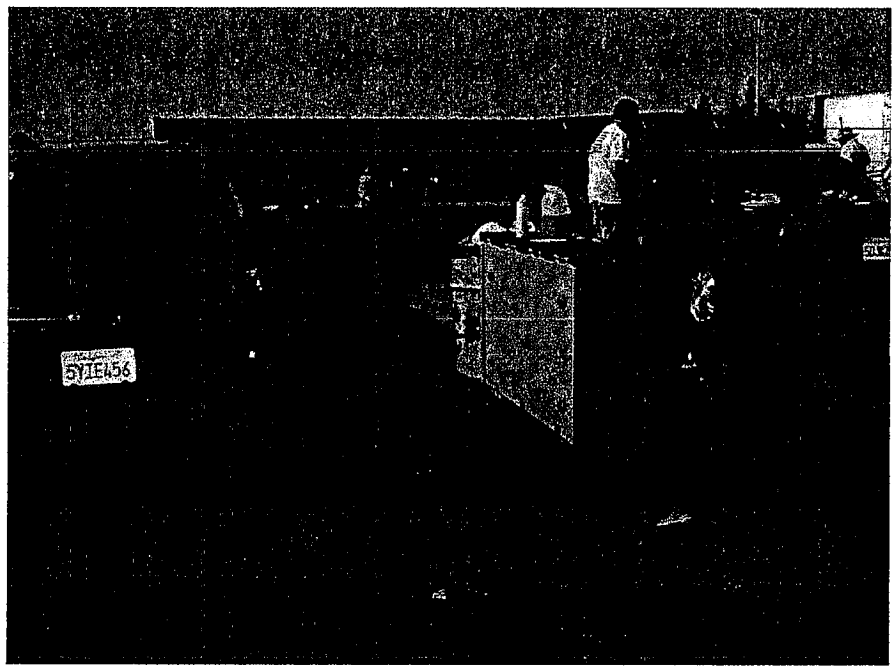

Photo 22: Rental car wash pad

A01125H

Santa Paula Airport (WDID 4 56I001102)
Inspected By: Slamal (Tt), Power (Tt), and Alimohammadi (RWQCB)

Photo 1: General airport view from fuel farm area facing east.

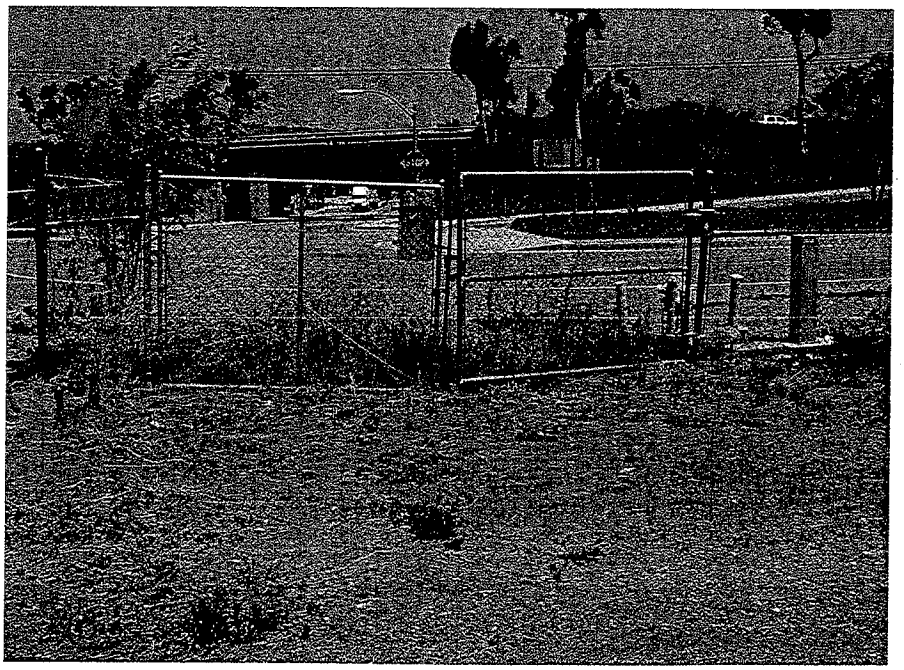

Photo 2: Run-off from the town of Santa Paula flows from 10th Street (under bridge) onto the airport at this location.

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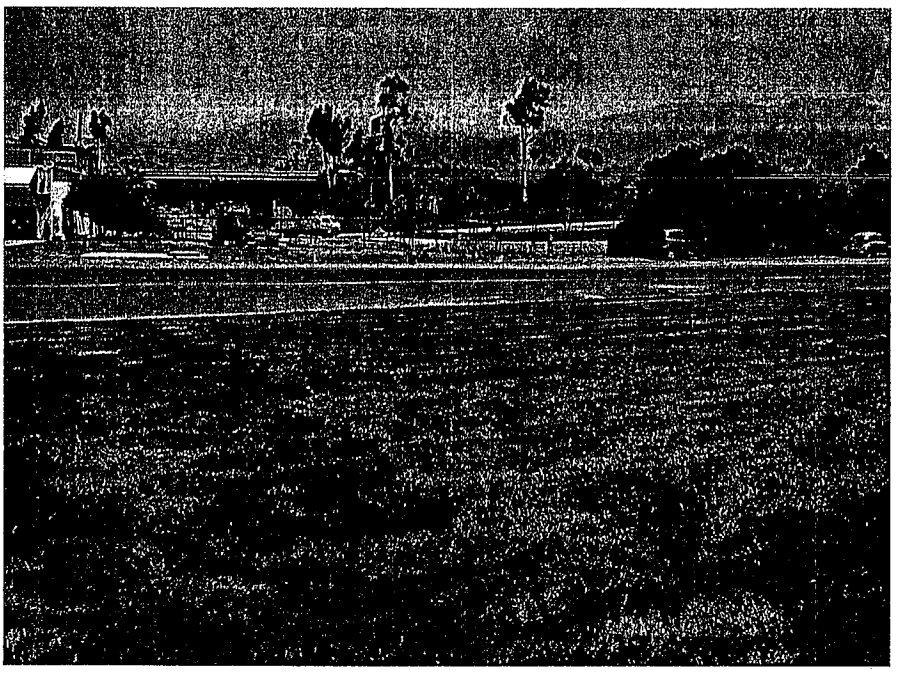


Photo 3: East bioswale (in foreground), the east portion of the runway, and the run-on point (Photo 2).

Photo 4: Eastern view of the east bioswale

A011266

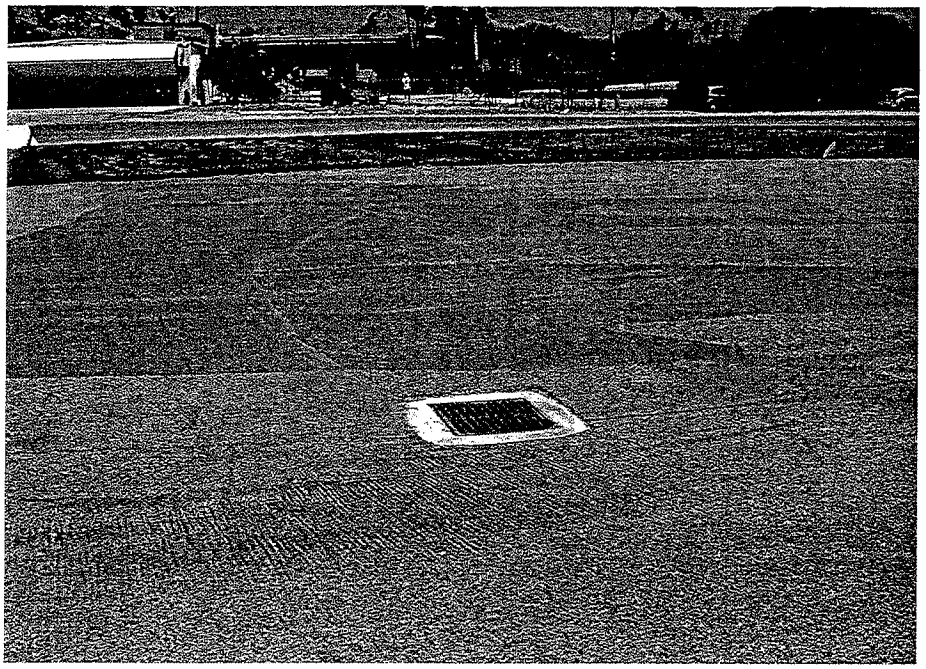


Photo 5: Storm drain to the south of the East Bioswale.

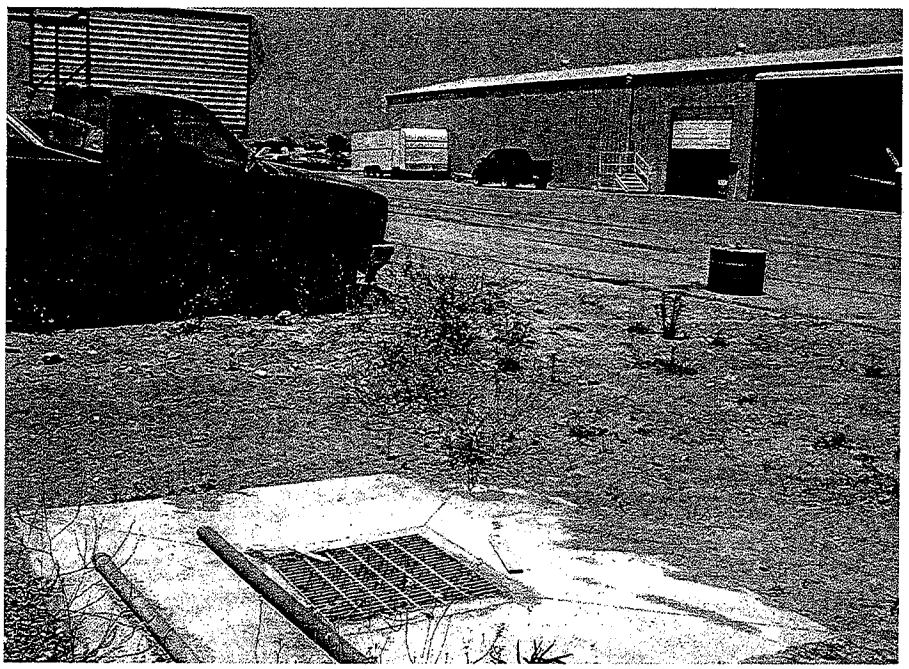


Photo 6: Storm drain behind Ray's Aviation, southeast corner.

A011267

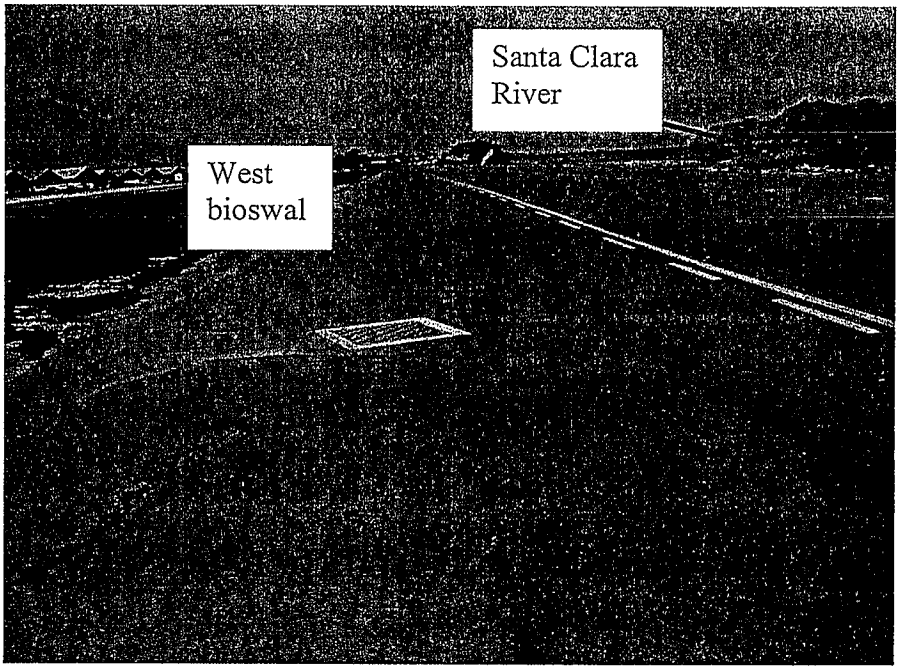


Photo 7: Sample Point #1 to the south of the West Bioswale, midfield.

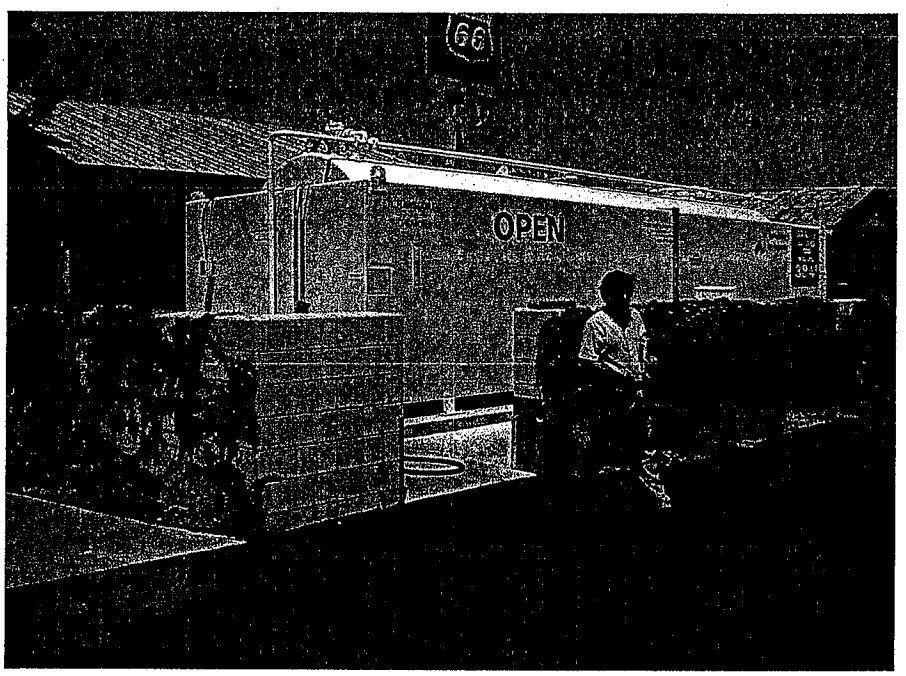


Photo 8: Fuel farm and associated secondary containment structure (fuel tanks are inside), near Sample Point #2.

A011268

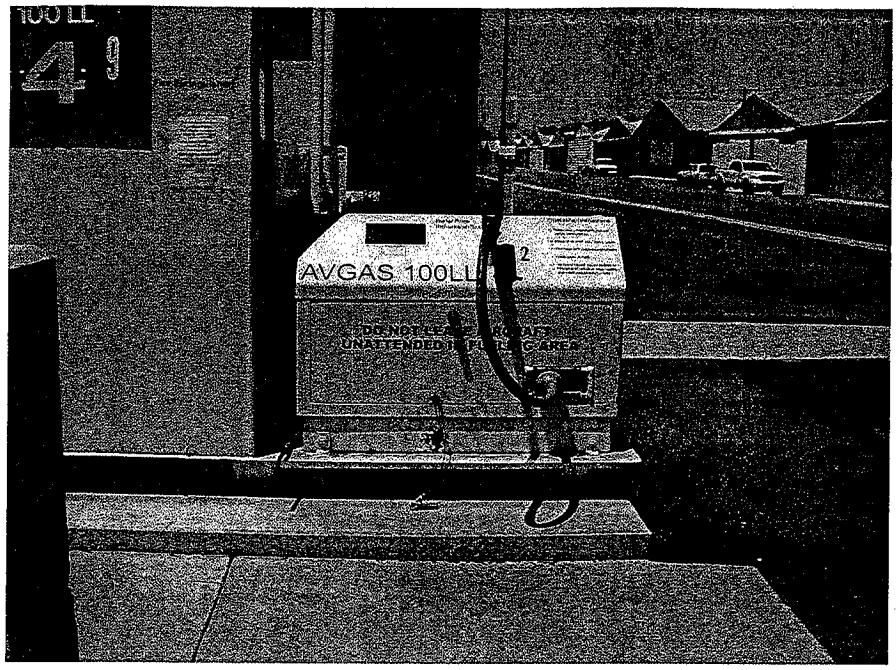
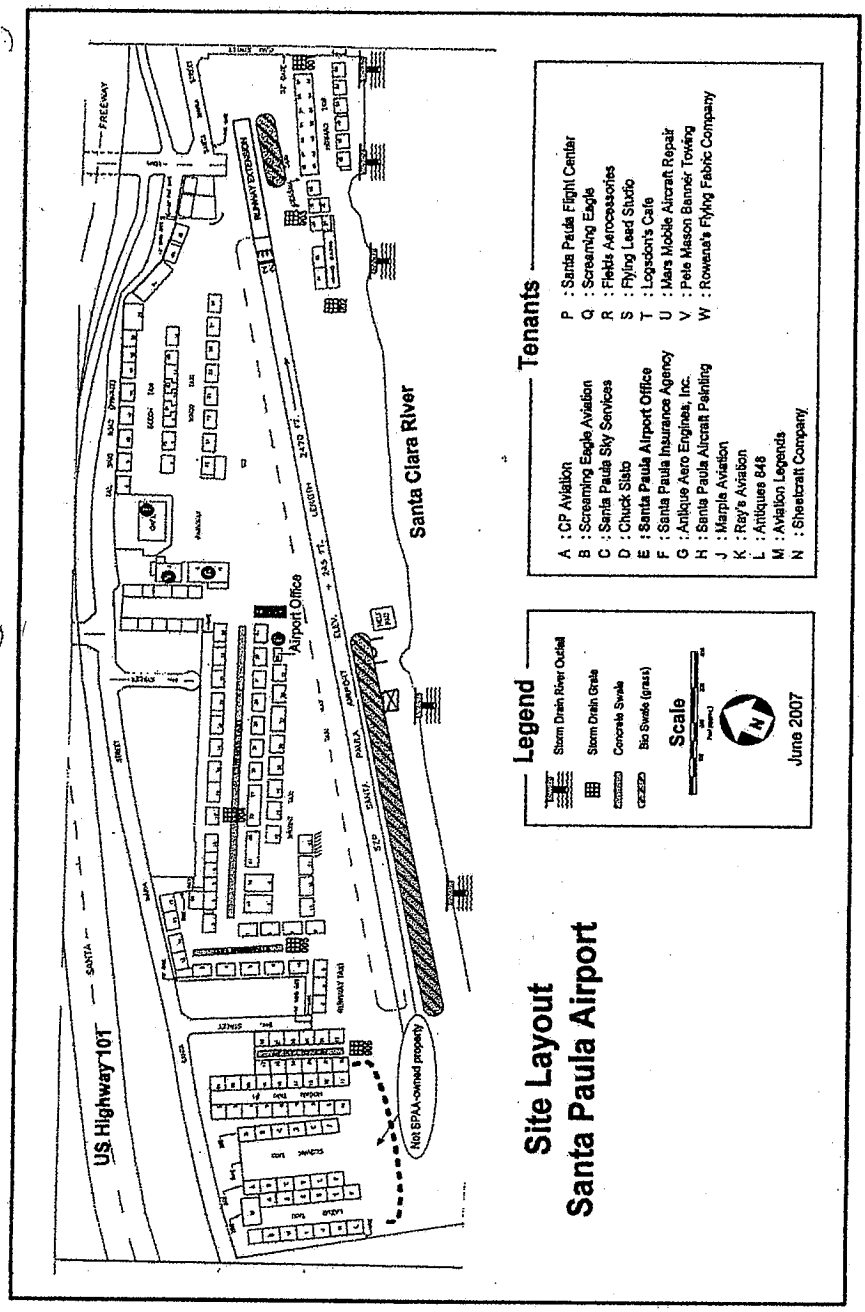


Photo 9: North side of fuel farm, with hangars beyond.

Photo 10: Staining on the pavement at the area to the east of the fuel farm (transient aircraft parking)

A011269



Attachment 1: The facility site map copied from the facility's SWPPP.

AQ11270

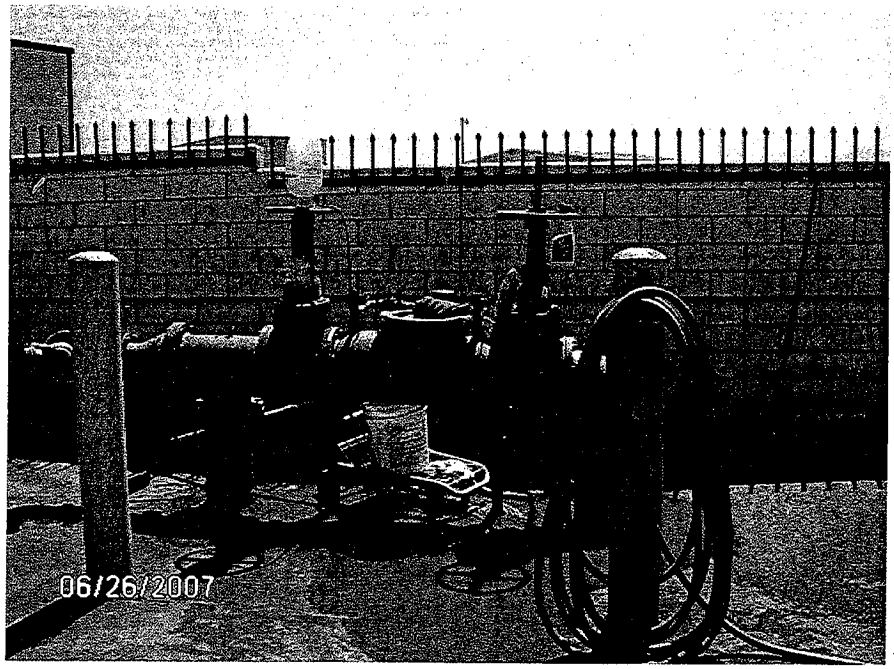


Photo 1: Evidence of washing at C and J Sales (lessee)

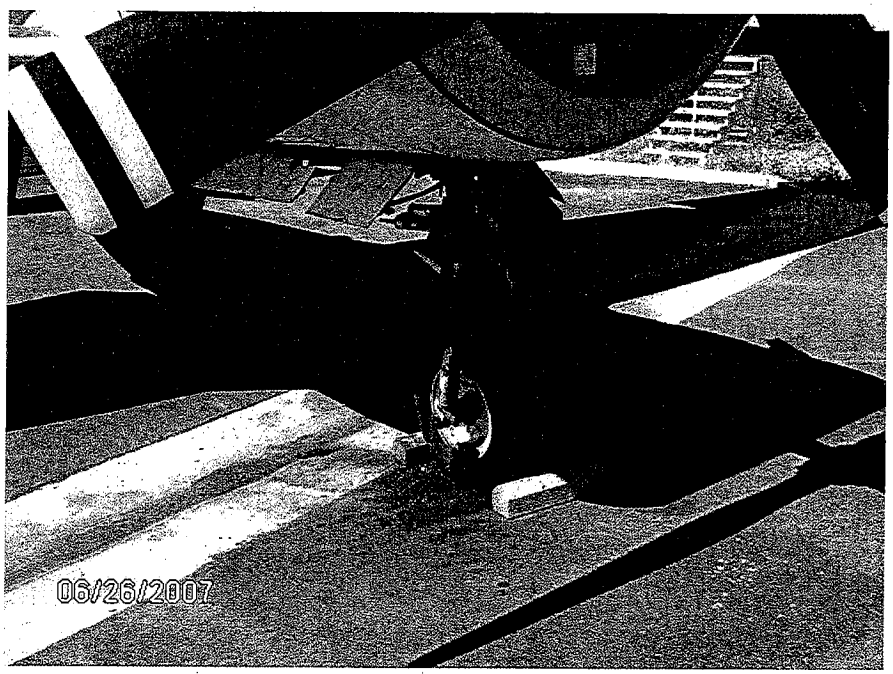


Photo 2: Staining adjacent to a storm water swale at C and J Sales.

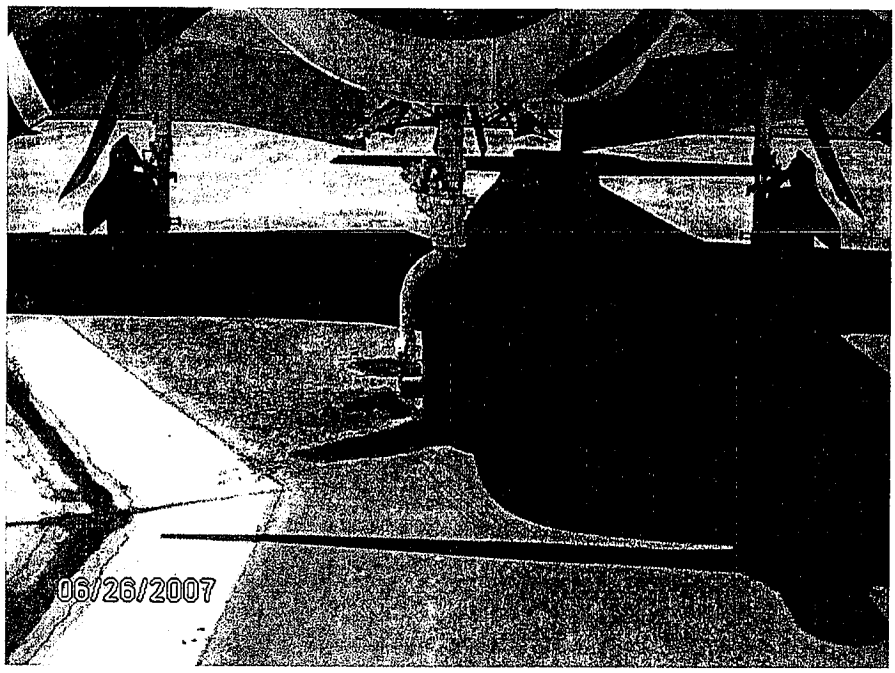


Photo 3: Hydraulic fluid leaking from an aircraft adjacent to a storm water swale at C and J Sales

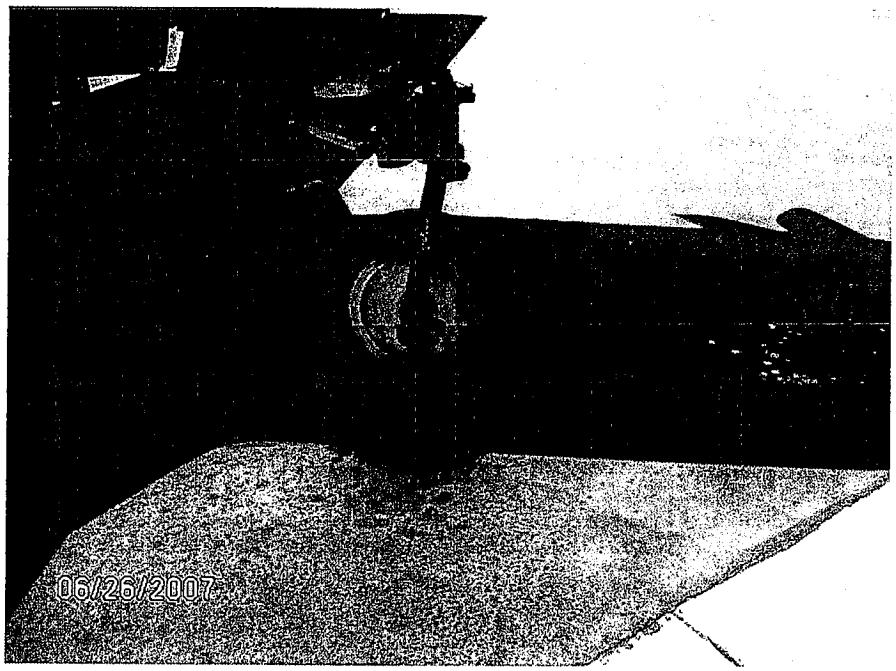


Photo 4: Hydraulic fluid leaking from an aircraft adjacent to a storm water swale at C and J Sales

A011272

Photo 5: Wash water flowing down the storm water swale toward the storm drain adjacent to C and J Sales. The aircraft seen here are also identified in Photos 2, 3, and 4.

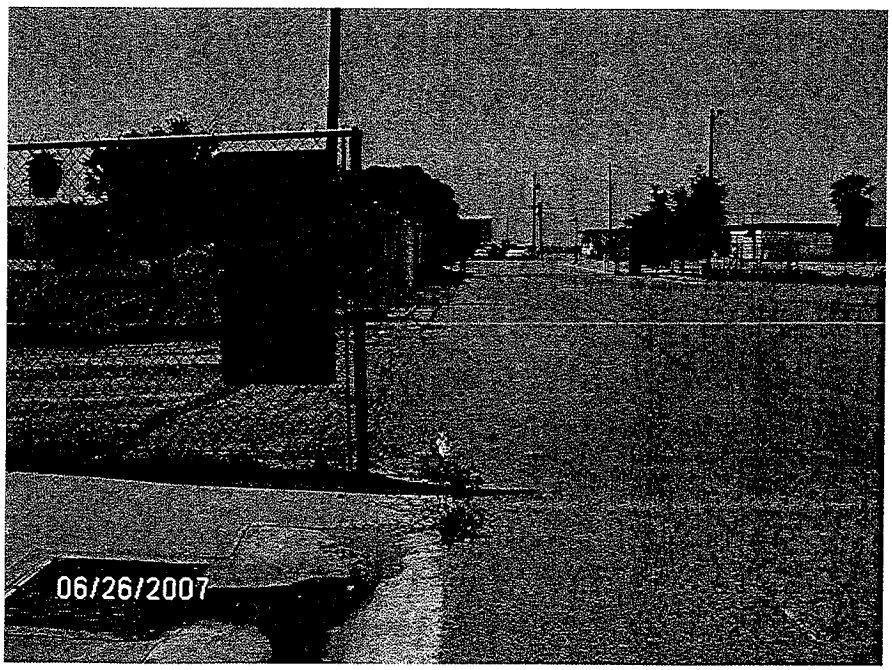


Photo 6: Wash water entering the storm drain adjacent to C and J Sales

A011273

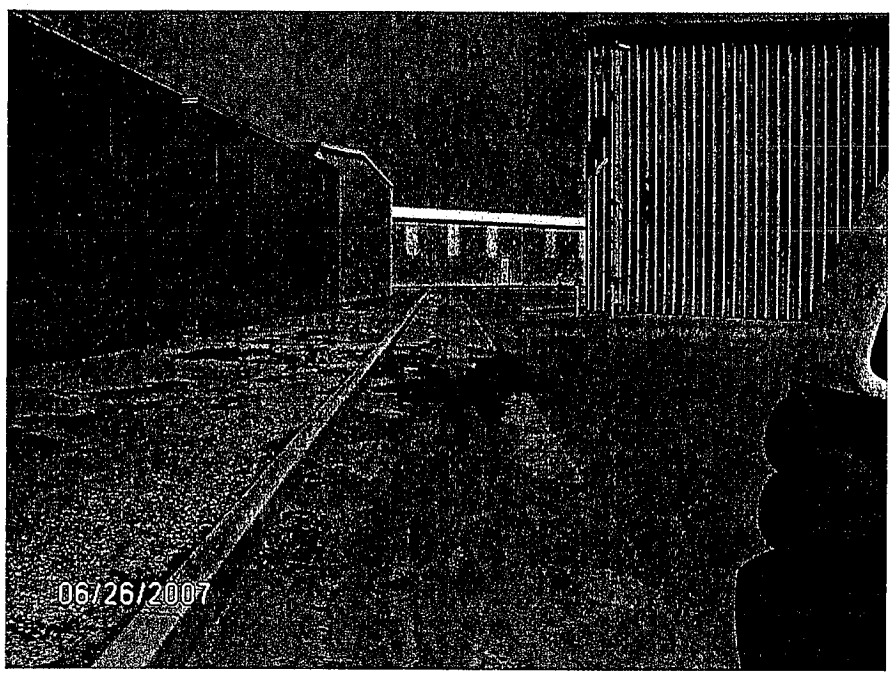


Photo 7: Unidentified water near the east end of the runway

Photo 8: Wash water entering a storm drain near the Sherriff's hanger

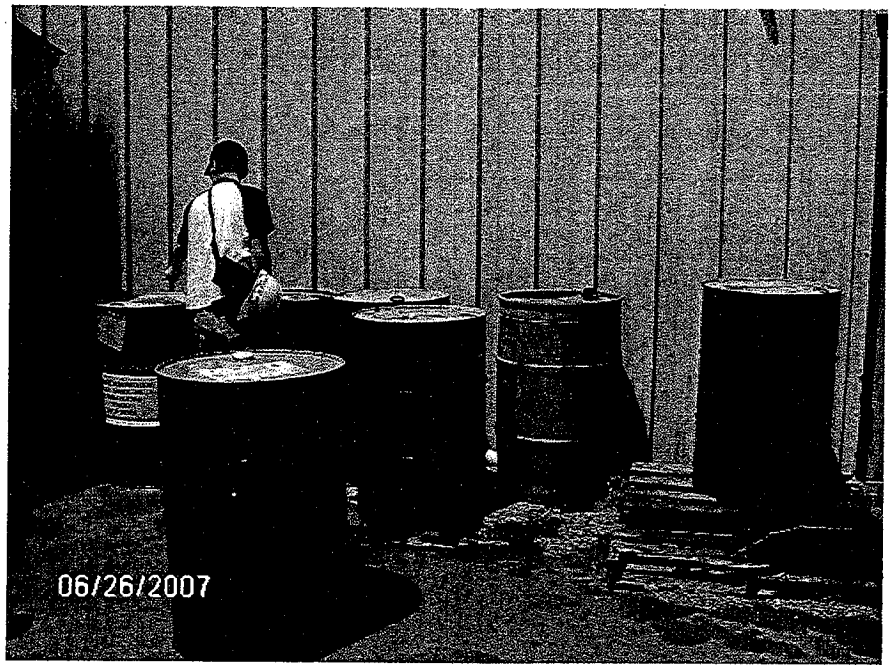


Photo 9: Staining around seven 55-gallon drums used for waste oil storage at the Commemorative Aircraft hanger

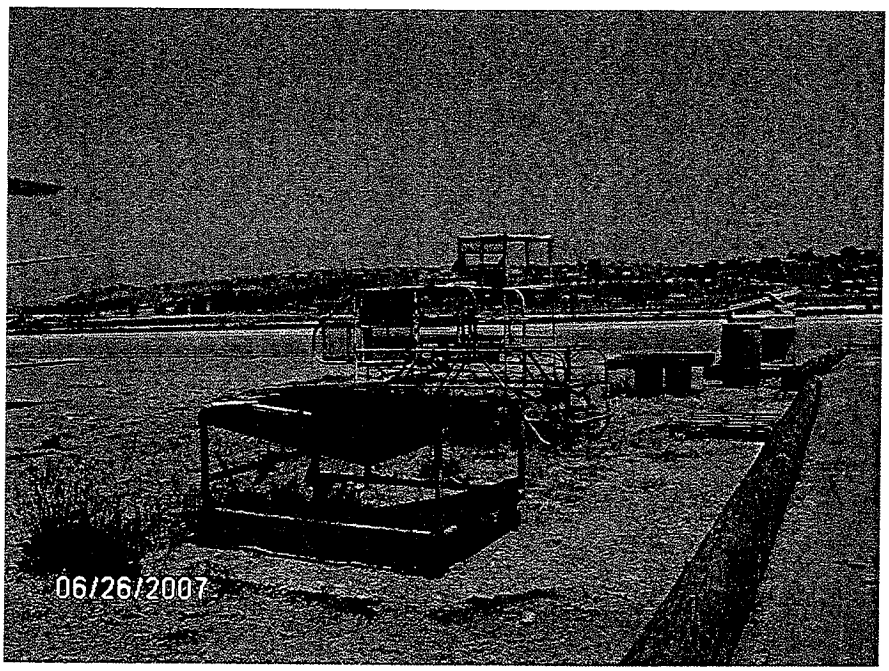


Photo 10: Oil pan and staining near the Commemorative Aircraft hanger

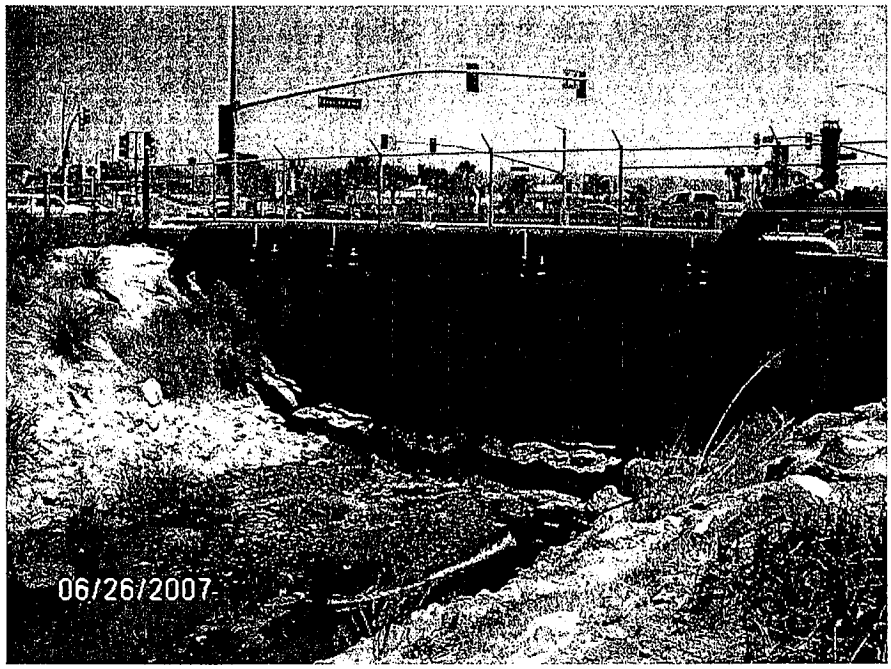


Photo 11: Camarillo Hills Drain at the northeast corner of the facility

Photo 12: Box culvert to the Camarillo Hills Drain along the northern boarder of the facility

A011276

Photo 13: Outfall 1

Photo 14: Outfall 2

A011277

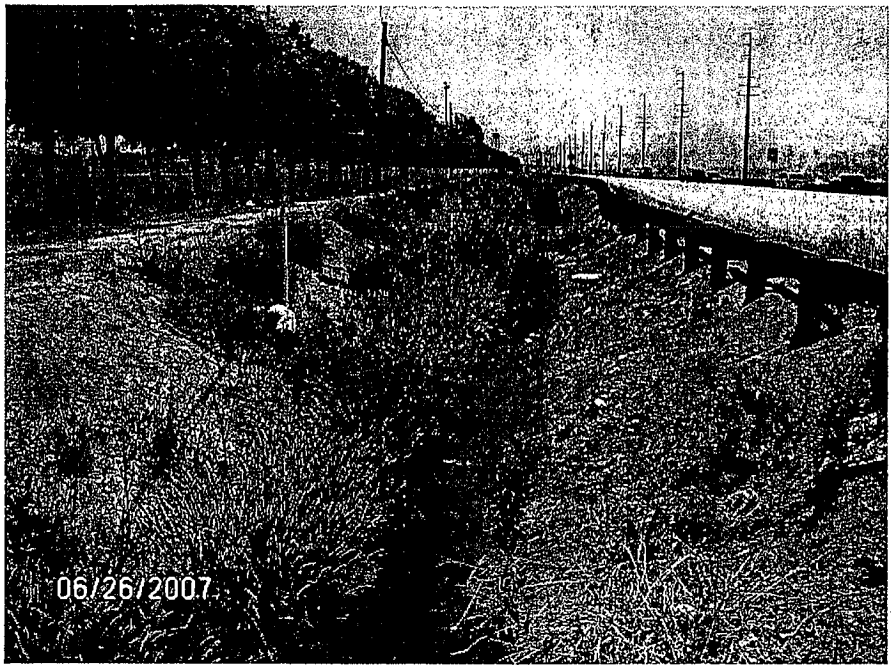
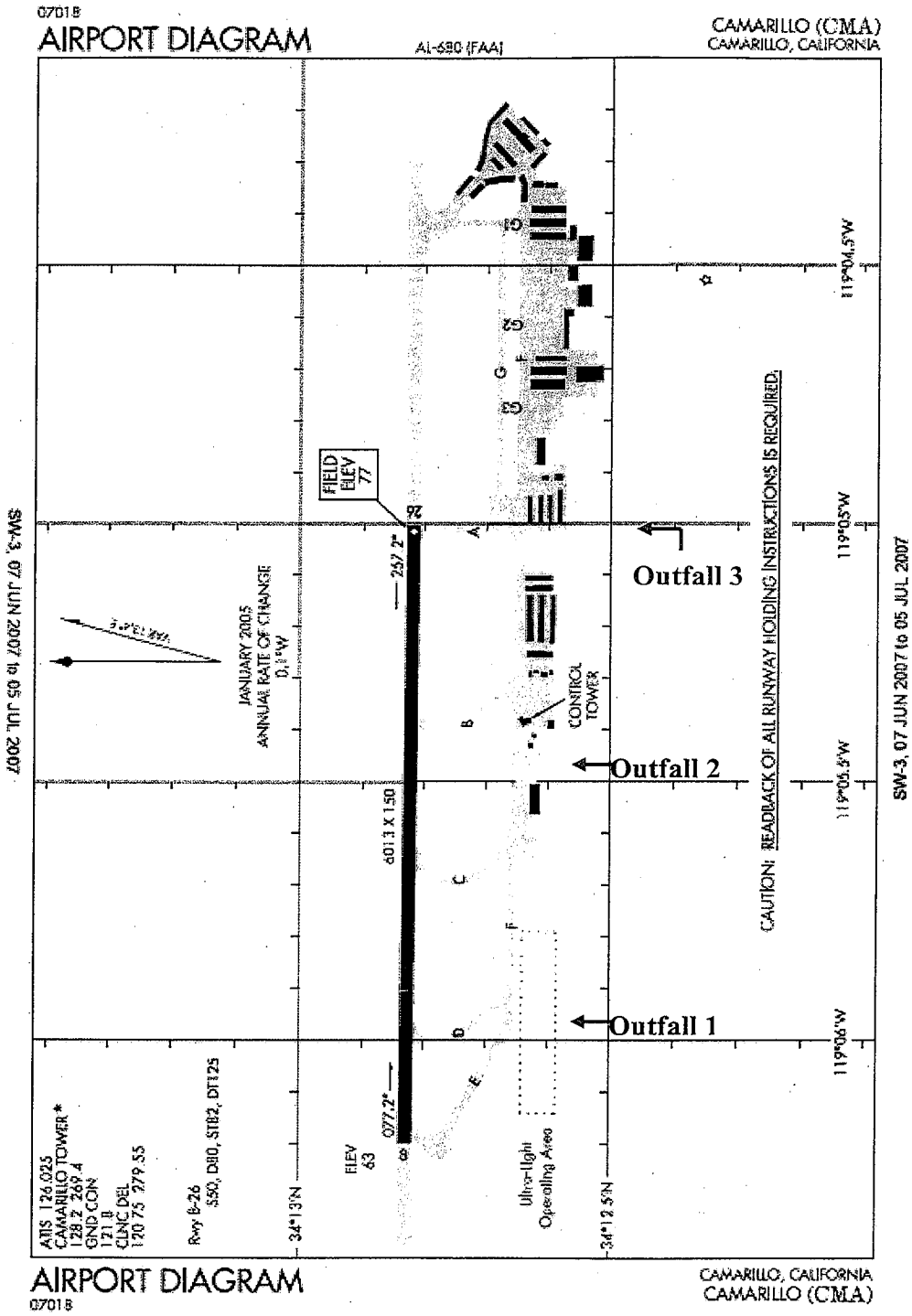


Photo 15: Outfall 3

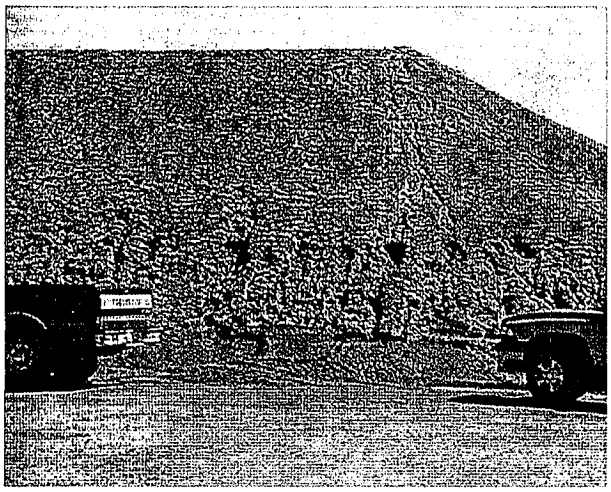
A011278

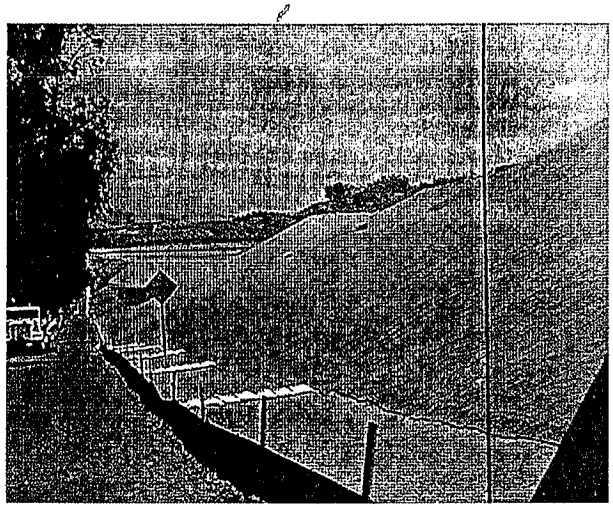


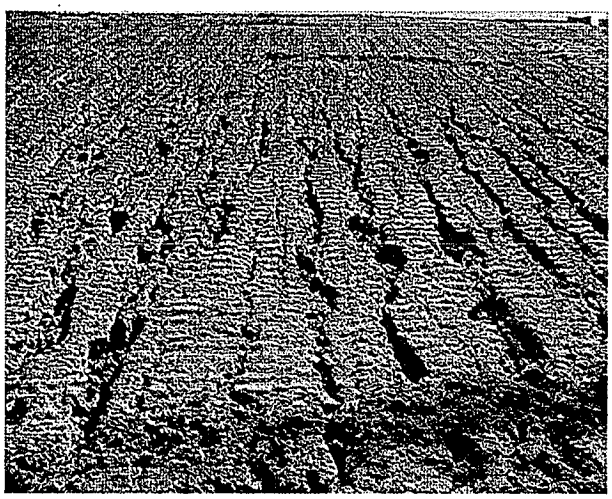
Attachment 1: County of Ventura Camarillo Airport

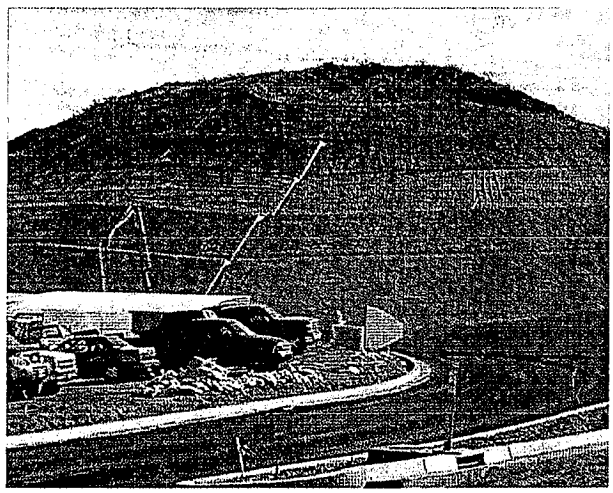
A011279

Spring of 2003
City of Camarillo (Upland Road & Woodcreek Road)
Toll Brothers

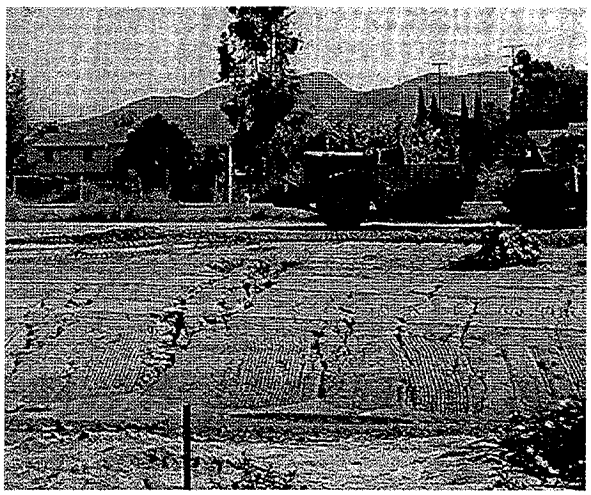


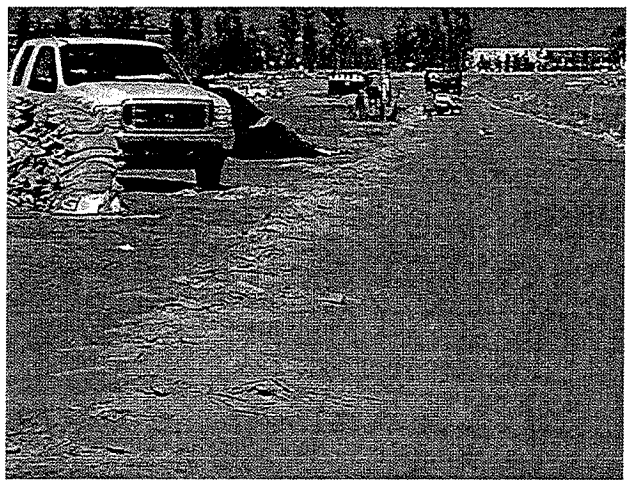


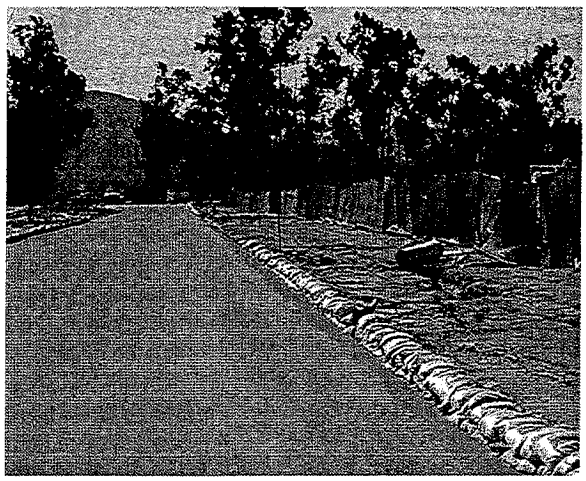


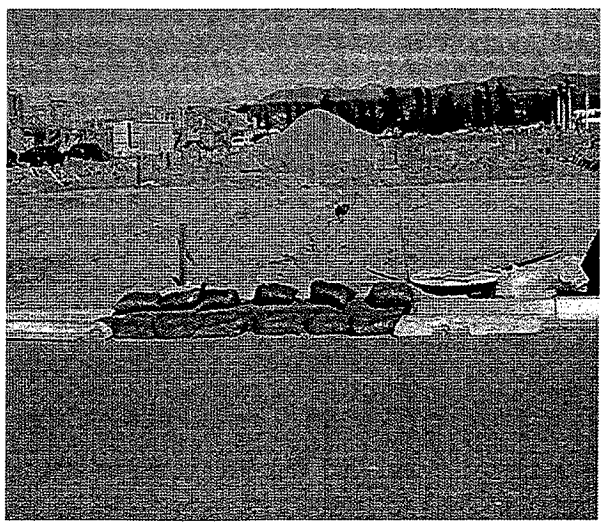


Fall of 2004
City of Camarillo (101 Freeway & Pleasant Valley Road)
Dr. Horton Homes

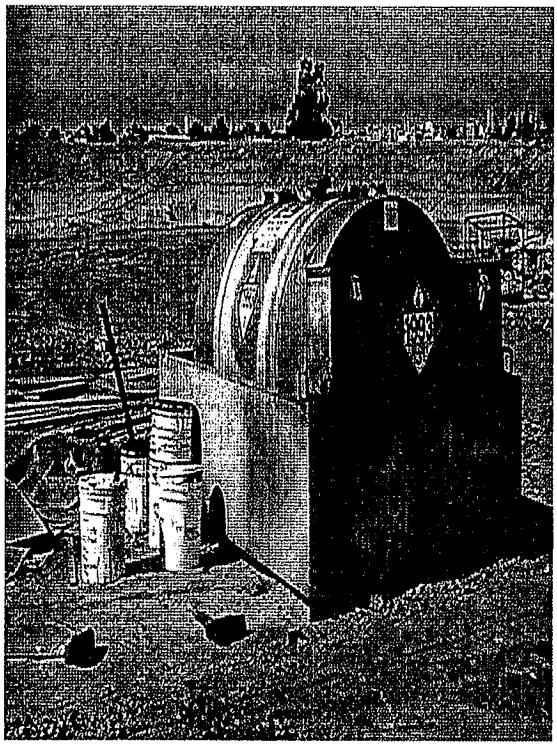


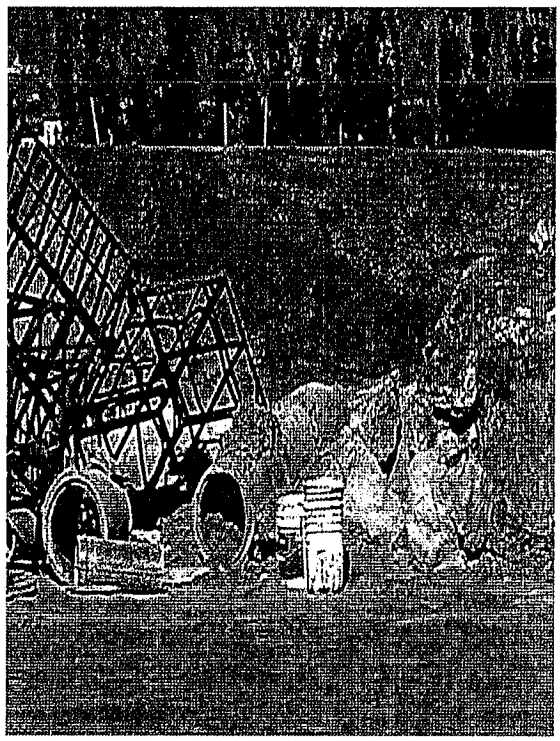






Fall of 2004
City of Camarillo (101 Freeway & Pleasant Valley Road)
Dr. Horton Homes

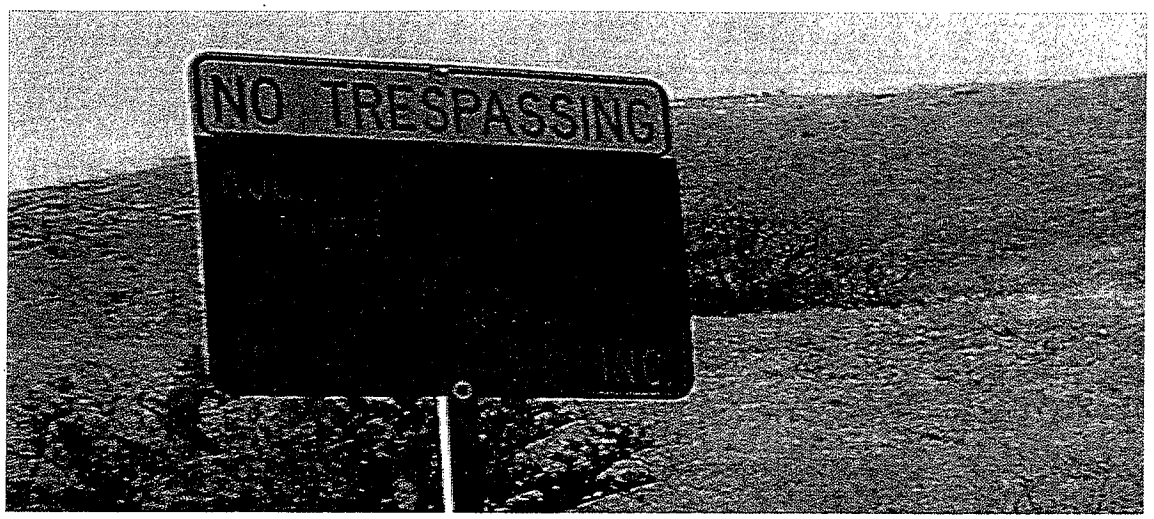




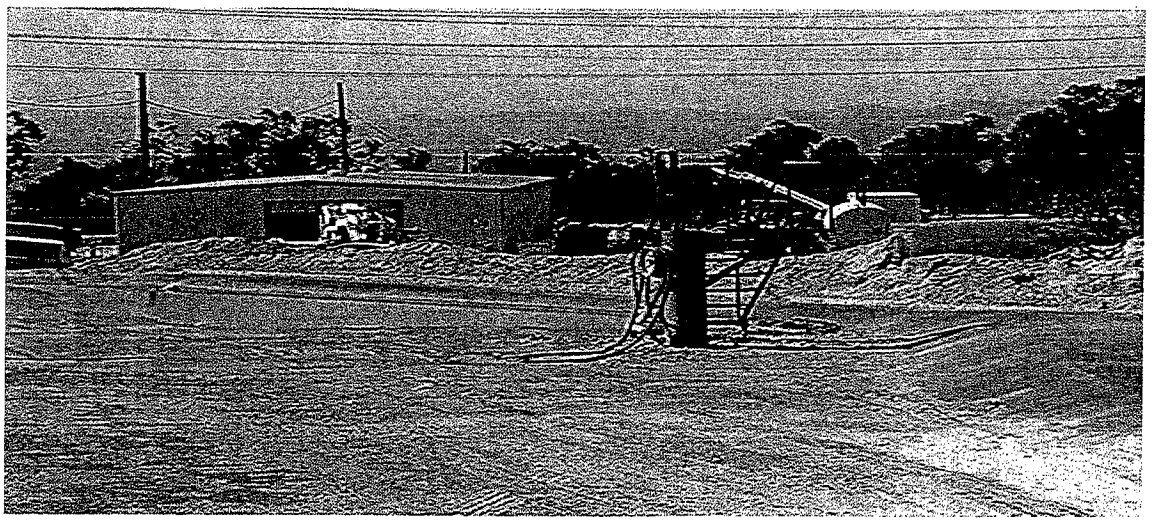
WDID#: 456I 012042
Inspection Date: May 13, 2004
Inspection Site: Wayne J. Sand & Gravel, Inc.
9455 Buena Vista., Moorpark, CA 93020

Industrial Follow up Inspection

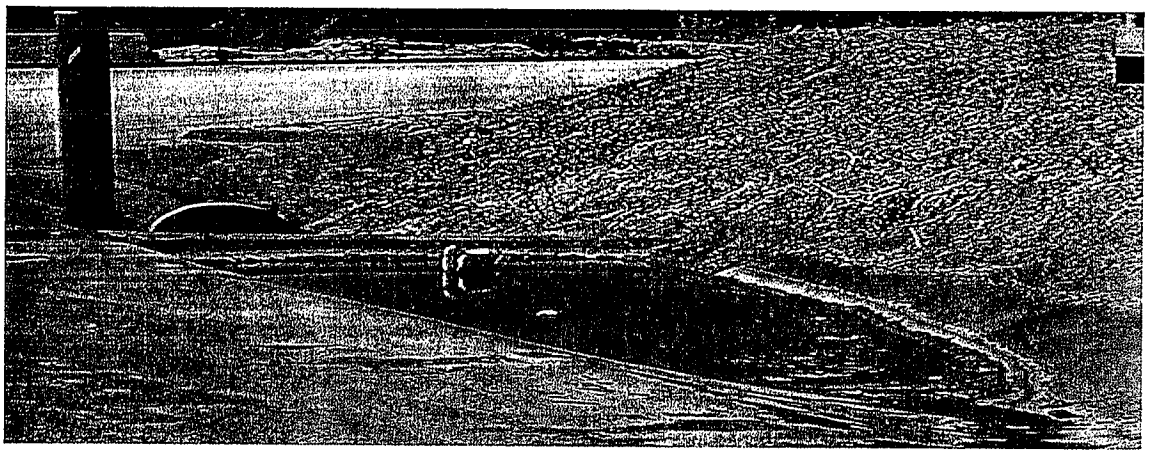
1) Showing facility name



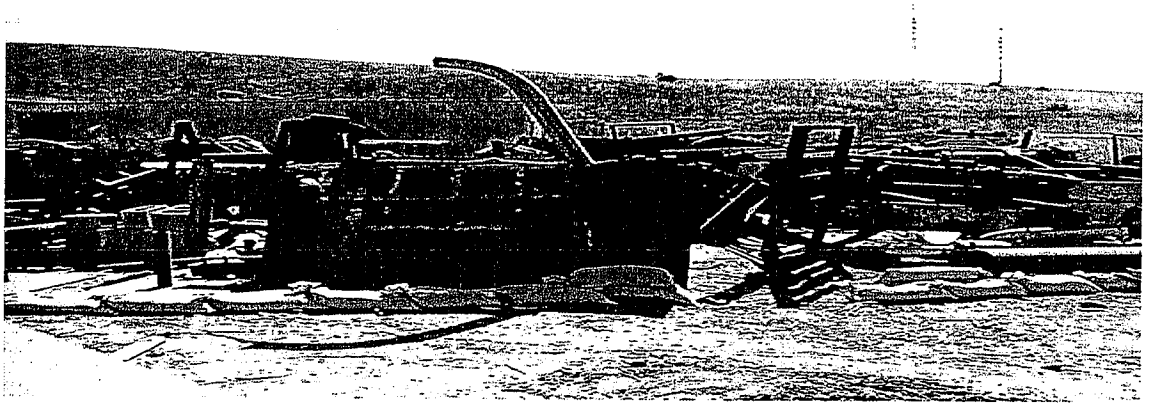
2) Showing a newly built upper settling/retention pond for non-storm water discharges. However, it could overflow during rainy season.

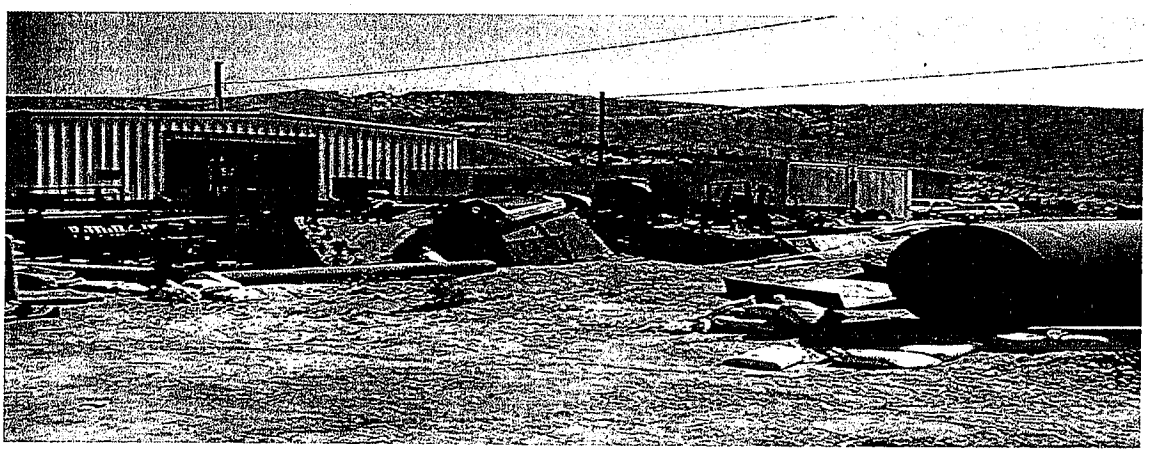


3) Showing a newly built small settling/retention pond for non-storm water discharges. However, it also could overflow during rainy season.



4) Showing still exposed various scrap metals at the facility with ineffective sandbag protection contrary to statements in SWPPP.

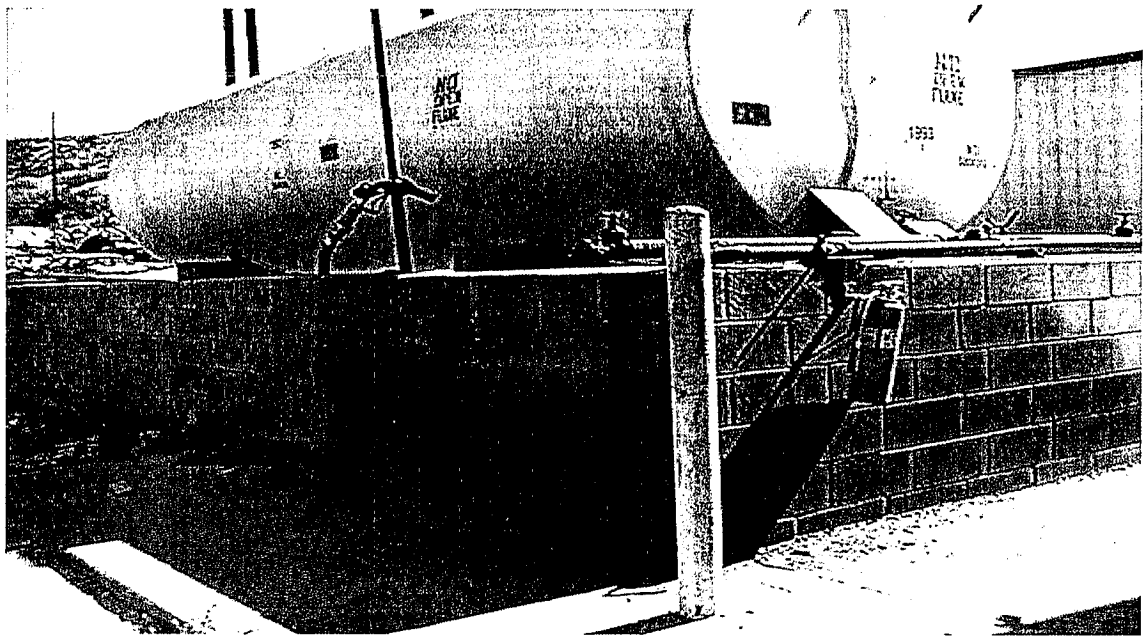




5) Showing burned wastes and residues on the ground, poor housekeeping practices

6) Showing oil spills on the ground w/o absorbent contrary to statements in SWPPP

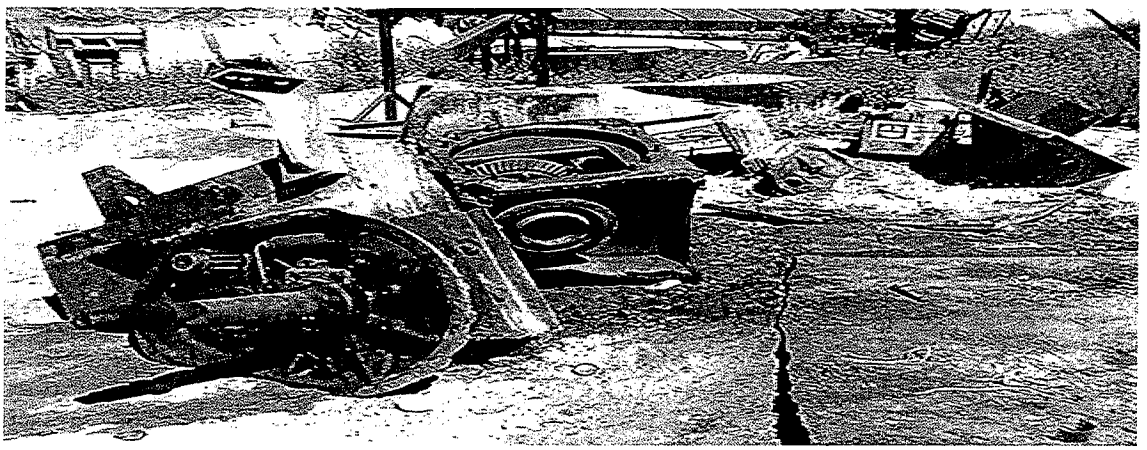
7) Showing oil stains on concrete containment walls, the SWPPP does not describe how to clean this stains

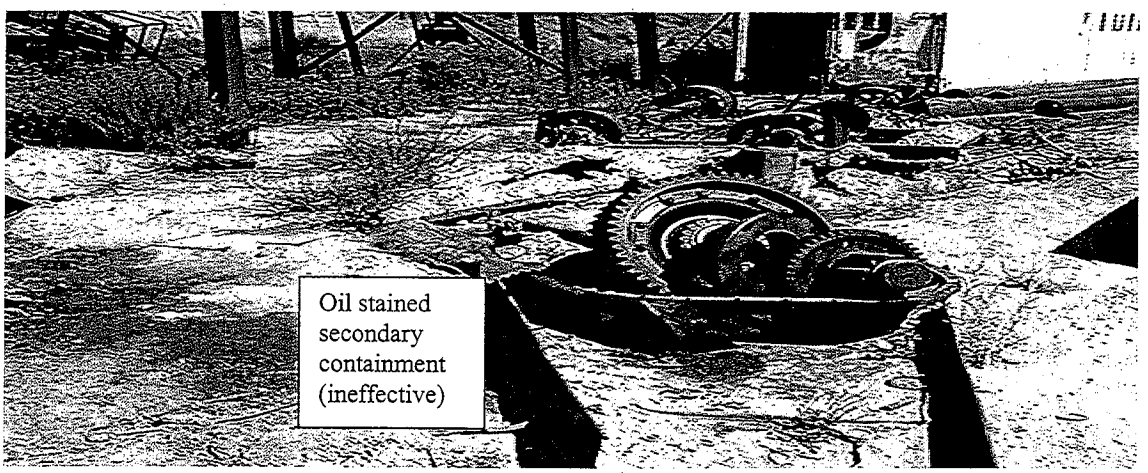


8) Showing outlet of roof pipe w/o appropriate BMPs for storm water run-offs from roof. The SWPPP fails to describe the BMPs for this.

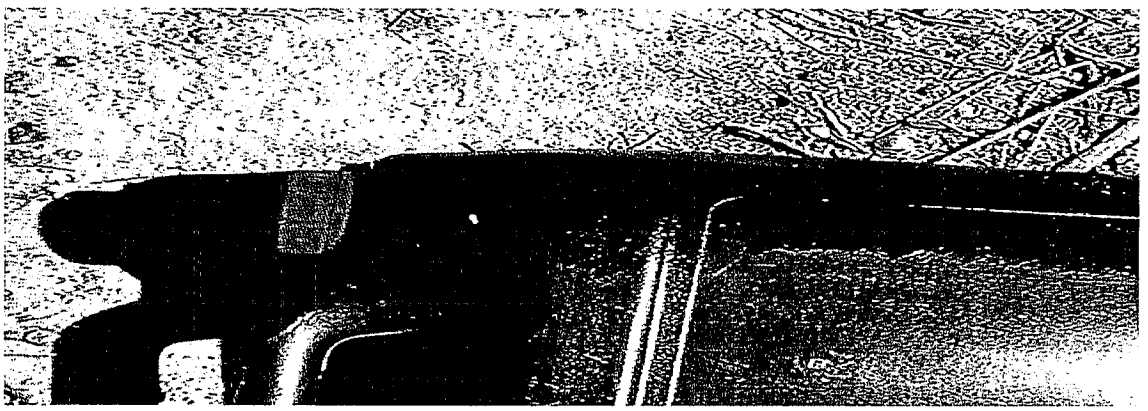
9) Showing ineffective oil absorbent on the ground, poor housekeeping practices contrary to statements in SWPPP.

10) Showing exposed and leaking machinery parts on the ground w/o BMPs contrary to statements in SWPPP

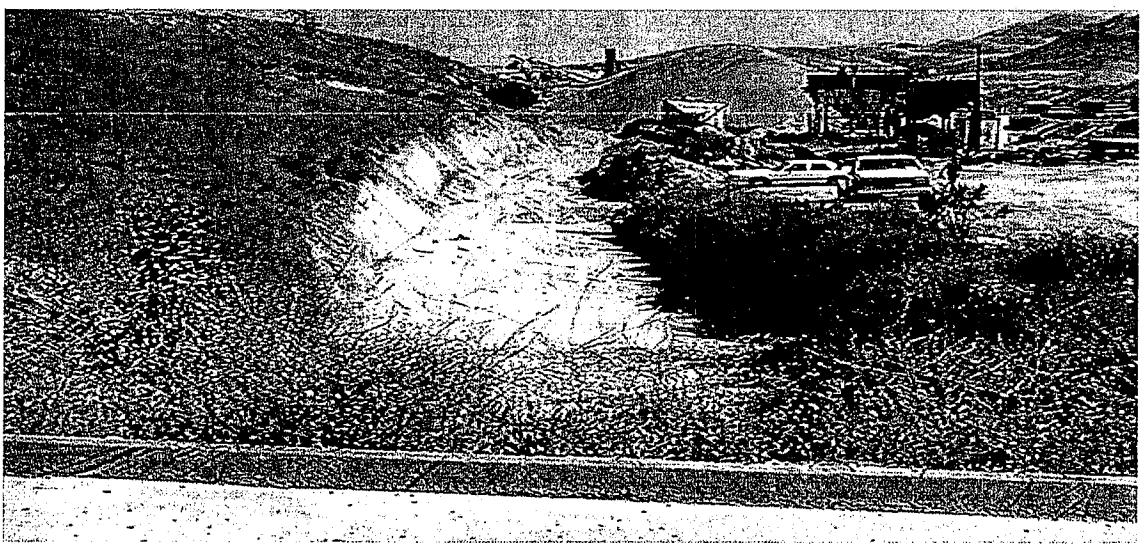




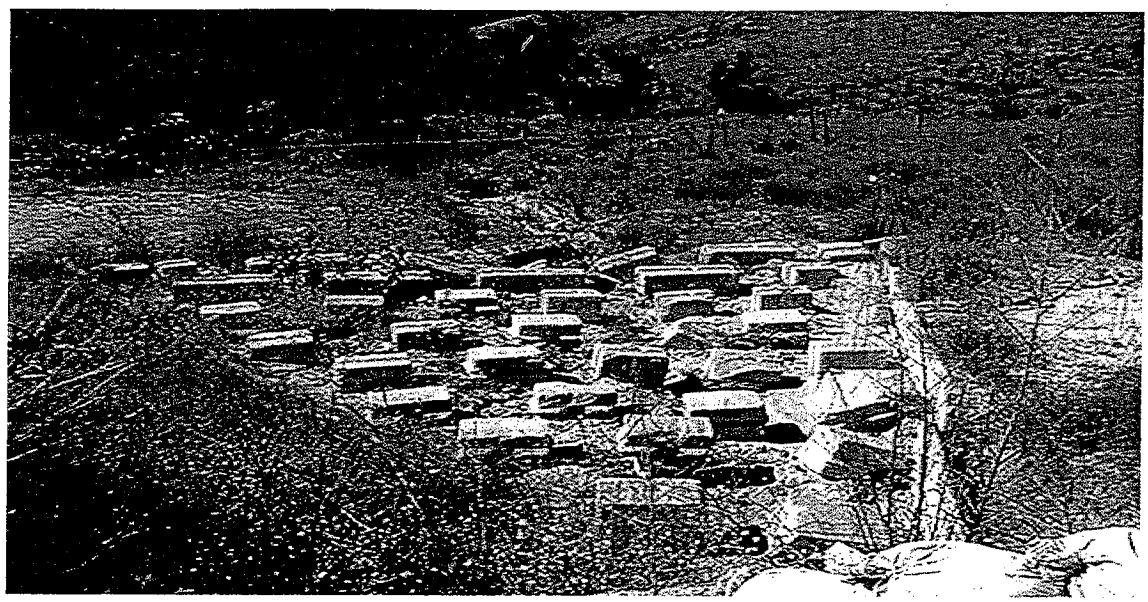
11) Showing anti-freezer container on the ground, poor housekeeping practices



12) Showing entrance of major drainage course of storm water run-offs at the facility



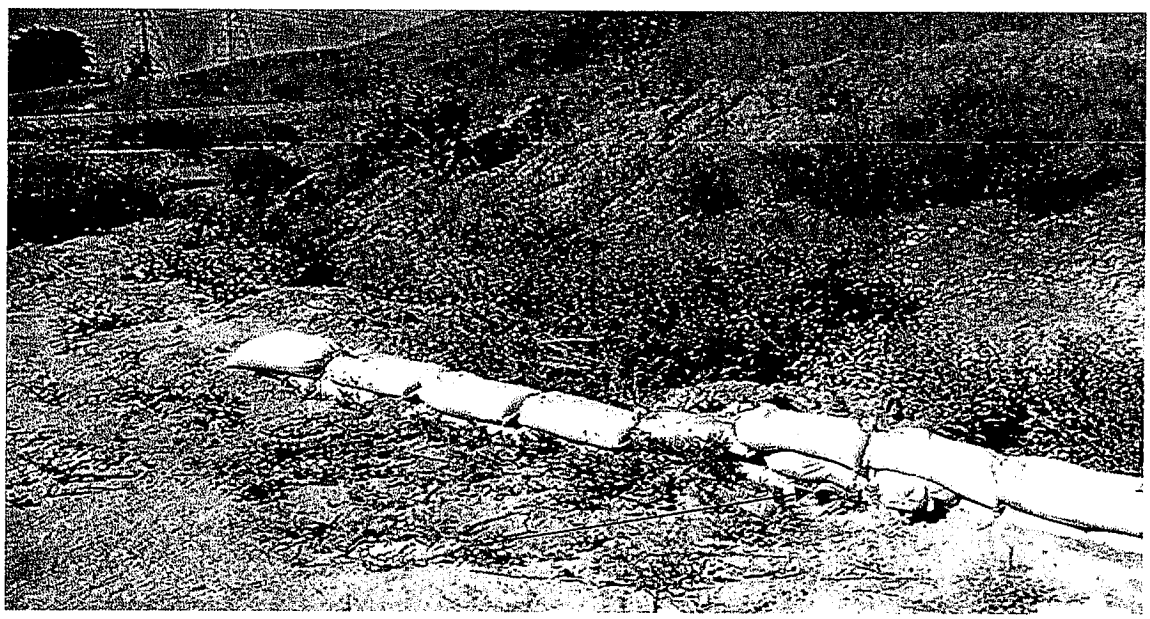
13) Showing outlet of drainage course of storm water run-offs which is connected to Grimes Cyn. Wash. Permanent sediment basin should be implemented in this area.



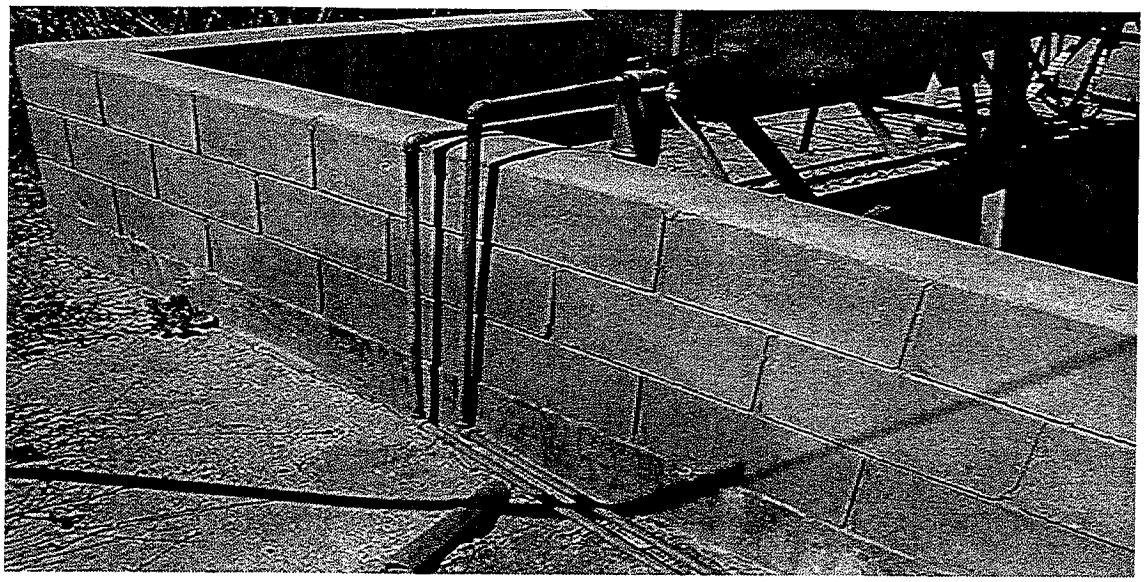
14) Showing another entrance of drainage course for storm water run-offs

15) Showing outlet of drainage course with evidence of major storm water run-offs. Permanent sediment basin should be implemented in this area to contain storm water run-offs. The SWPPP fails to describe the BMPs for this.

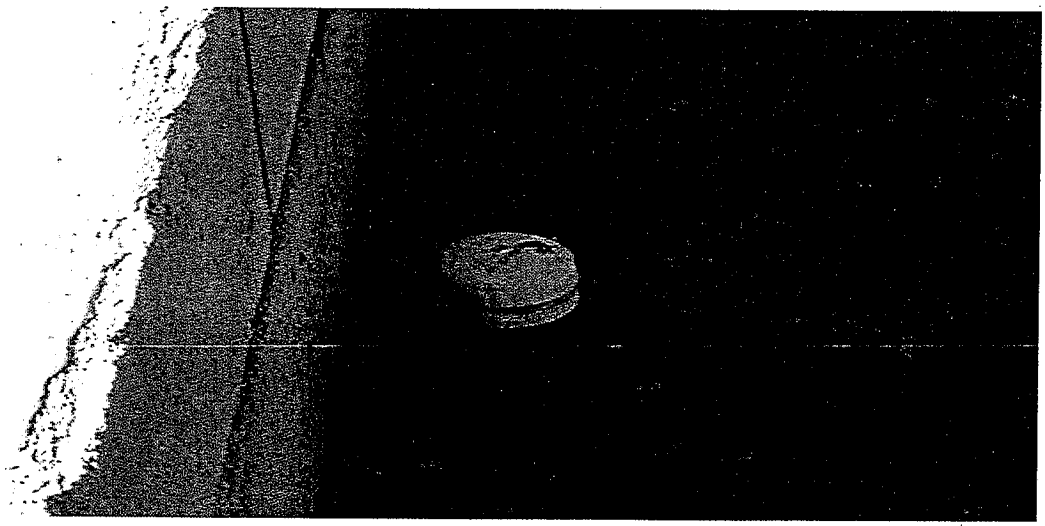
16) Showing a pipe connected to a drainage course under sandbags. This area is used as storage of hazardous wastes and scarp metals, and maintenance of machinery parts



17) Showing oil stains on concrete wall containment



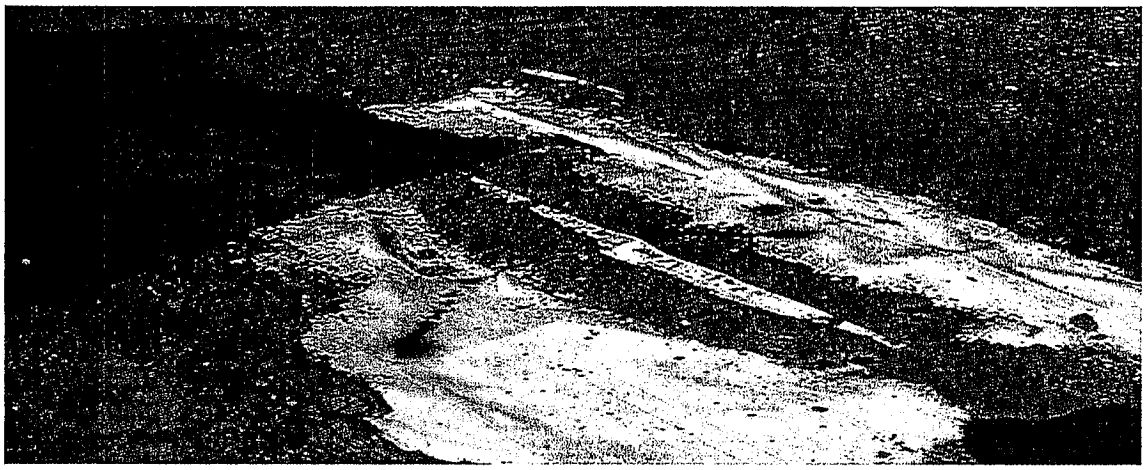
18) Showing cap on inlet of pipe in oil tank storage areas complying with EPA staff's recommendation.



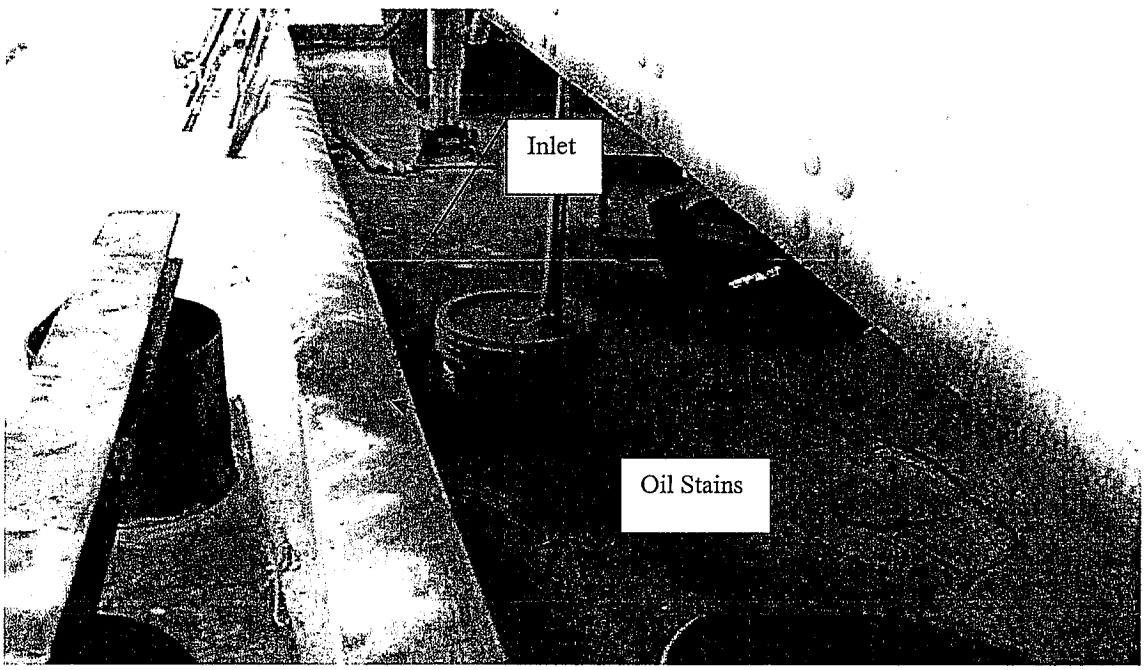
WDID#: 456S012042
Inspection Date: March 20, 2003
Inspection Site: Wayne J. Sand & Gravel
Grimes Cyn Rd & Shekell Road., Moorpark, CA 93020

Industrial

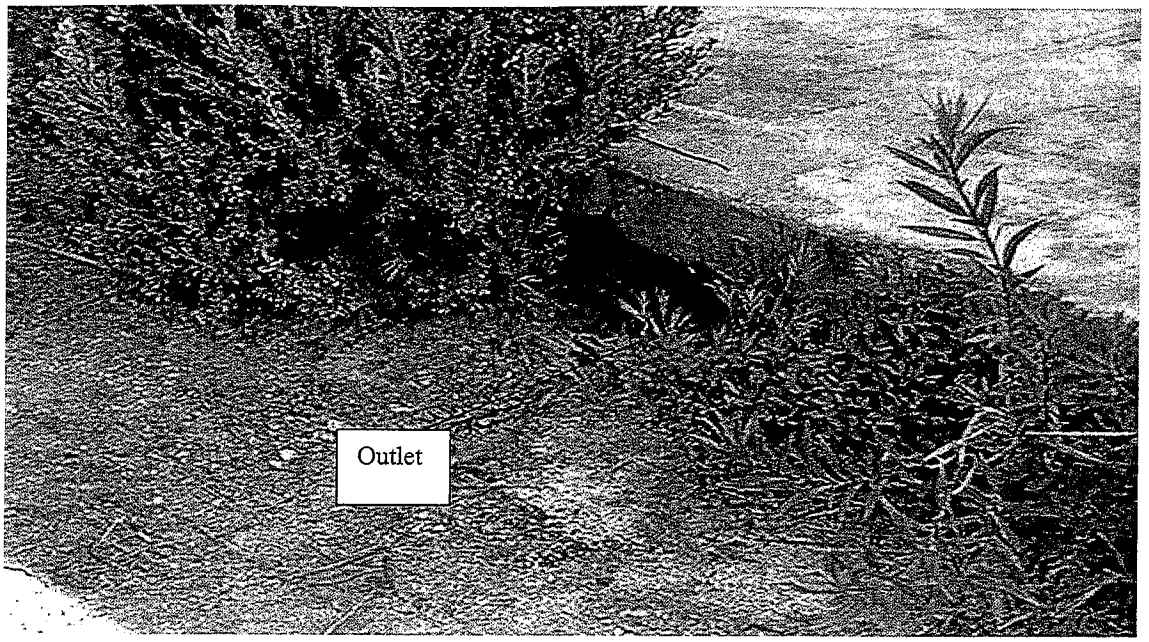
1) Showing oil spills on the ground at the facility



2) Showing drain inlet connected to the ground from oil tank area and oil stains on berms

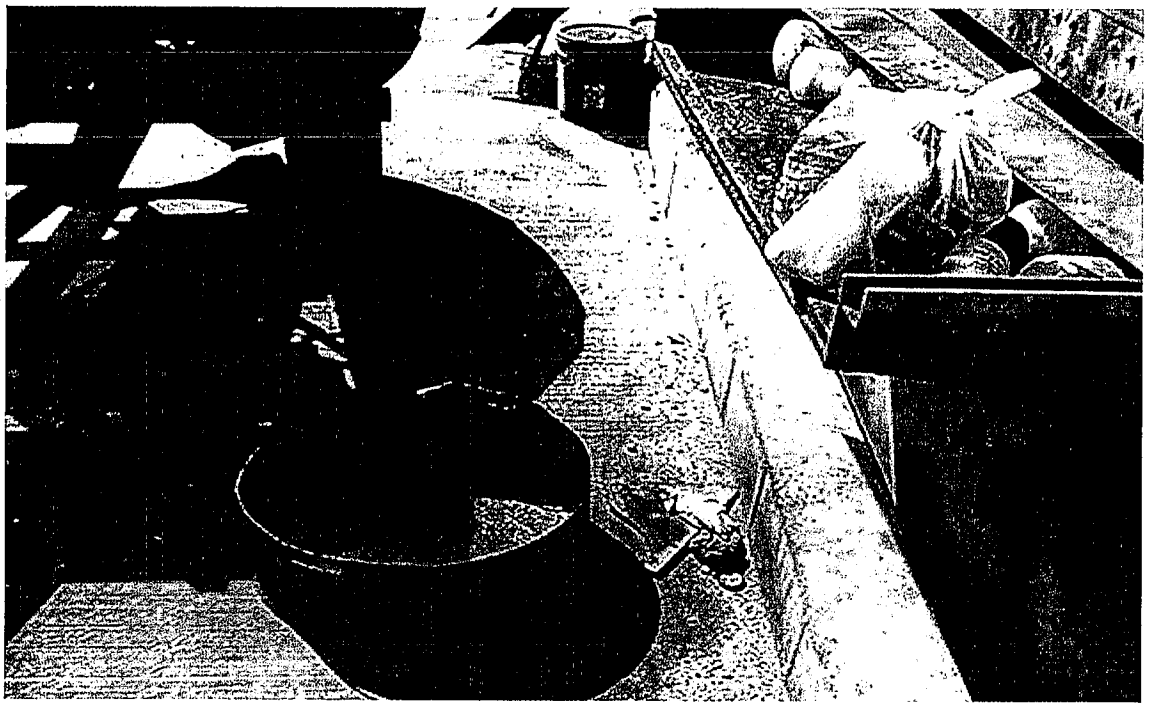


3) Showing drain outlet connected to oil tank area

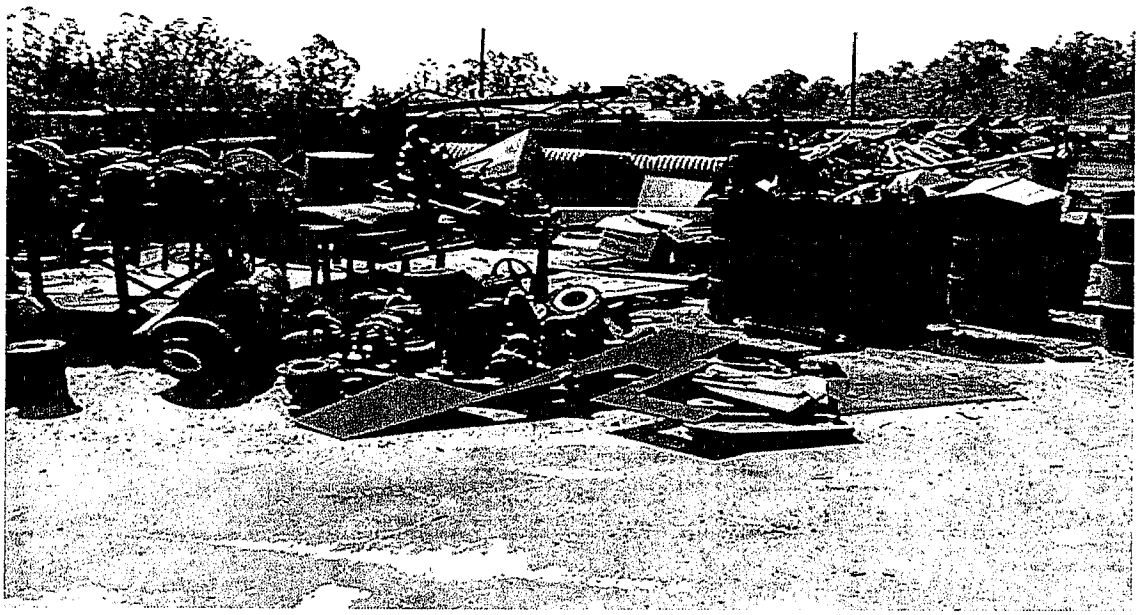


4) Showing exposed oil drum on the ground

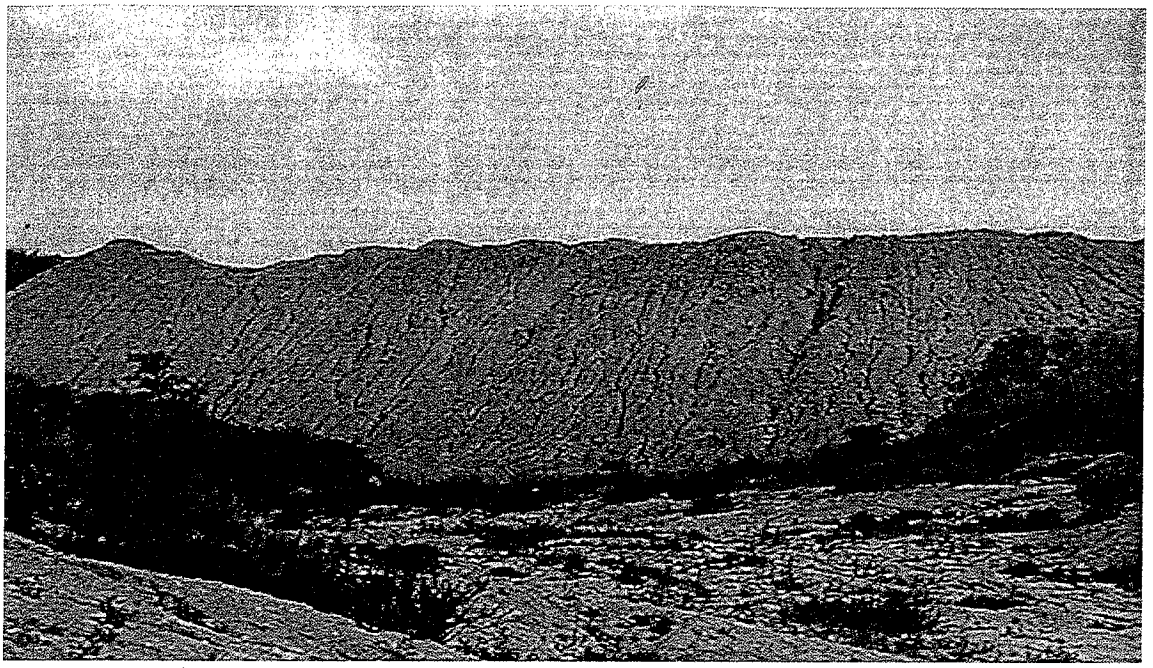
5) Showing oil stains and dripping pan on the ground



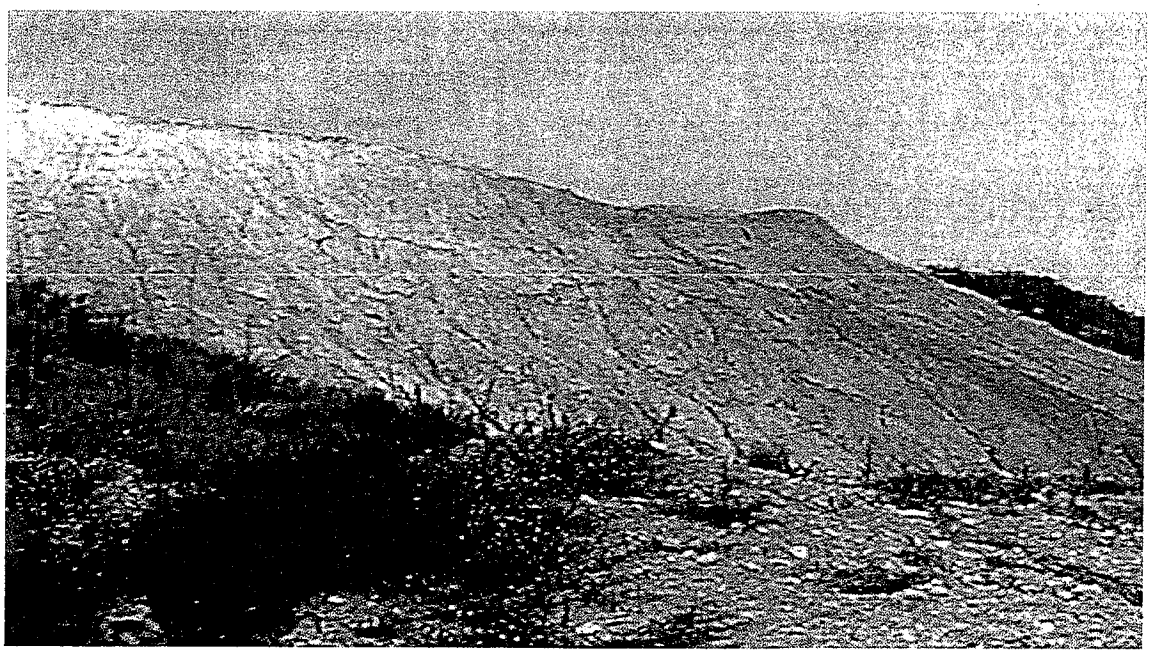
6) Showing various rusted metals on the ground



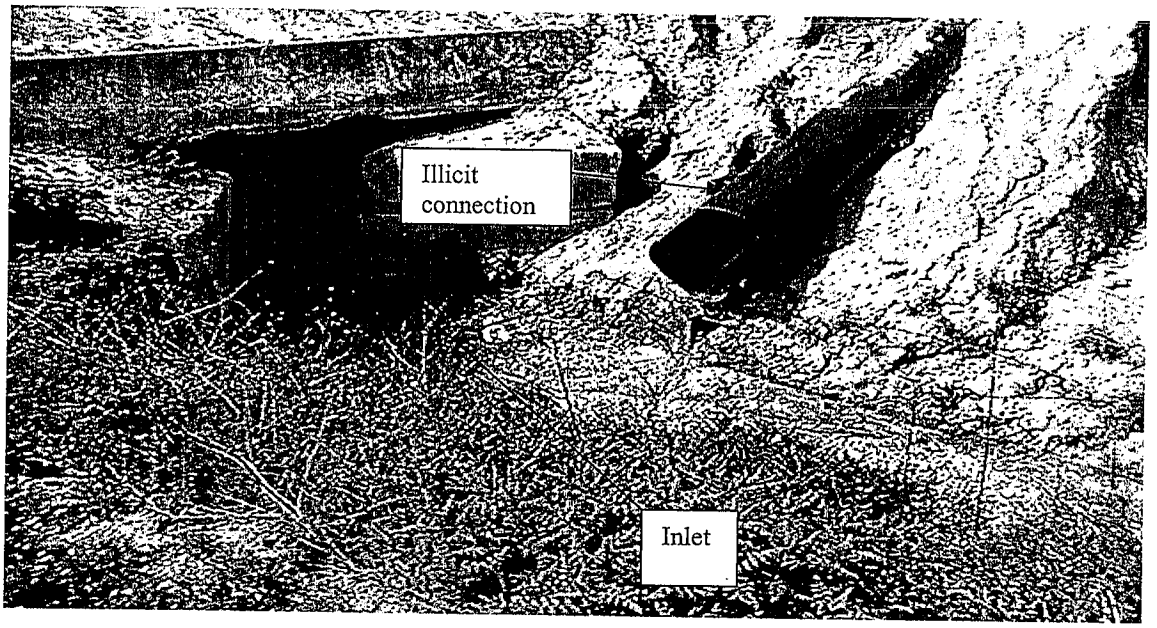
7) Showing erosions on slopes w/o effective erosion control BMPs



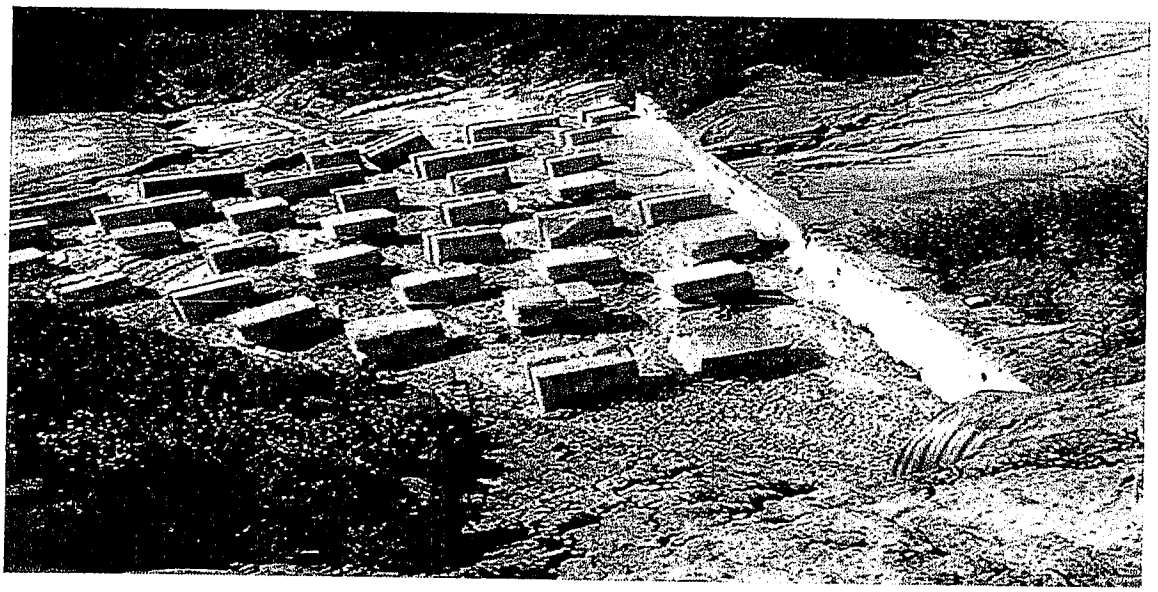
8) Showing erosions on slopes w/o effective erosion control BMPs



9) Showing inlet connected to natural habitat, illicit pipe connection and eroded slopes



10) Showing discharged sediments to natural habitat coming out of mining area



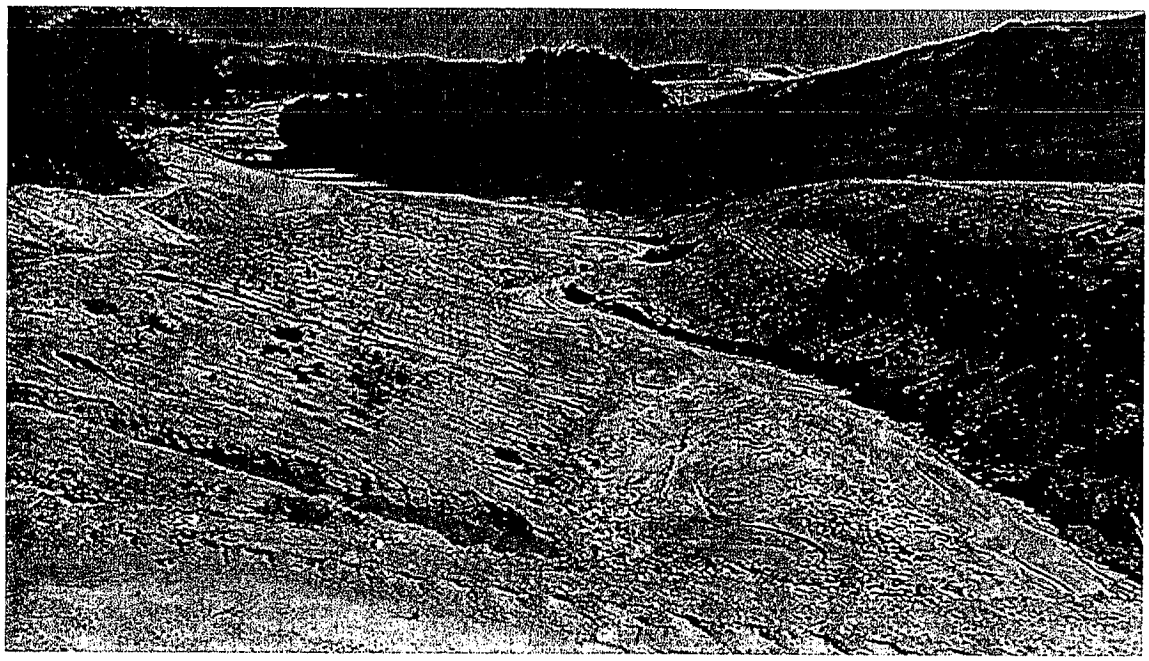
WDID#: 456S315884
Inspection Date: March 20, 2003
Inspection Site: Wayne J. Sand & Gravel
Grimes Cyn Road & Shekell Road., Moorpark, CA 93021

Construction

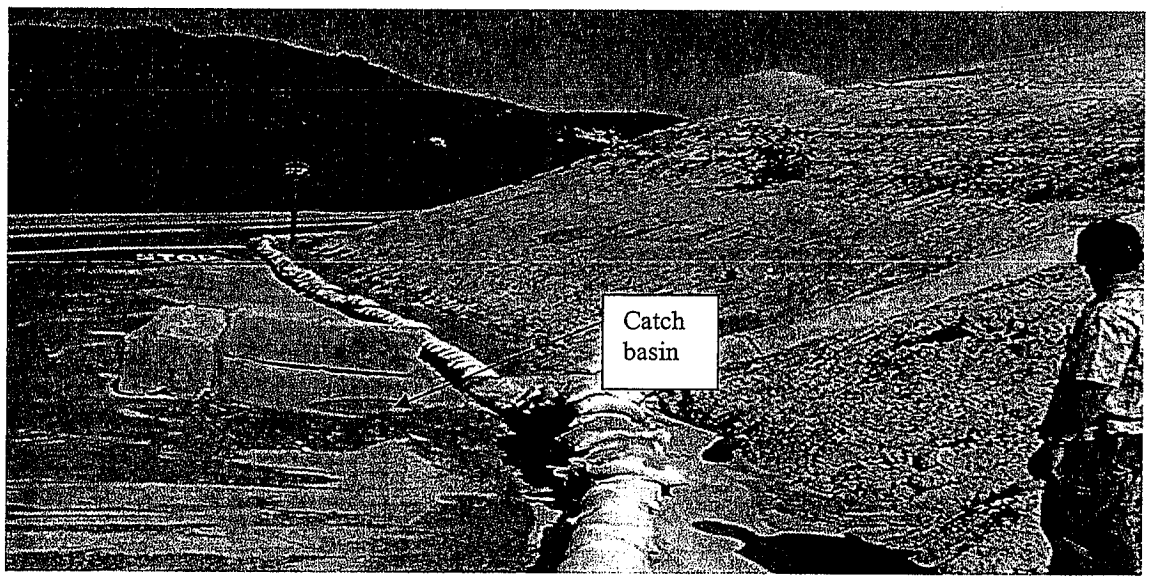
1) Showing erosions on slope, ineffective erosion control BMPs

2) Showing ineffective erosion control BMPs on site

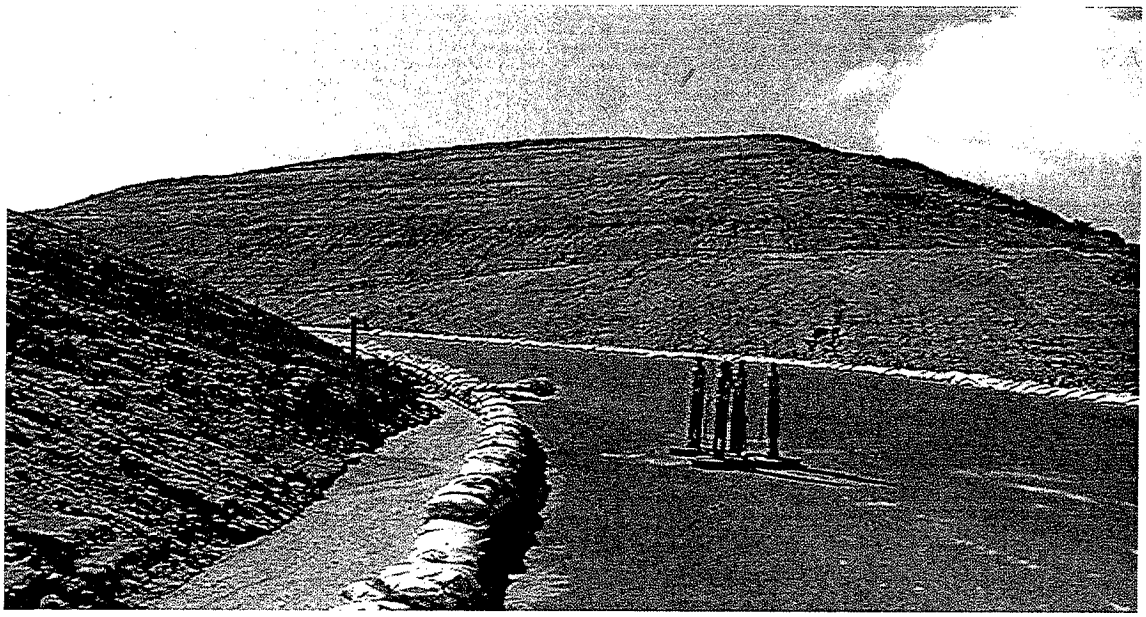
3) Showing erosions on slopes and sediment discharges to natural habitat



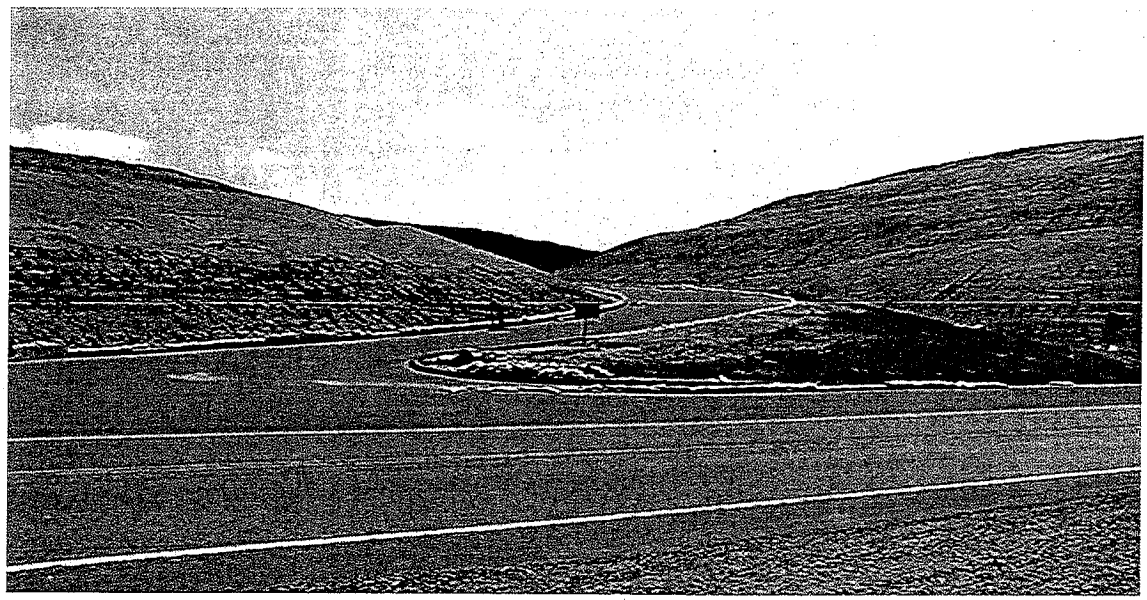
4) Showing erosions on slopes and sediments on street near catch basin



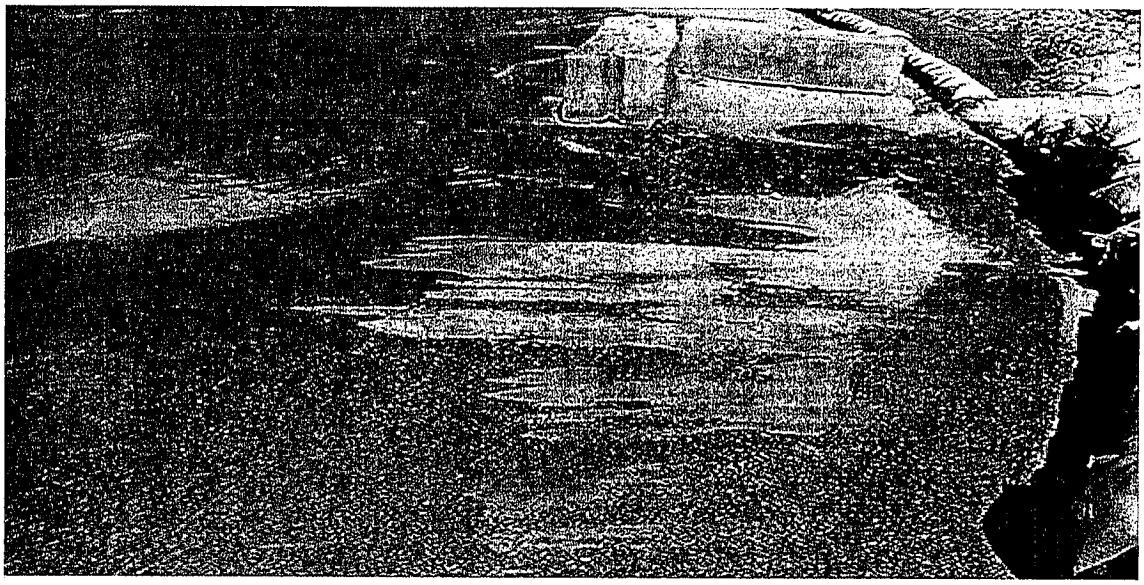
5) Showing slopes w/o effective erosion control BMPs on site



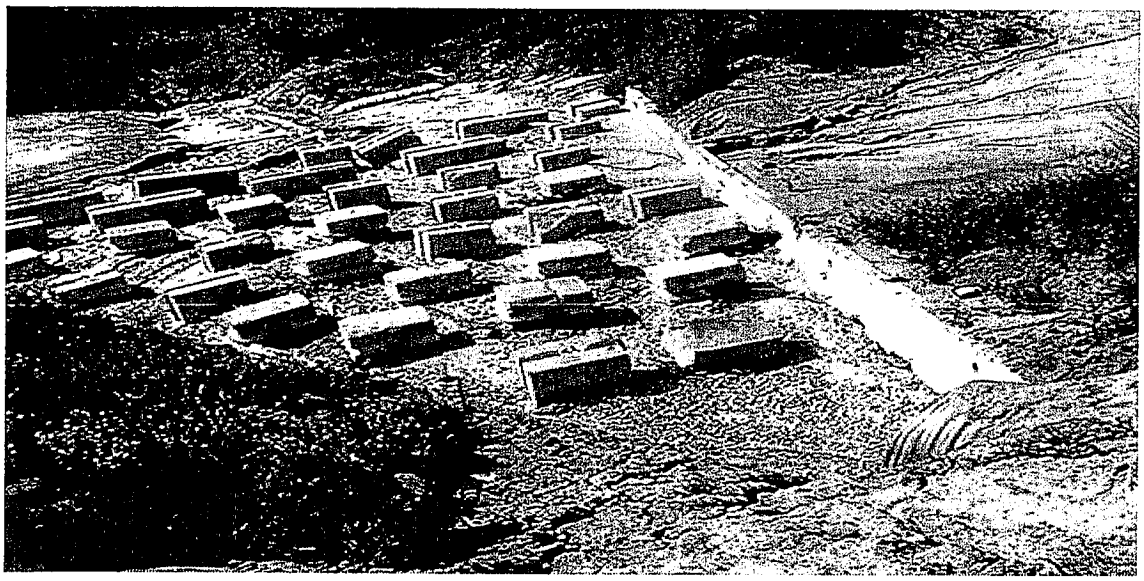
6) Showing erosions on slopes w/o effective erosion control BMPs on site



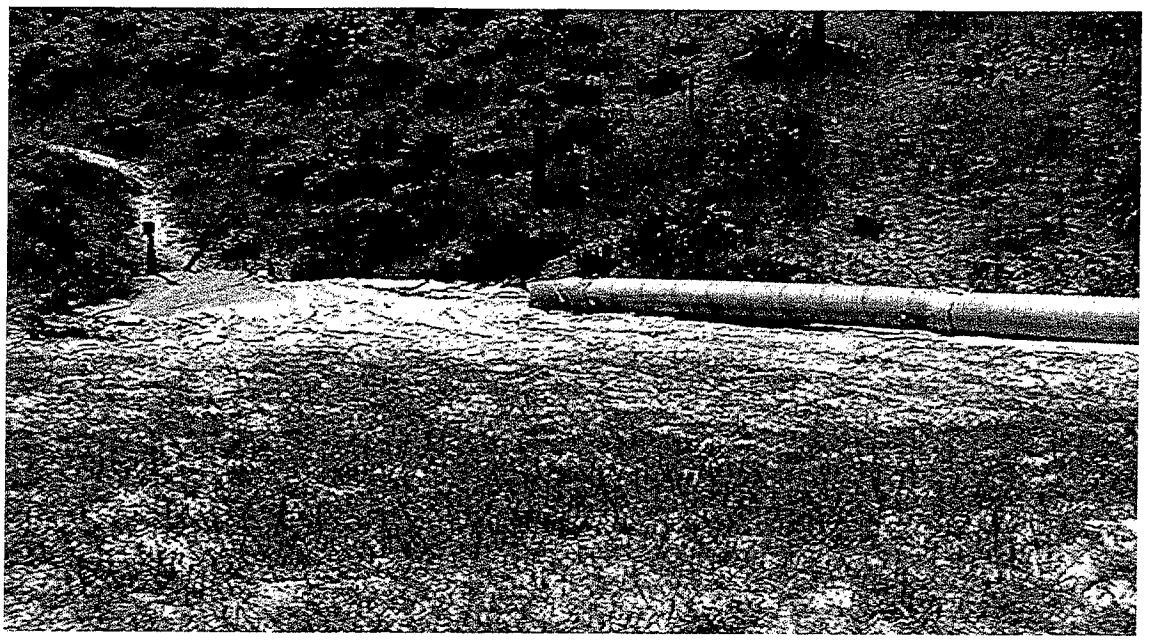
7) Showing sediments on street, ineffective sediment control BMPs



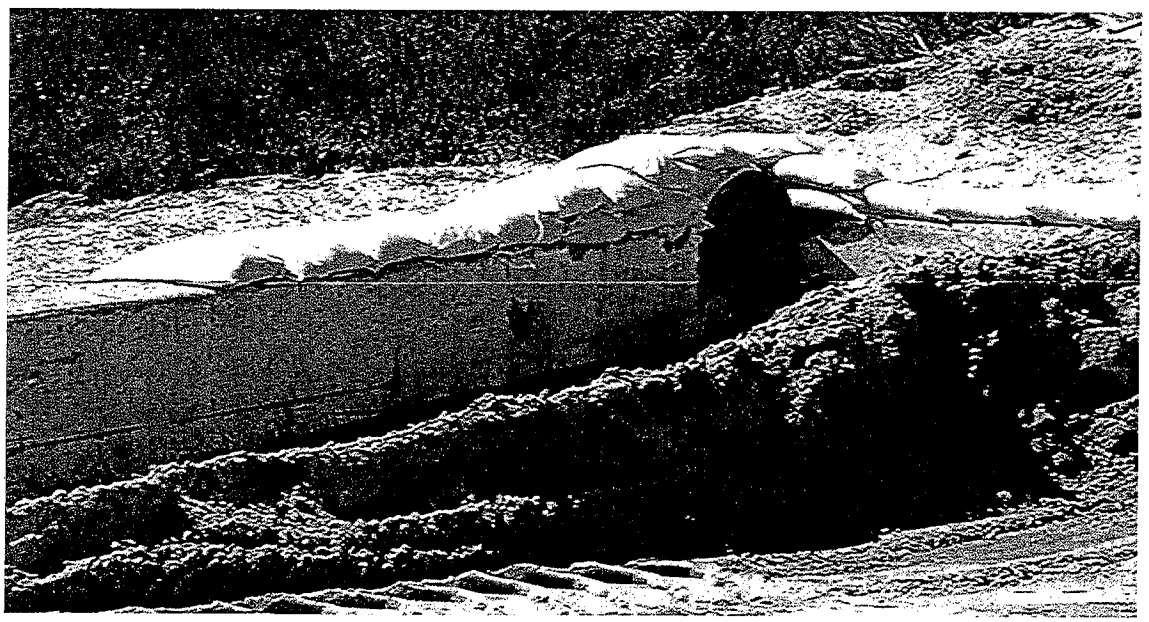
8) Showing sediment discharges to natural habitat out of the site due to ineffective sediment control BMPs



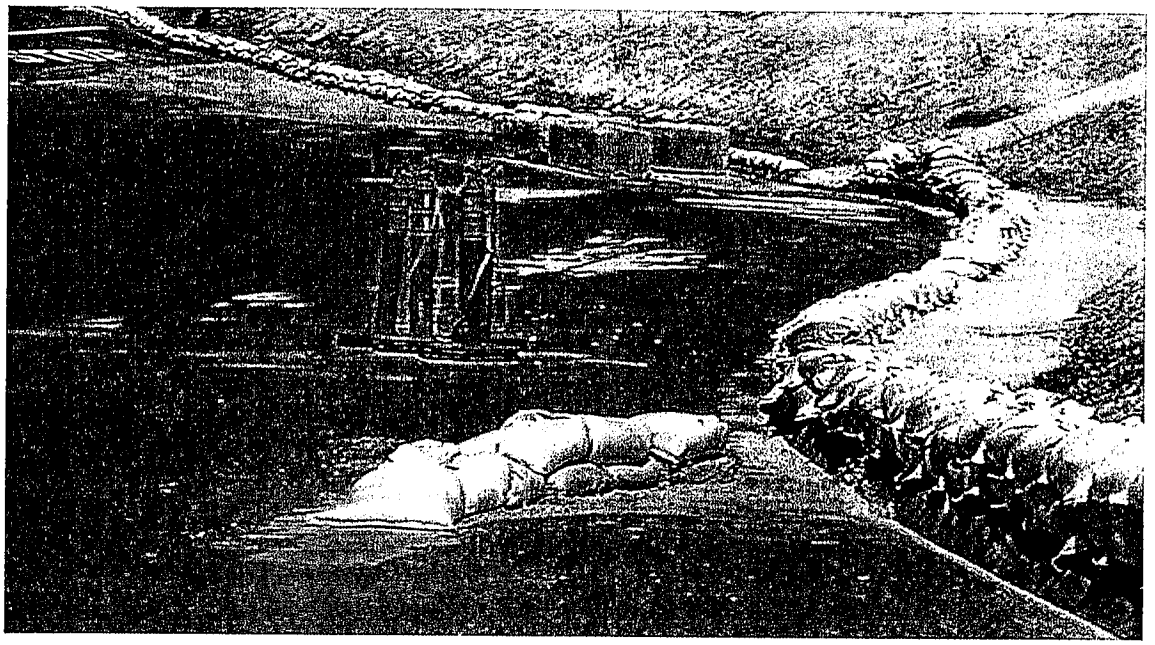
9) Showing sediment discharges to natural habitat through the pipe connected to the site



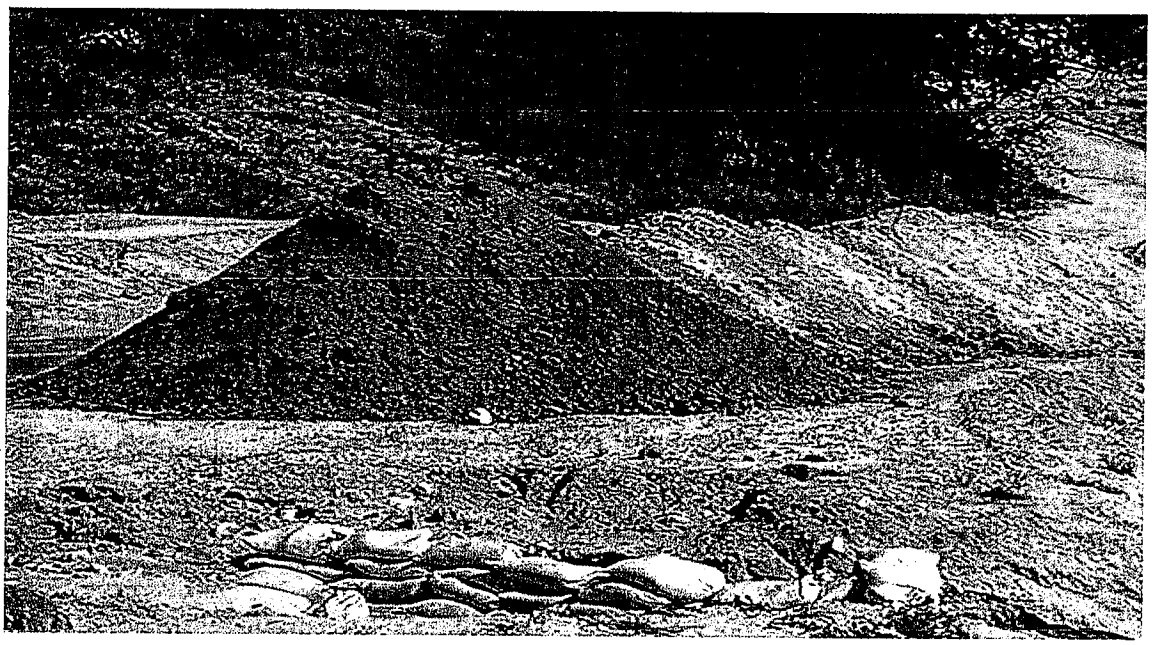
10) Showing pipe inlet w/o effective sediment control BMPs



11) Showing ineffective sandbagging sediment control BMPs



12) Showing dirt piles w/o effective wind erosion control BMPs



City of Ojai

Corporation Yard
408 S. Signal st.
Ojai, CA 93023

Contact: William G. Frank
Inspection Date: February 24, 2004
Time of inspection: 9:15 a.m.

Site information:

% impervious:	70 %
Area:	3-4 acres
Major receiving water body:	Fox Canyon

Violations:

Storm Water Pollution Control Plan

- Generic SWPCP
- Training Records were missing
- Inspection Records were missing, only one recent inspection checklist was filled out on 2/5/04.
- BMPs listed in the SWPCP are not site specific and chemical storage area was not specified in the SWPCP.

Non-Filer issues

- The trolley service they provide for the community is not covered under the general permit for industrial activities. A permit is needed for including maintenance and fueling.

BMP concerns

- Some scrap metal and other waste materials were not covered.
- A waste oil drum did not have secondary containment.
- stock piles of dirt and concrete waste were not covered.

Positive:

- The City of Ojai is in the process of installing a grassy swale behind the maintenance building and at the discharge point.
- All maintenance is done indoors
- Chemical storage area is covered and well contained.
- Trash and green waste bins were covered.

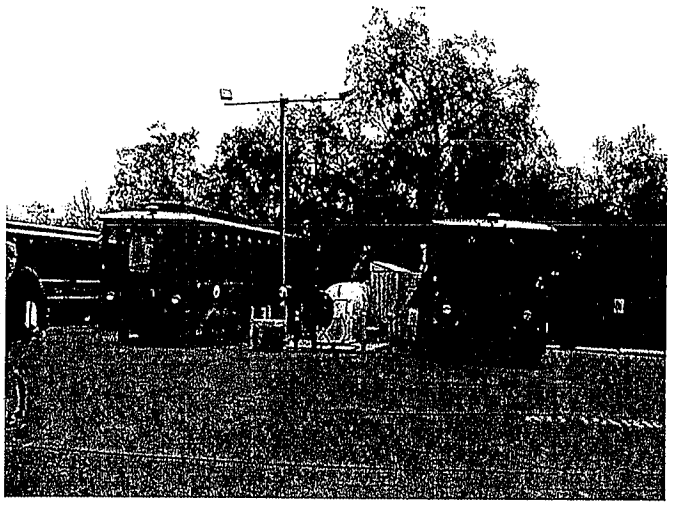


Photo 1. Trolley and fueling area.

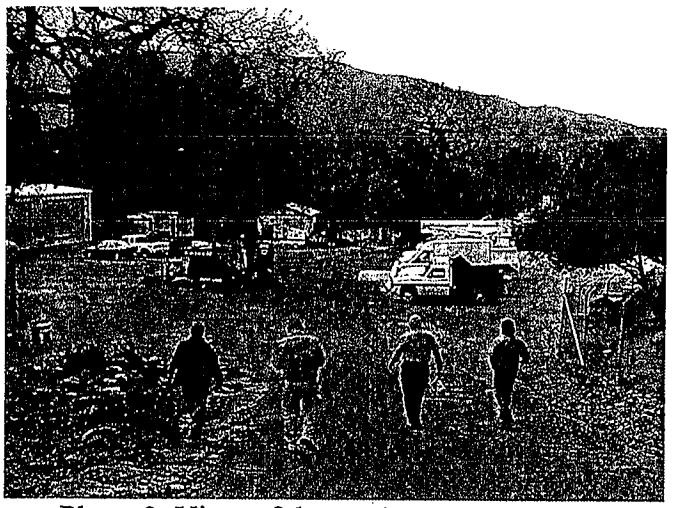


Photo 2. View of the yard

Photo 3. Scrap metals that need to be covered or disposed.

Photo 4. Concrete waste and debris

Photo 5. Shows area behind the maintenance building where a swale will be installed.

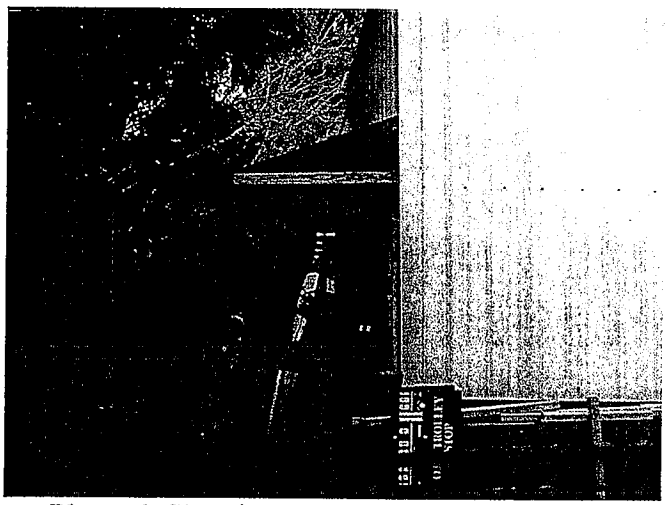


Photo 6. Showing a shed to cover metals parts.

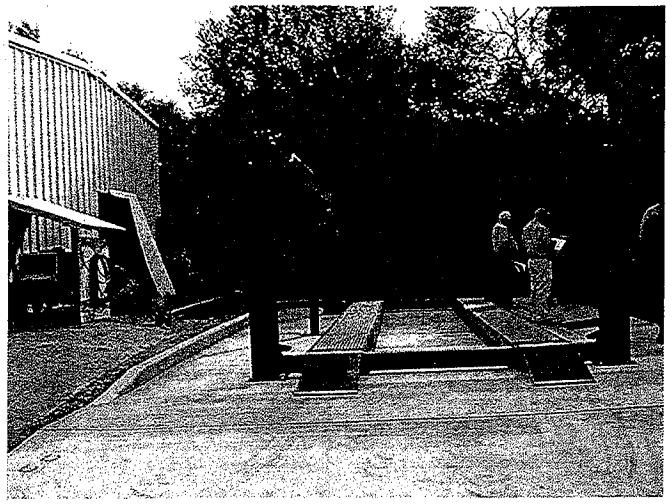


Photo 7. Vehicle washing area with underground sump.

Photo 8. Chemical Storage area.

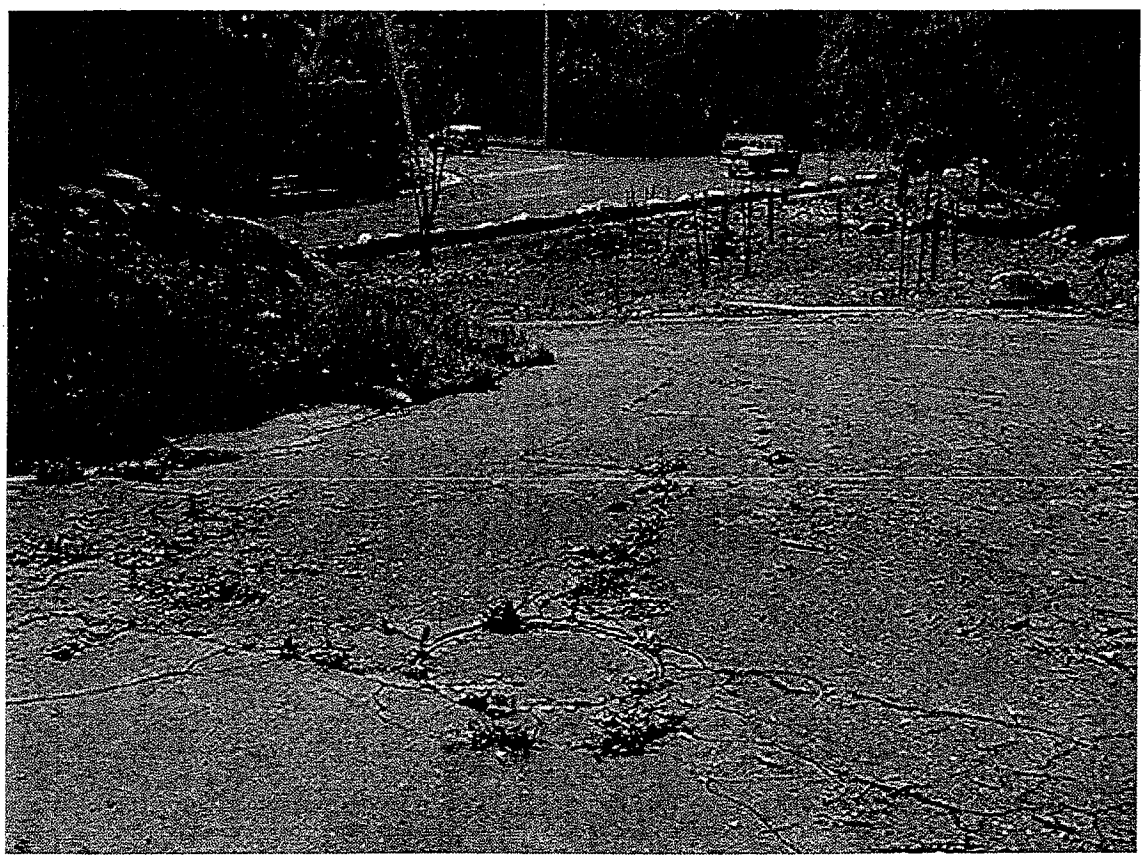


Photo 9. Exit/discharge point.

City of Ojai

Corporation Yard
408 S. Signal st.
Ojai, CA 93023

Contact: Glen Hawks
Inspection Date: February 1, 2005
Time of inspection: 11:15 a.m.

Site information:

% impervious:	70 %
Area:	3-4 acres
Major receiving water body:	Fox Canyon

Violations:

Storm Water Pollution Control Plan

- SWPCP has been updated to include specific BMPs, training records, and inspection reports

Non-Filer issues

- Facility has filed an NOI for the trolley service. WDID # 456I018830

BMP concerns

BMPs were updated to address concerns pointed on the 2004 audit.

- Scrap metals were covered or discarded.
- Waste oil drums were placed in area the collects spills
- stock piles of dirt and concrete waste were removed.

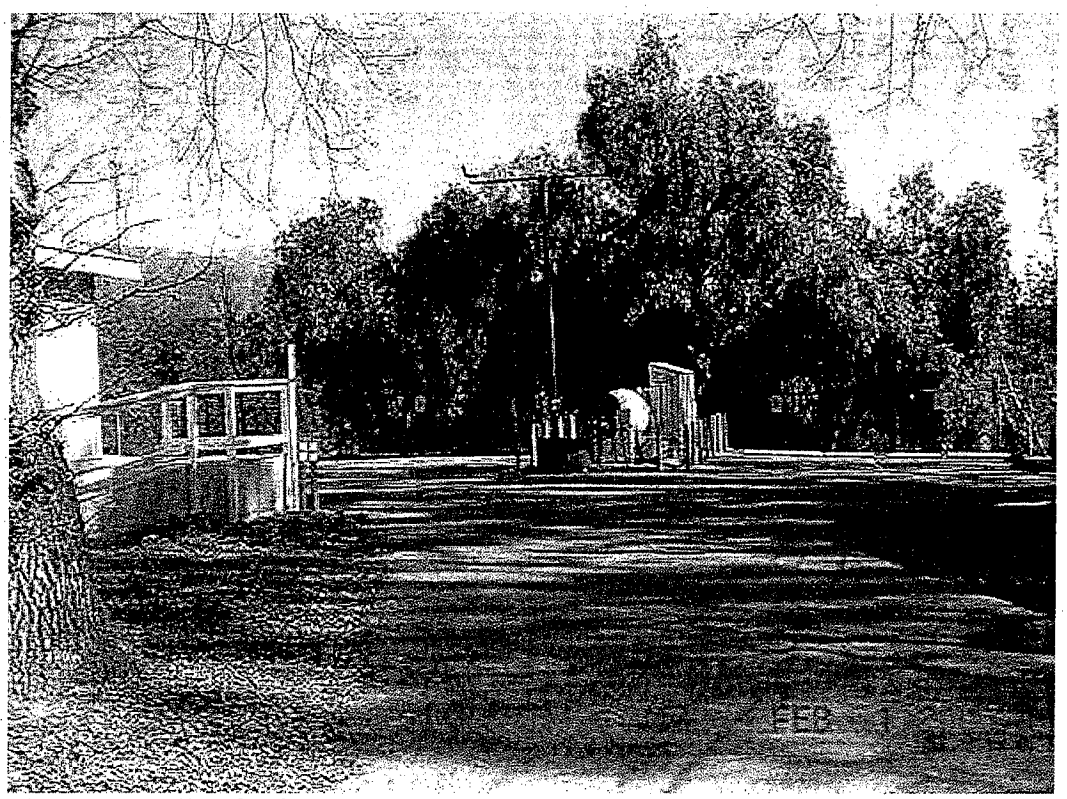


Photo 1. Trolley fueling area

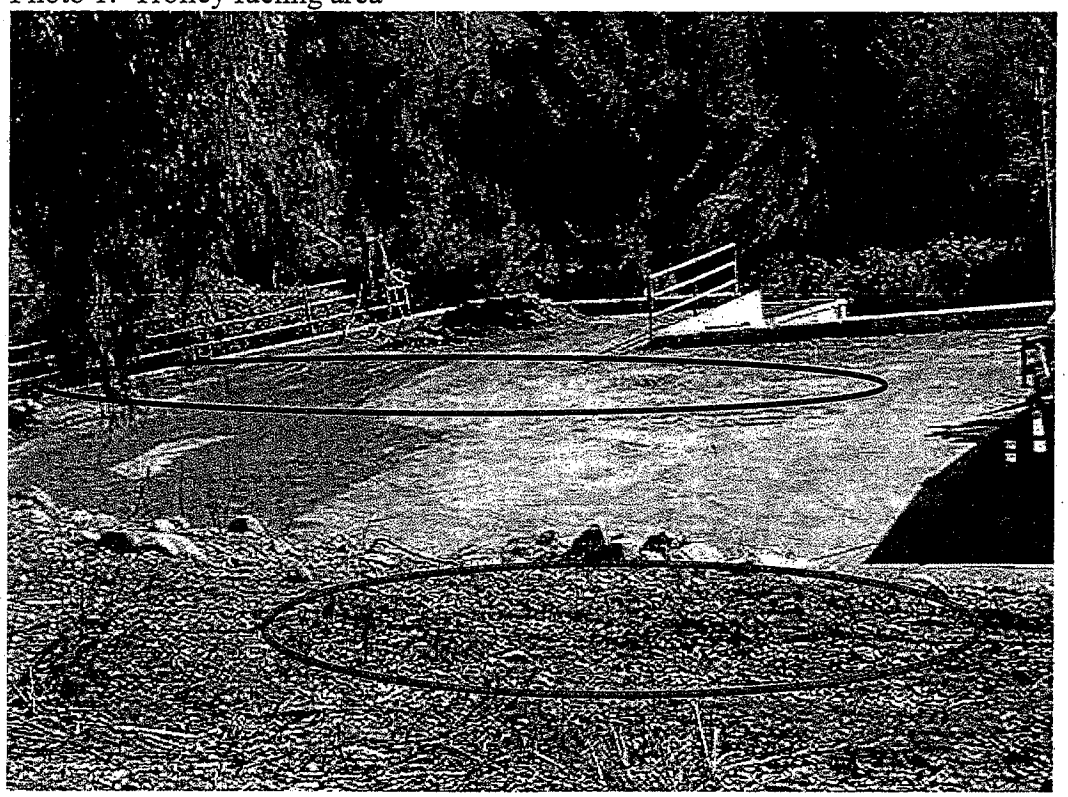


Photo 2 Scrap metals and construction debris removed.

Photo 3. Oil drums placed on concrete pad that drains to a sump.

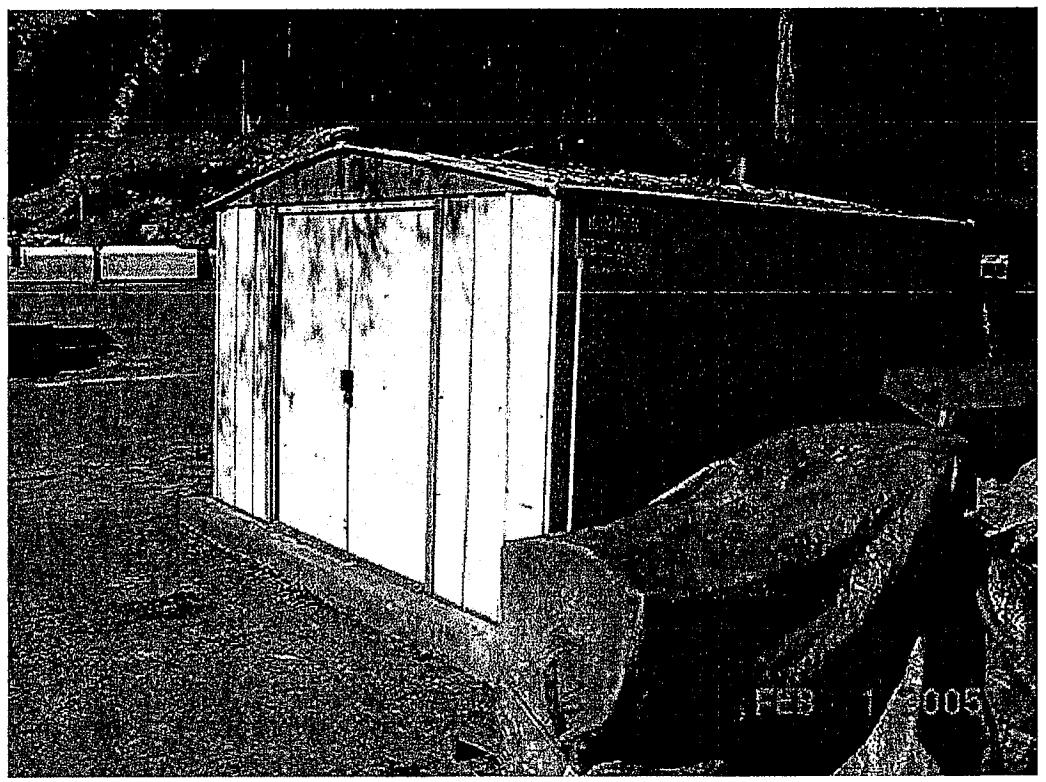
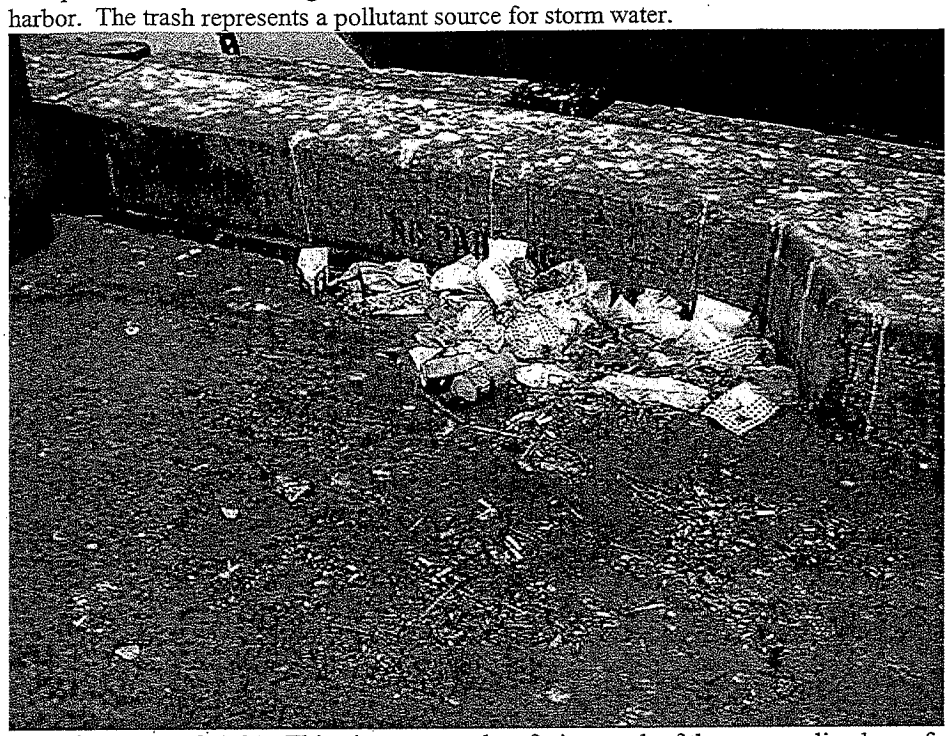
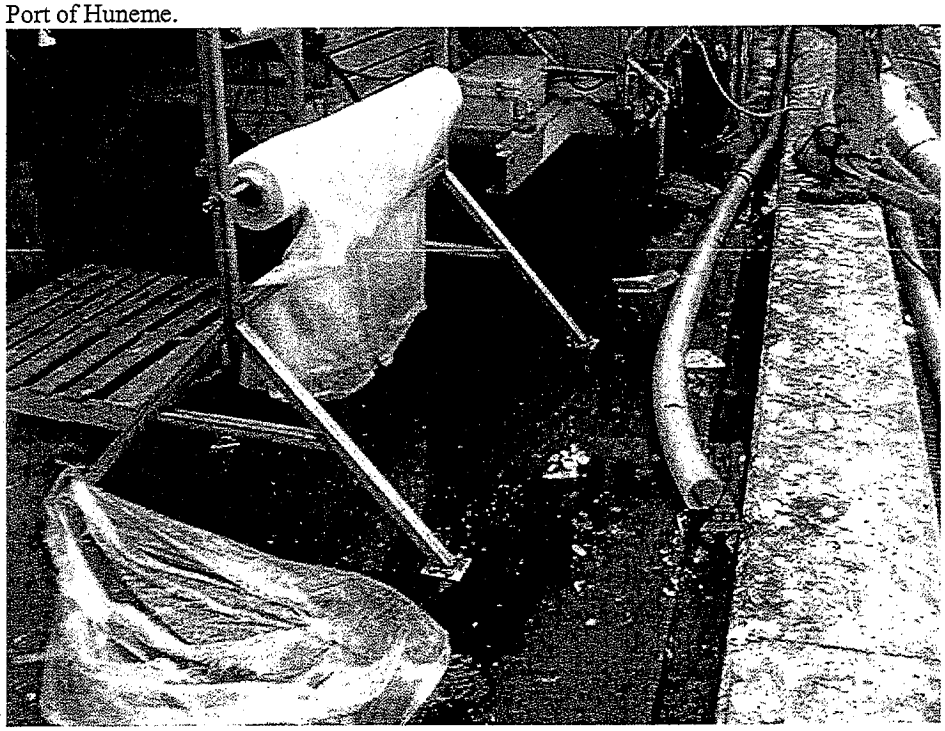


Photo 4. New storage area and tap covers

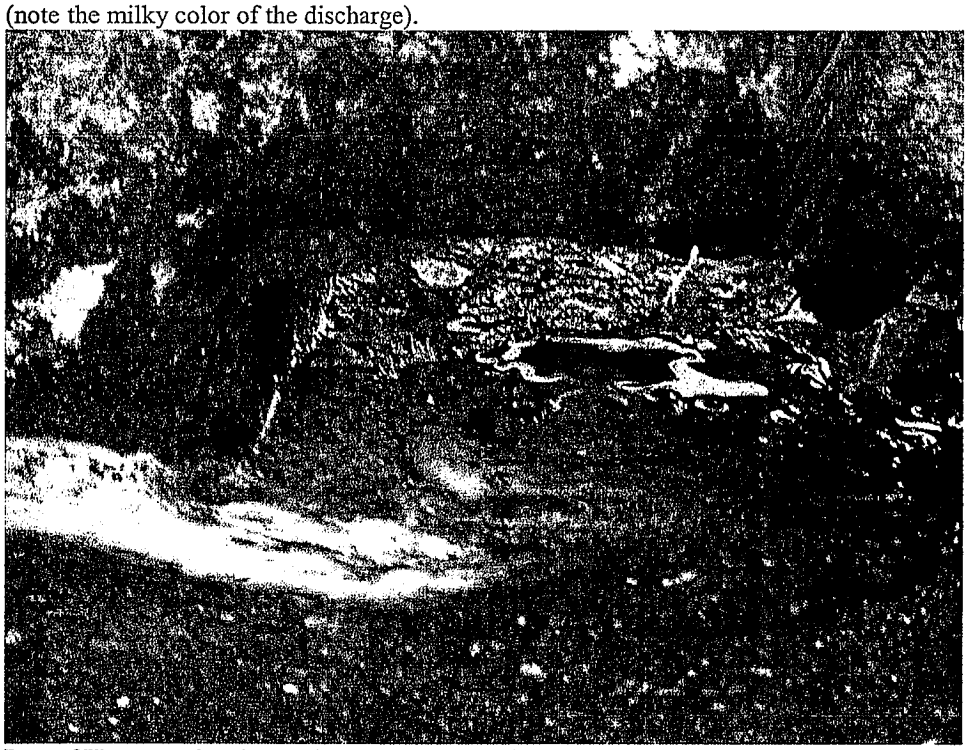
Port of Hueneme WDID #456S 006736 8-1-01. Camera: Sony MVC FD-90.
This picture was taken facing south of the berm surrounding the perimeter of the inner harbor. The trash represents a pollutant source for storm water.



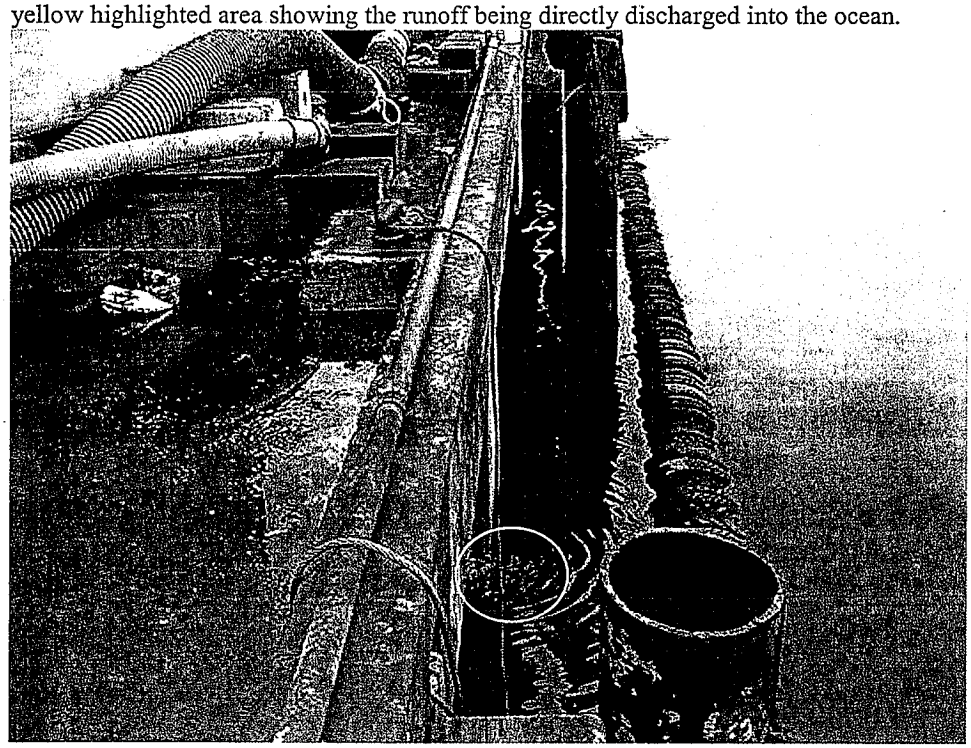
Port of Hueneme 8-1-01. This picture was taken facing south of the surrounding berm for the inner harbor. The standing process water is left from a company that has vacated the Port of Huneme.



Port of Huneme WDID # 456S 006736 8-1-01. Camera: Sony MVC FD-90. This picture was taken facing south, of a water drainage hole in the surrounding berm, on the Port's outter harbor. The water being discharged is traveling through a squid processing area (note the milky color of the discharge).



Port of Hueneme 8-1-01. This picture is a broad overview of the picture above with the yellow highlighted area showing the runoff being directly discharged into the ocean.



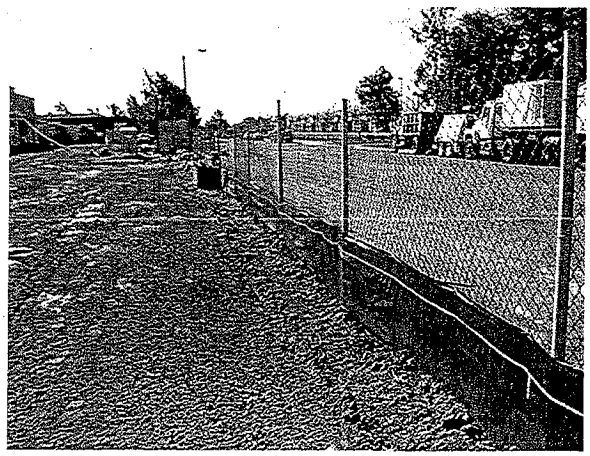
WDID#: 456C 334514
Inspection Date: February 1, 2006
Inspection Site: Grigor E. Atoian & etc.
3000 Bunsen Ave., Ventura, CA

Construction

1) Showing not maintained concrete washout bin on the ground

2) Showing waste-piles on the ground

3) Showing silt fence sediment control BMPs

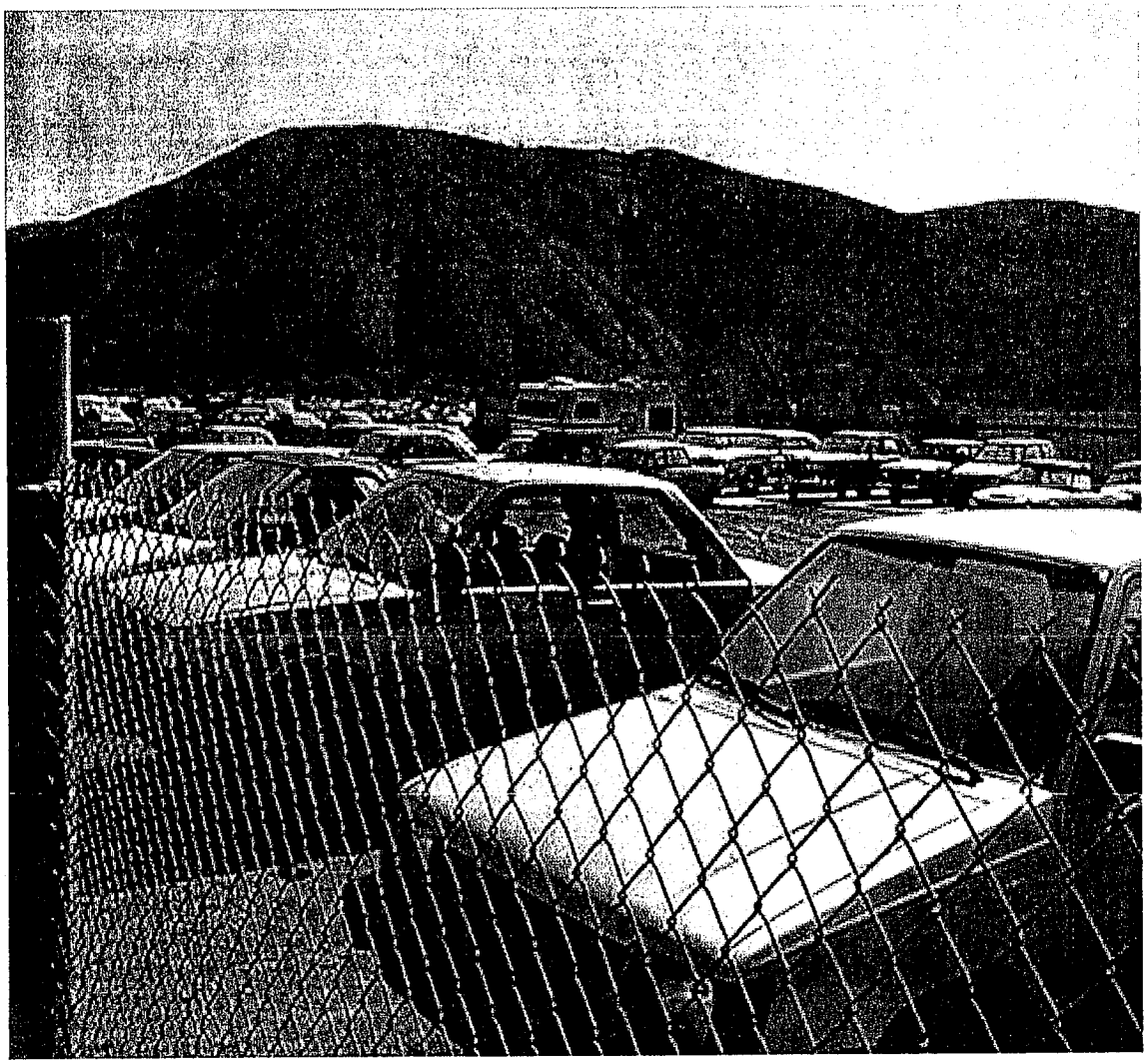


4) Showing finished structure on site

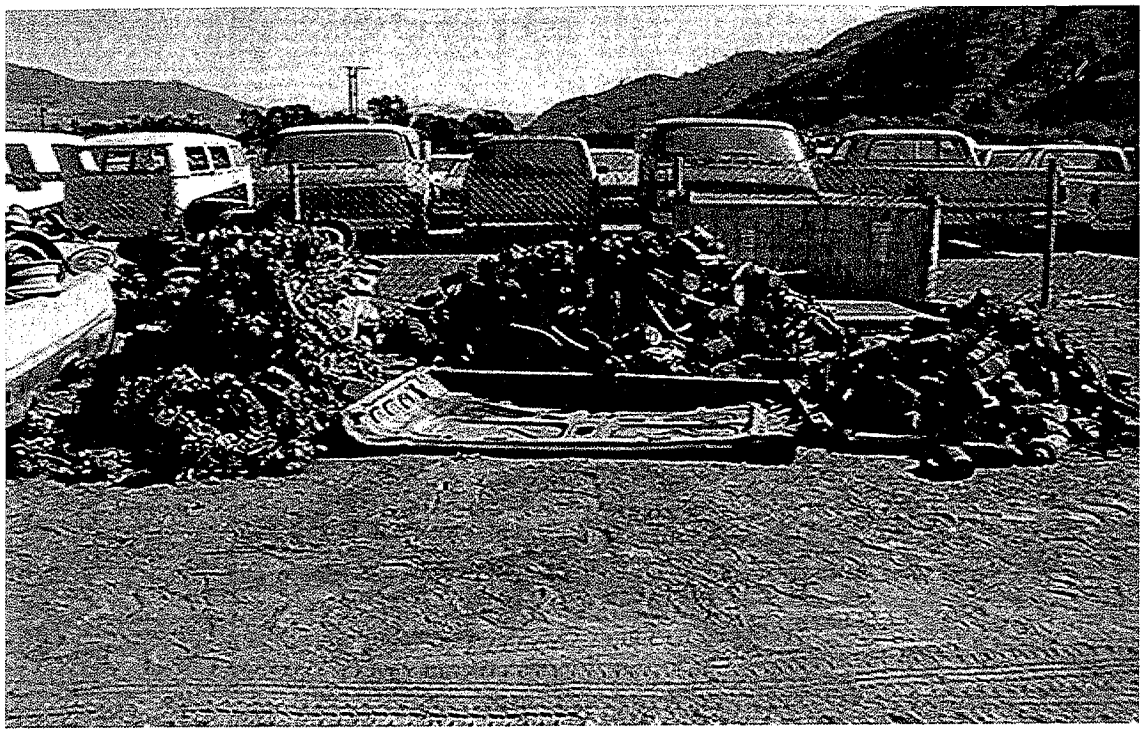
WDID#: 456S015940
Inspection Date: September 26, 2001
Inspection Site: Pick the Part
936 Mission Rock Rd, Santa Paula, CA 93060

Industrial

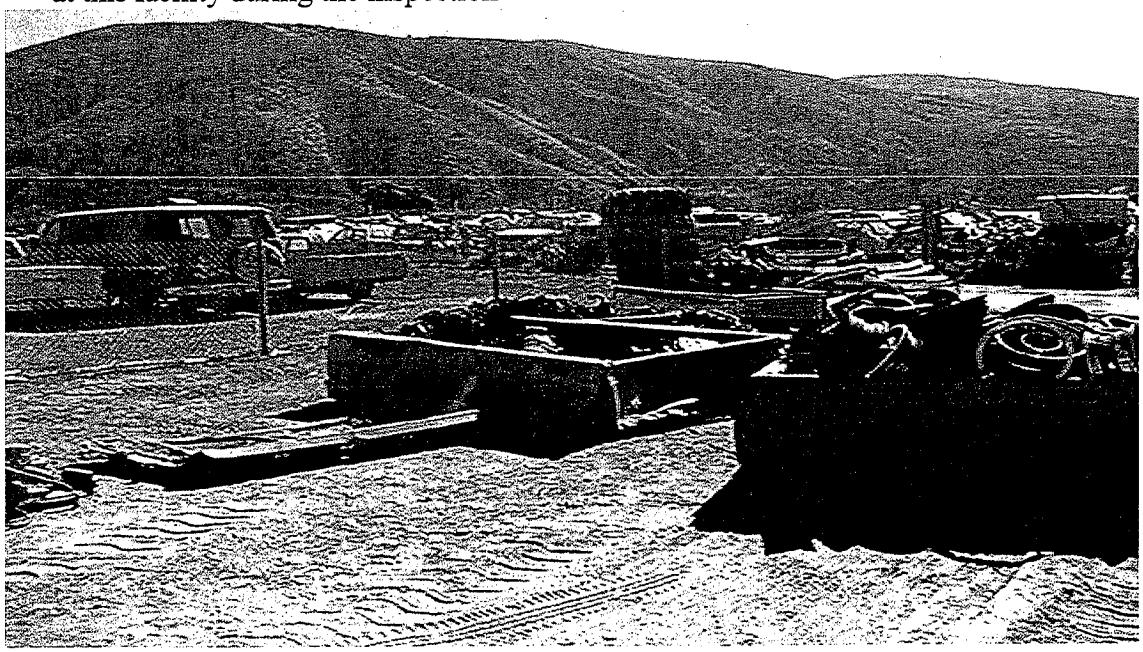
1) Showing the used vehicles at this facility during the inspection



2) Showing the exposed auto parts w/o effective Best Management Practices(BMPs)



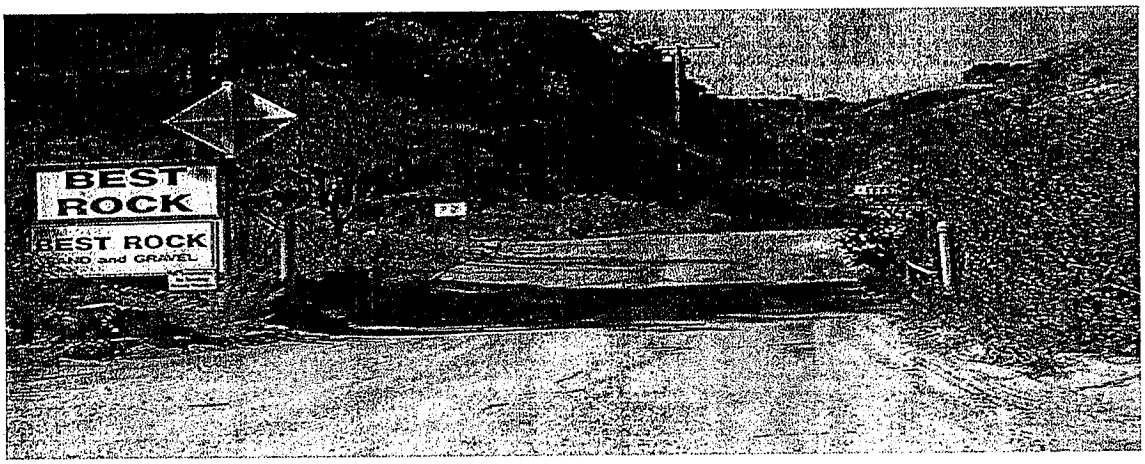
3) Showing auto parts w/o effective material storage Best Management Practices(BMPs) at this facility during the inspection



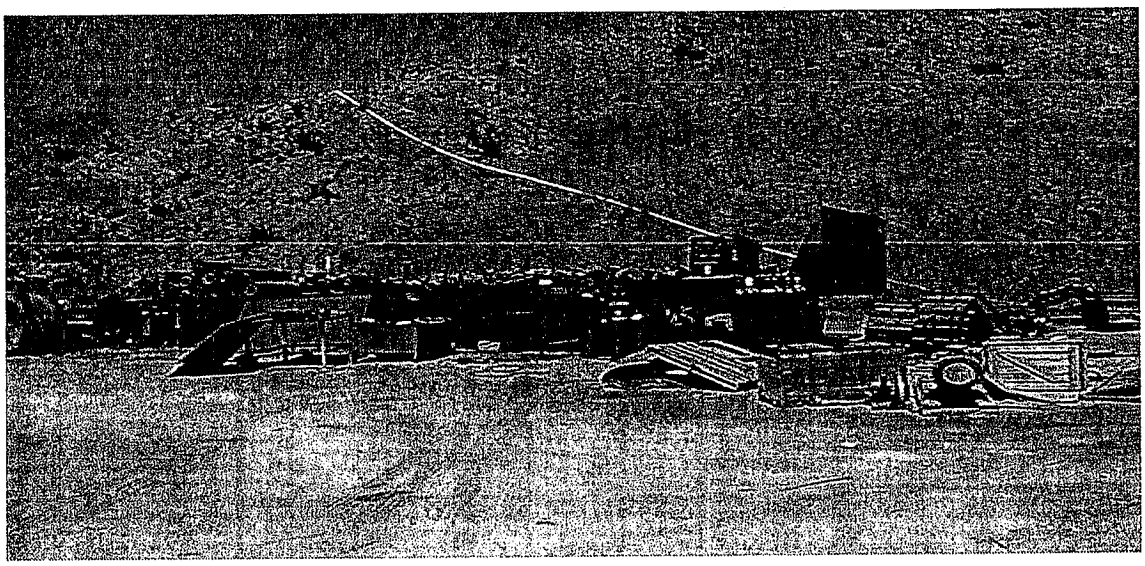
WDID#: NF 482 (Non-Filer)
Inspection Date: June 4, 2004
Inspection Site: Best Rock, Inc. in Fillmore (County Jurisdiction)

Industrial Facility

1) Showing facility name and entrance (storm water runoff could discharge through this entrance)

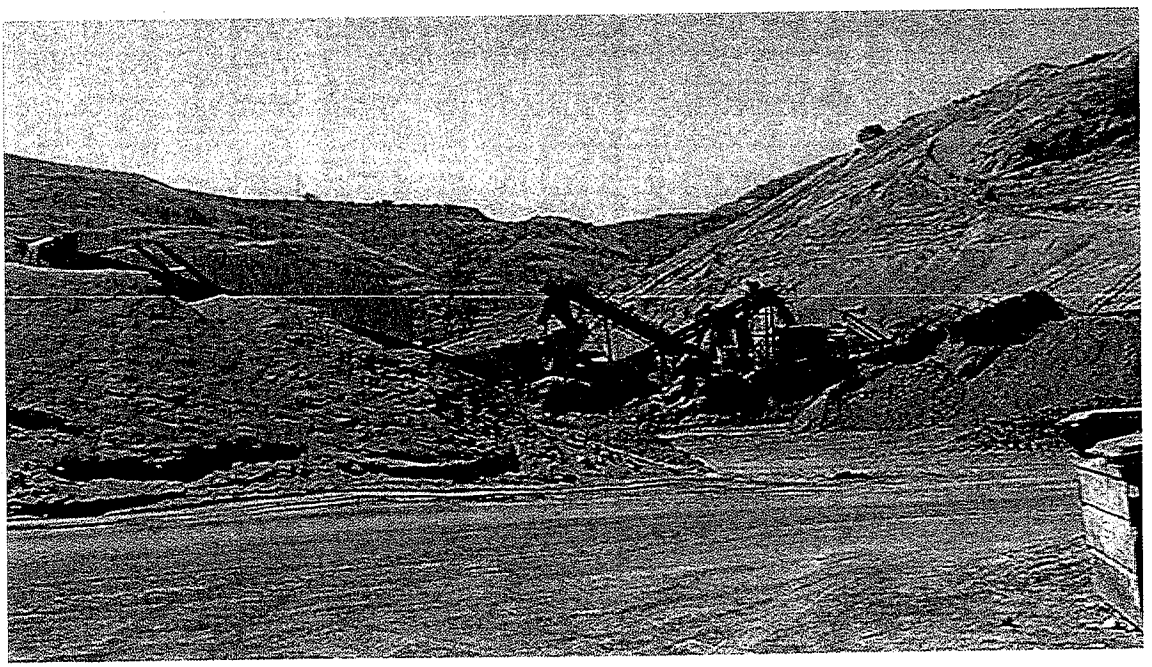


2) Showing exposed various rusty metal on the ground w/o BMPs



3) Showing exposed various rusty and greased equipment and waste products on the ground w/o BMPs

4) Showing exposed stock-piles of their raw materials in the industrial processing area



06/13/05 Follow Up Inspection
CEMEX - WDID # 456I012014
300 W. Los Angeles
Simi Valley, CA 93062

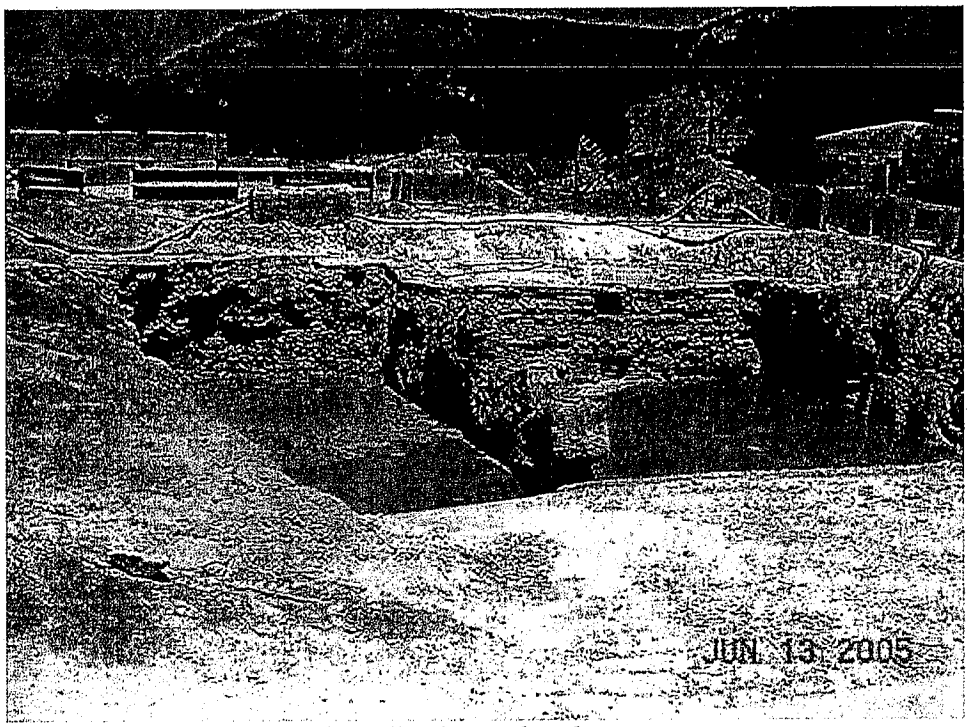


Photo 1. Old pits have not been lined or replaced.

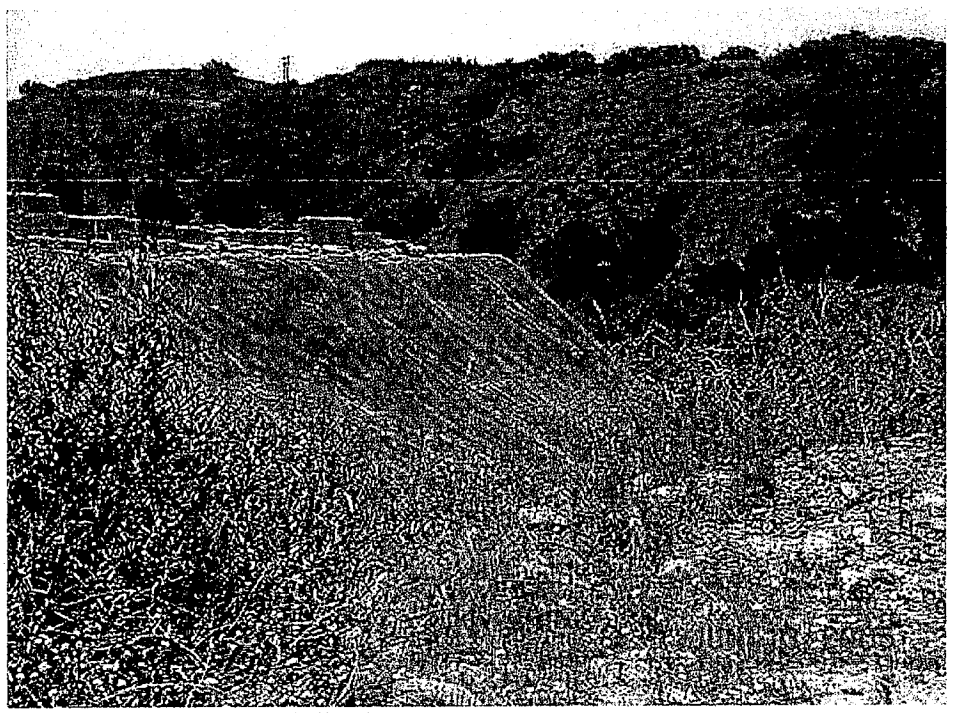


Photo 2. Slopes were stabilized

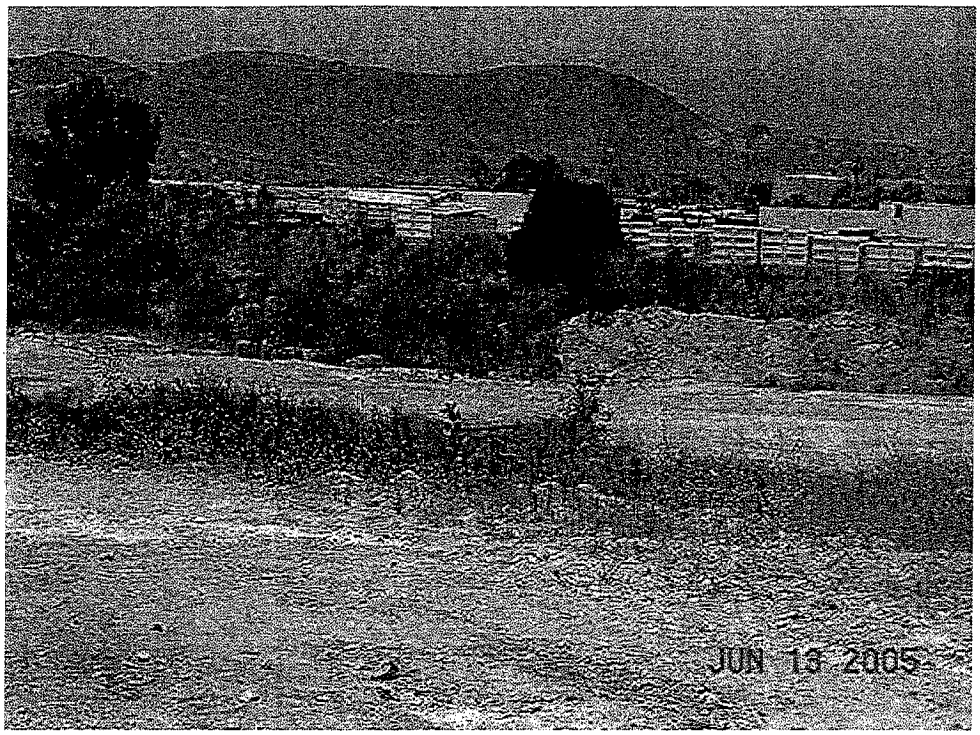
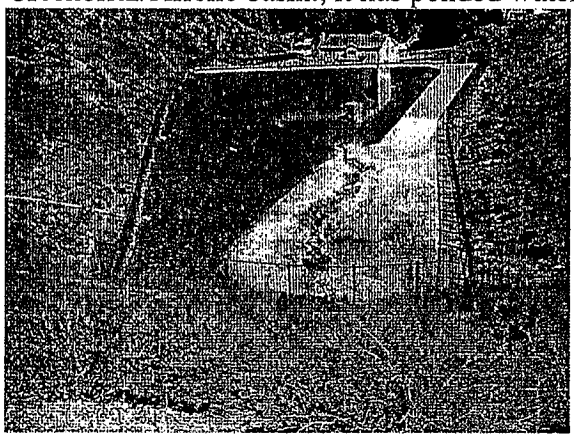
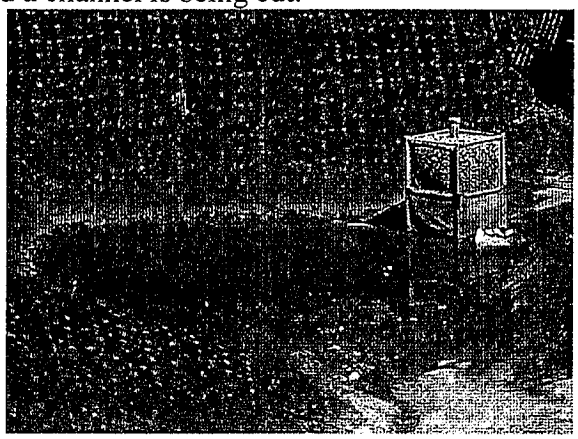


Photo 3. Area near arroyo Simi was cleaned.

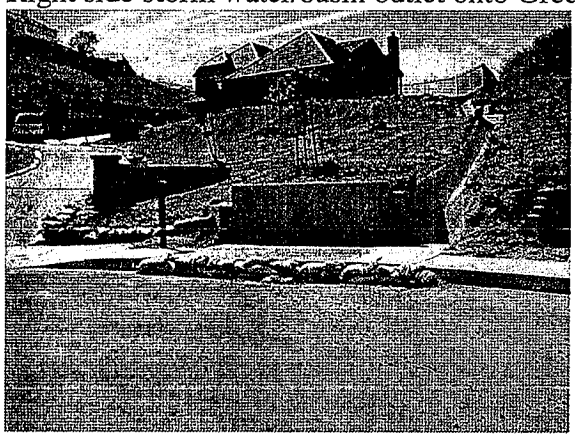
WDID #56S3 06969 (Owner- SouthHills) 189 LLC
Inspection Date: 03/08/04
Non-Active Site- North End of Crosby Rd., Simi Valley

Residential- Madleigh of South Hills (Tract 3045) This site was terminated

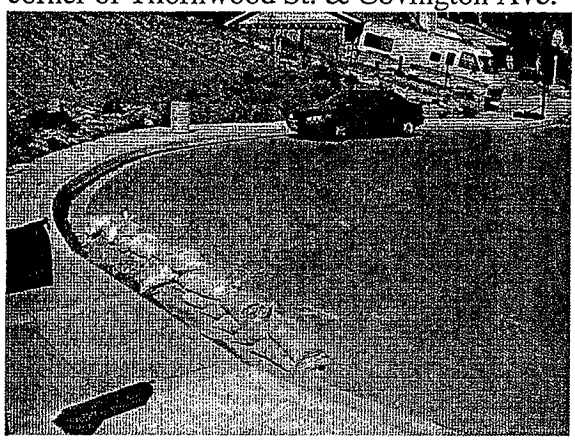
Greenbriar/Arielle basin., it has ponded water and a channel is being cut.

Right side storm water/basin outlet onto Greenbriar Street. There is a constant flow exiting the outlet.



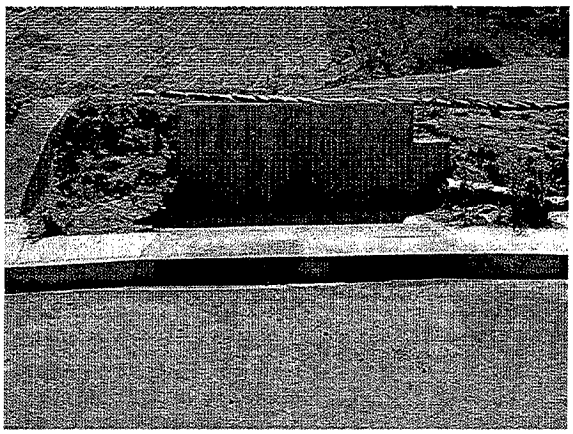
Water travels down Greenbriar St. onto Thornwood St., were it enters the storm drain inlet on the corner of Thornwood St. & Covington Ave.

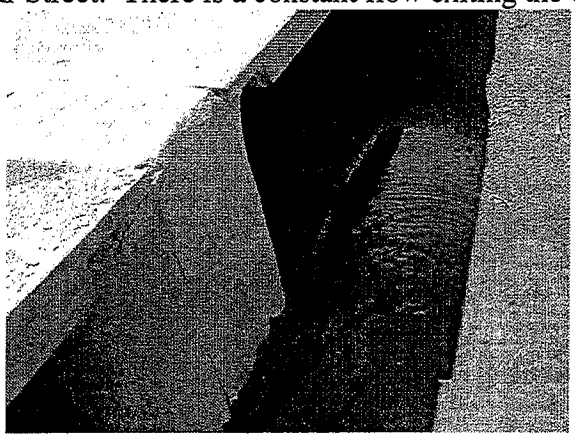


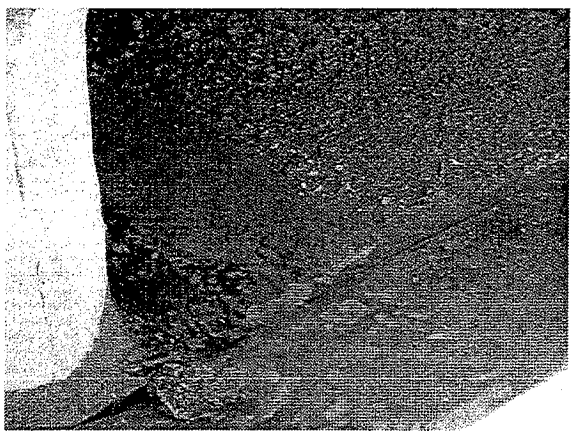
Inspection Date: 03/08/04
Non-Active Site- North End of Crosby Rd., Simi Valley

Residential- Madleigh of South Hills (Tract 3045) This site was terminated

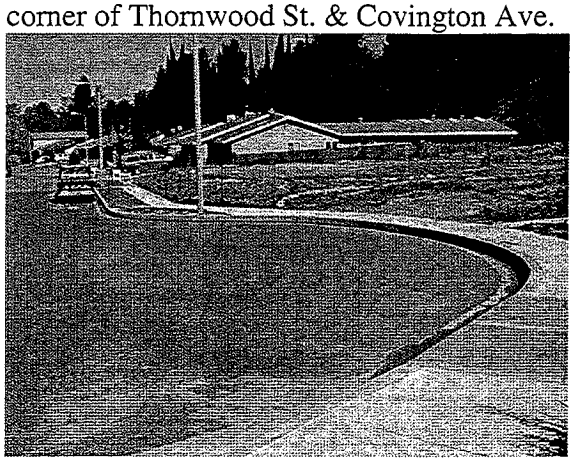
Left side storm water/basin outlet onto Greenbriar Street. There is a constant flow exiting the outlet.







Water travels down Greenbriar St. onto Thornwood St., were it enters the storm drain inlet on the corner of Thornwood St. & Covington Ave.



3/3/04 Follow Up Inspection
Cemex - WDID # 456I012014
300 W. Los Angeles
Simi Valley, CA 93062

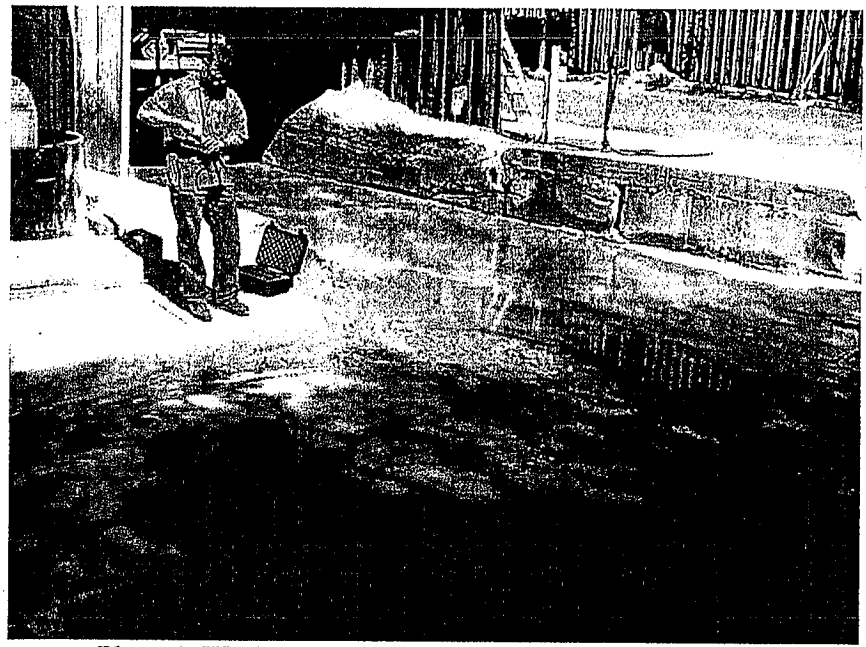


Photo 1. Washout area and other industrial water that leads to a settling tank. This tank has a connection to Arroyo Simi. Belongs to Precon, used by Cemex.

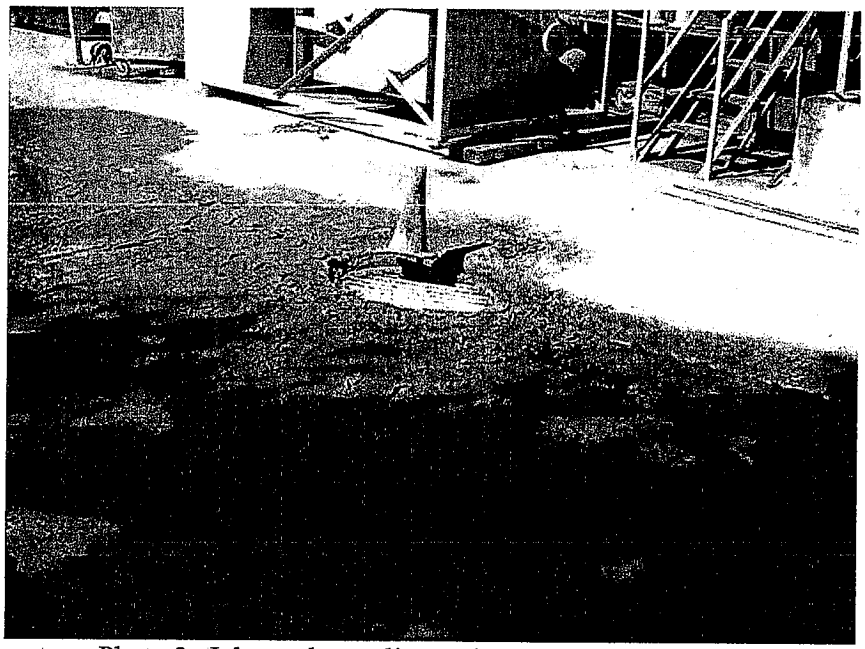


Photo 2. Inlet to the settling tank.

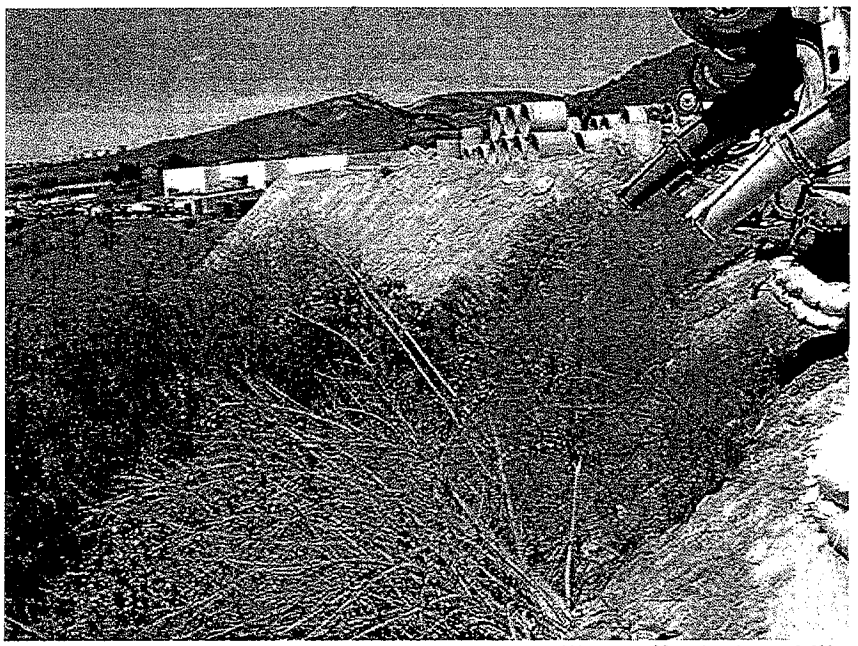


Photo 3. Slopes on Cemex Property, still not effectively stabilized.

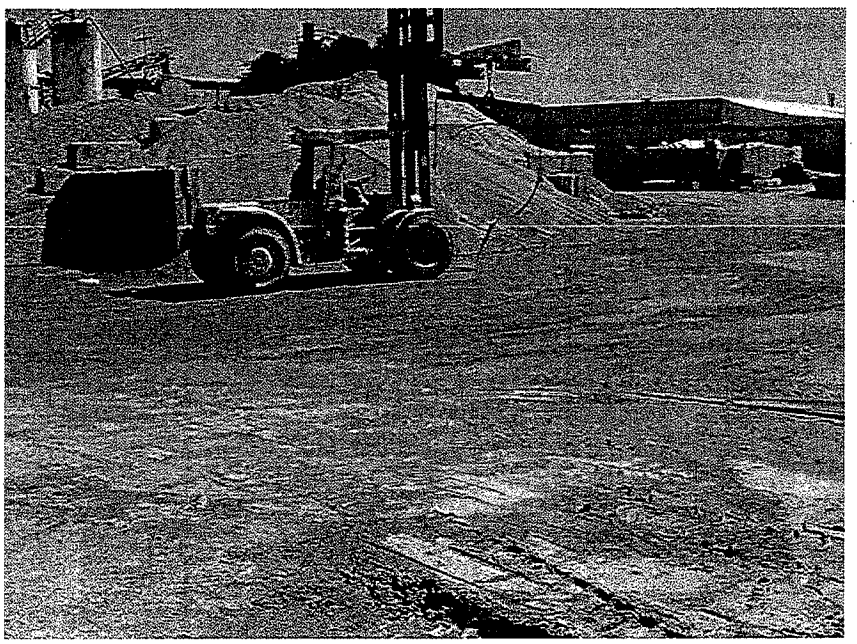
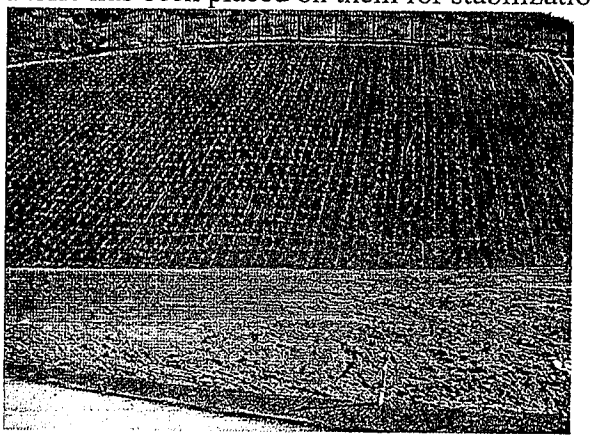


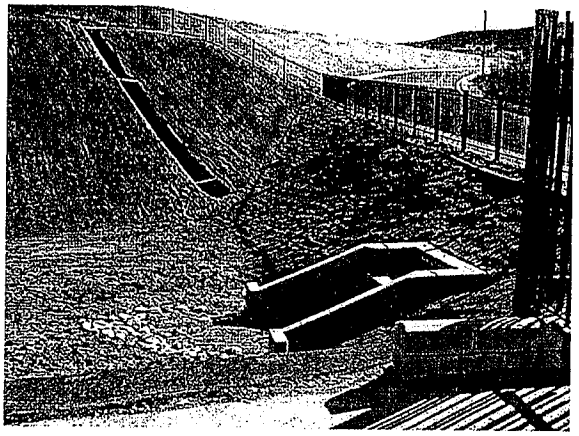
Photo 4. Aggregate overflow.

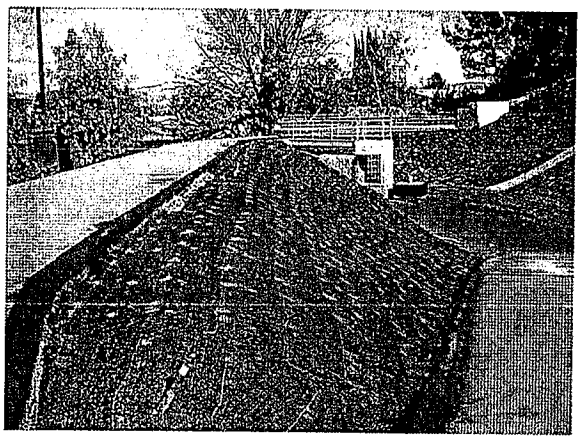
WDID #4 56S3 06969 (SouthHills 189 LLC)
Owner- SouthHills 189 LLC
Inspection Date: 12/15/03
Active Site- North End of Crosby Rd., Simi Valley

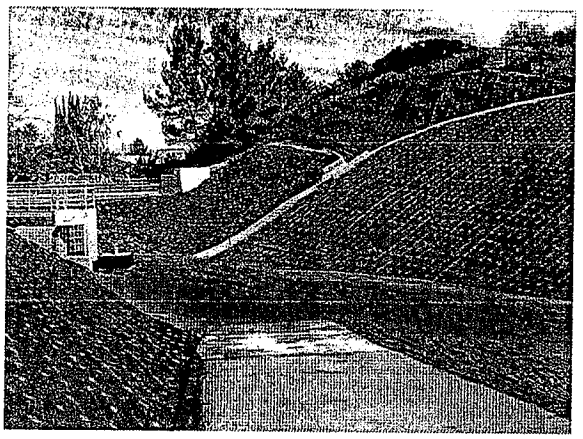
Residential- Madleigh of South Hills (Tract 3045- 1, 3 & 4)

Muirfield Ave. basin- Vegetation has been removed, basin floor has been brought to grade by removing sediment. Rills have been removed from the slopes, they have been hydroseeded and fabric has been placed on them for stabilization.

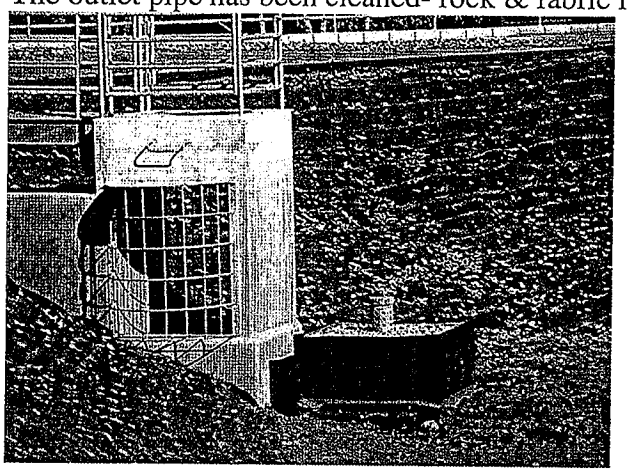








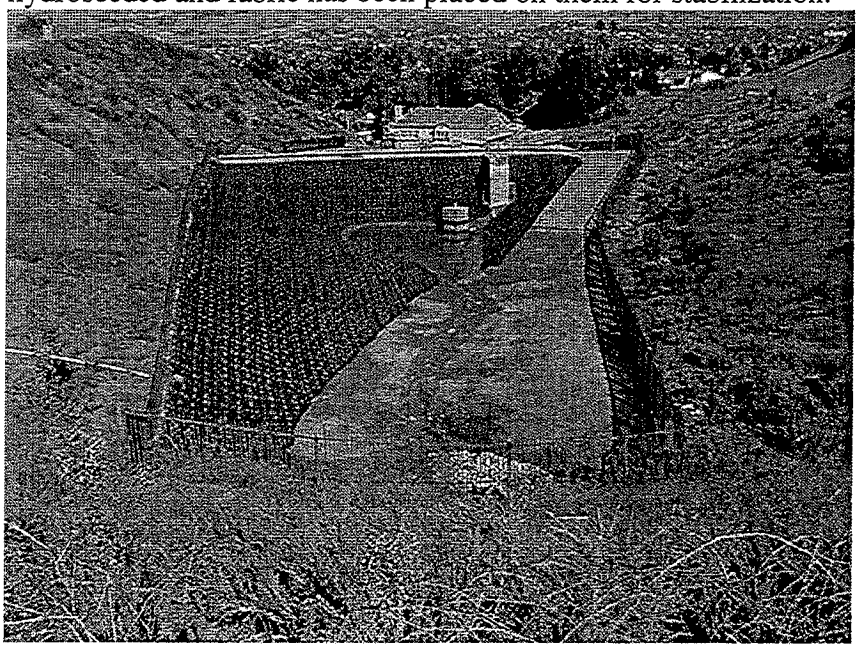
The outlet pipe has been cleaned- rock & fabric replaced.



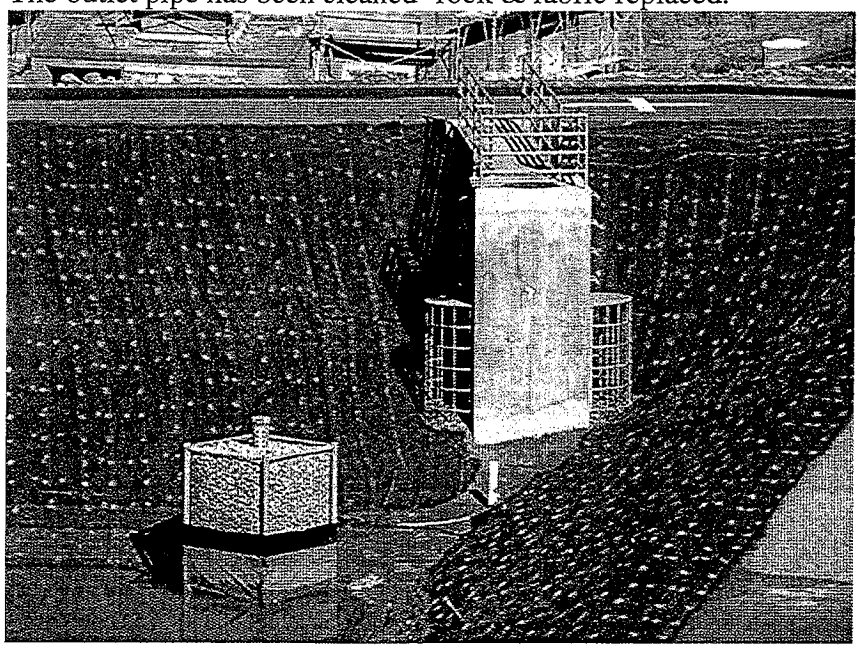
Owner- SouthHills 189 LLC
Inspection Date: 12/15/03
Active Site- North End of Crosby Rd., Simi Valley

Residential- Madleigh of South Hills (Tract 3045- 1, 3 & 4)

Arielle basin/Greenbriar basin- Vegetation has been removed, basin floor has been brought to grade by removing sediment Rills have been removed from the slopes, they have been hydroseeded and fabric has been placed on them for stabilization.



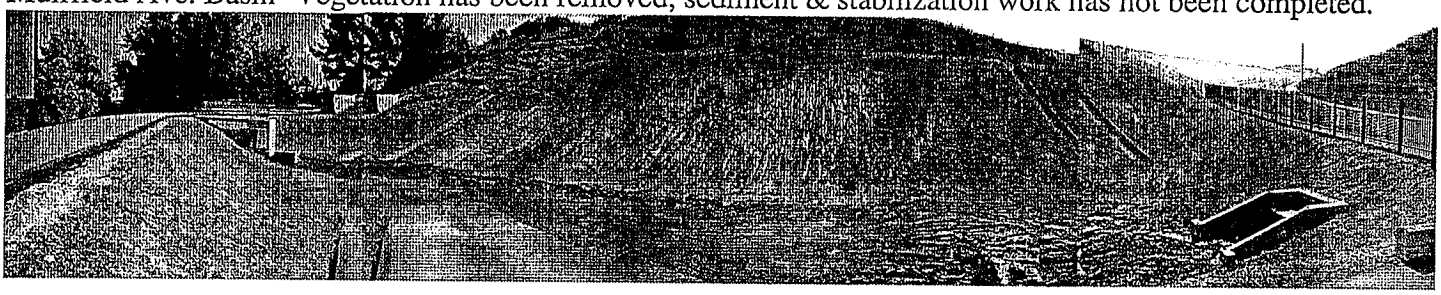
The outlet pipe has been cleaned- rock & fabric replaced.

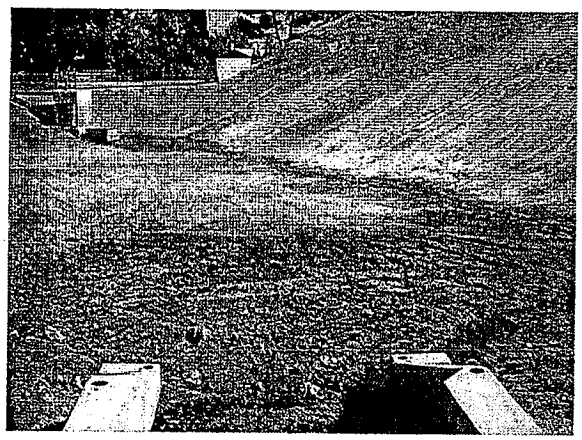


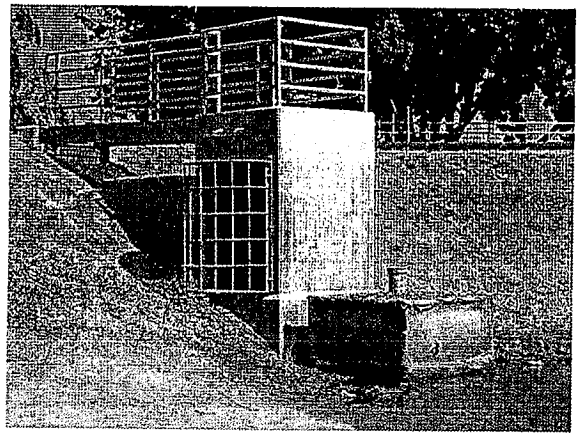
WDID #4 56S3 06969 (SouthHills 189 LLC)
Owner- SouthHills 189 LLC
Inspection Date: 09/17/03
Active Site- North End of Crosby Rd., Simi Valley

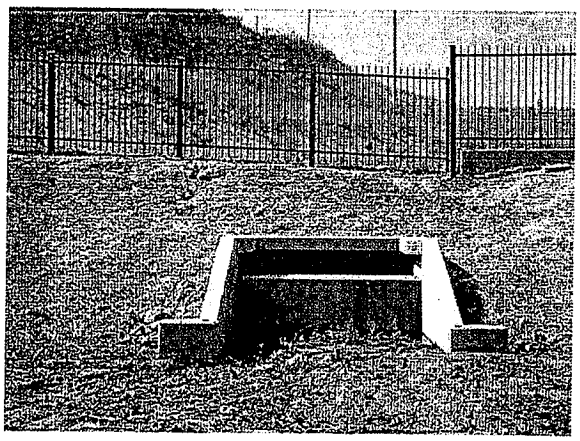
Residential- Madleigh of South Hills (Tract 3045- 1, 3 & 4)

Muirfield Ave. Basin- Vegetation has been removed, sediment & stabilization work has not been completed.





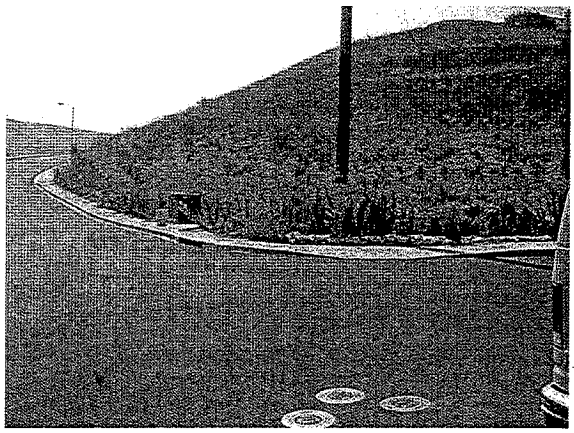




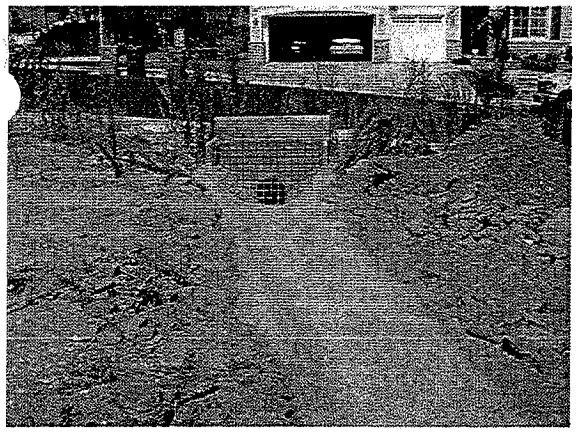
Owner- SouthHills 189 LLC
Inspection Date: 09/17/03
Active Site- North End of Crosby Rd., Simi Valley

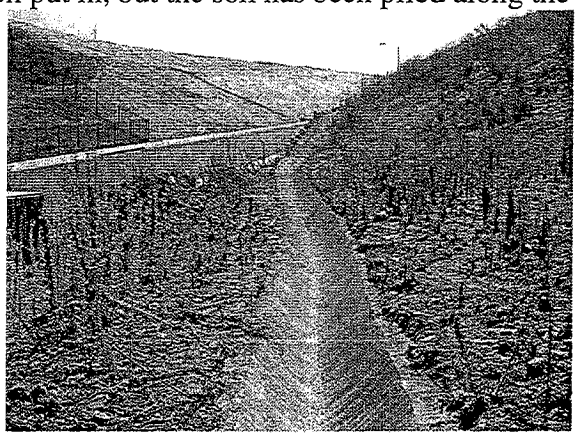
Residential- Madleigh of South Hills (Tract 3045- 1, 3 & 4)

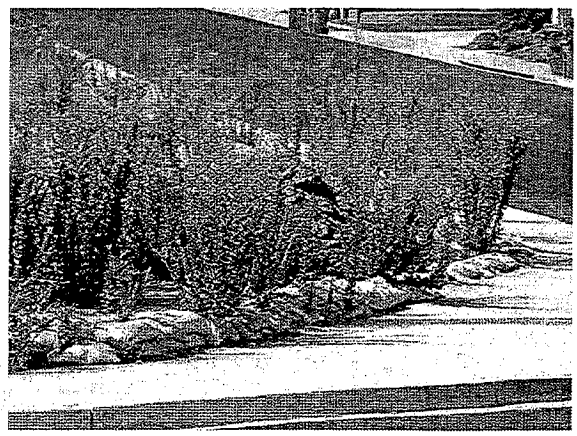
Corner of Muirfield Ave. & Arielle Lane across from basin, custom lot-204 still has broken sandbags.



Custom lot-204 has had an outlet drain & "V" ditch put in, but the soil has been piled along the curb.



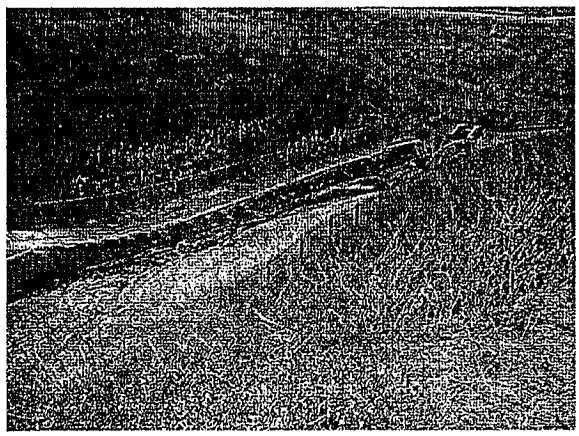
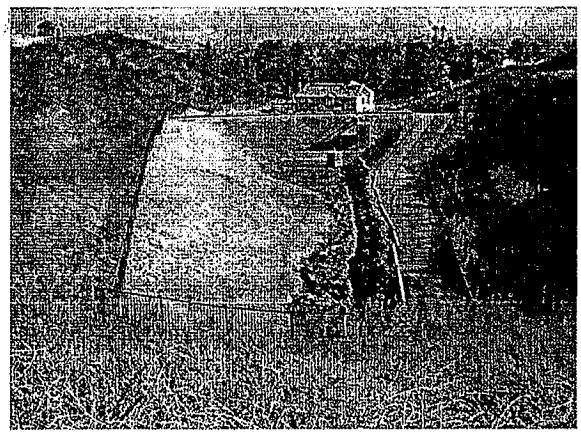
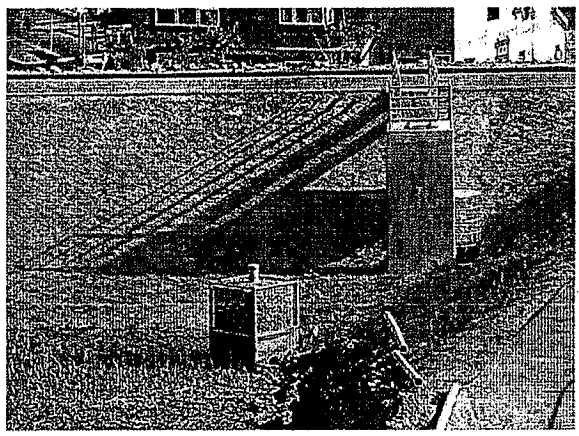




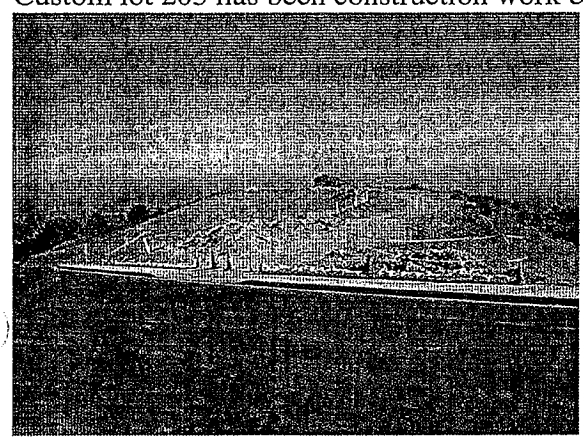
Owner- SouthHills 189 LLC
Inspection Date: 09/17/03
Active Site- North End of Crosby Rd., Simi Valley

Residential- Madleigh of South Hills (Tract 3045- 1, 3 & 4)

Arielle basin/Greenbriar basin- Vegetation has been removed, sediment, stabilization & bypass pipe work has not been completed. City has issued a stop work order due to RWR performing work without approved plan from Ventura Flood Control District.

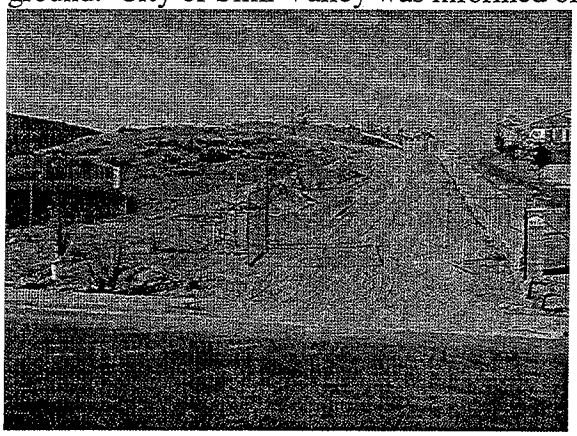




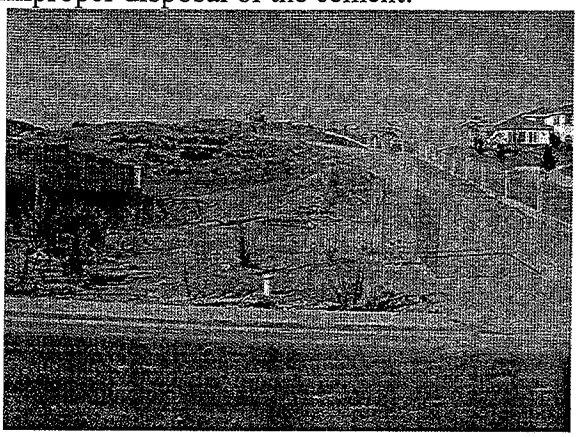
Custom lot 203 has been construction work & has stabilized its entrance.

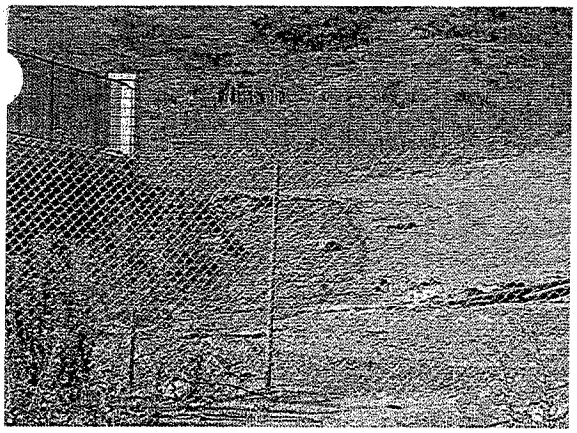


Residential- Madleigh of South Hills (Tract 3045- 1, 3 & 4)

Custom lot- 206, 1935 Arielle Lane does not have stabilized entrance & cement has been disposed of on the ground. City of Simi Valley was informed of the improper disposal of the cement.



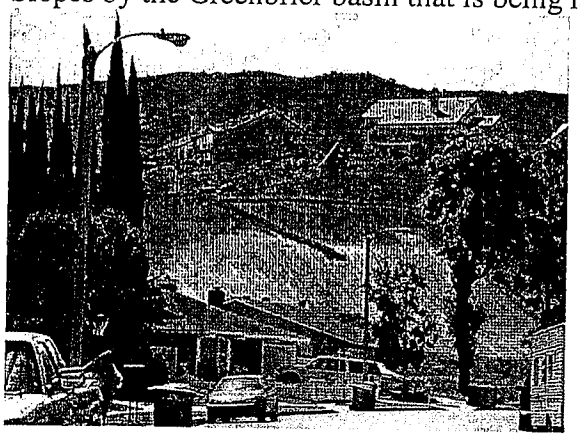


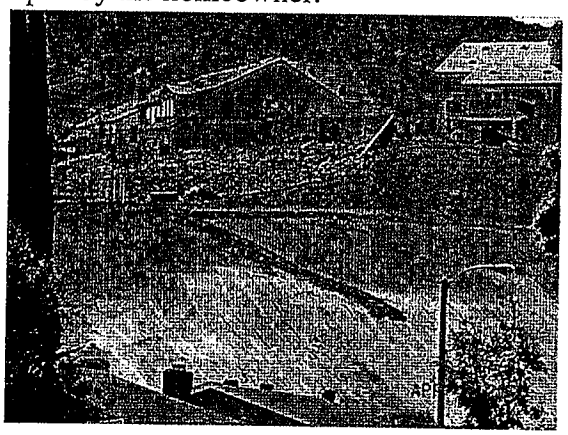


WDID #56S3 06969 (SouthHills 189 LLC)
Owner- SouthHills 189 LLC
Inspection Date: 04/02/03
Active Site- North End of Crosby Rd., Simi Valley

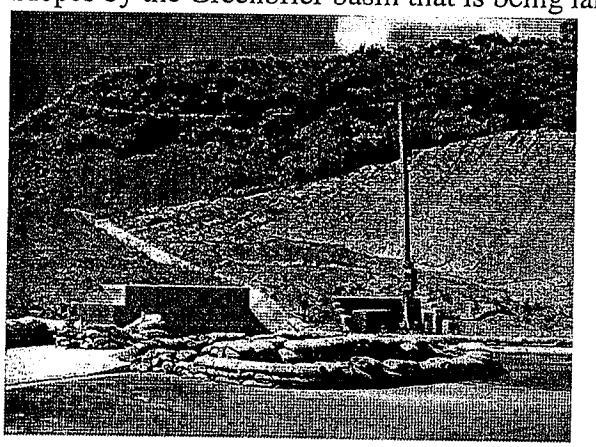
Residential- Madleigh of South Hills (Tract 3045)

Slopes by the Greenbrier basin that is being landscaped by the homeowner.

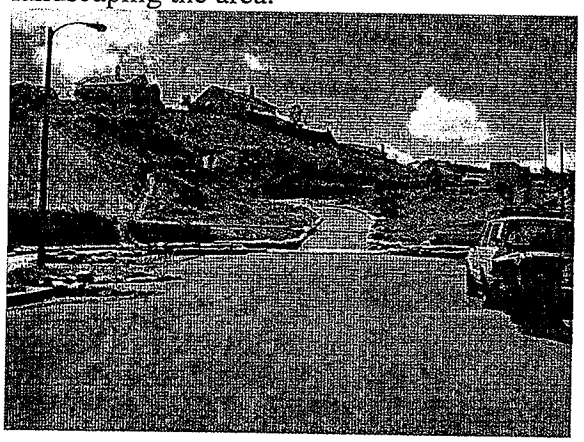


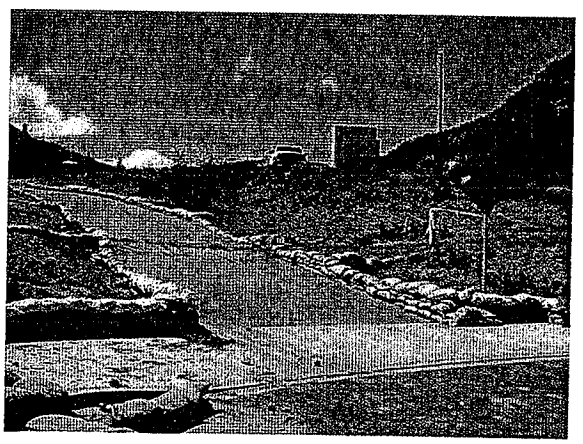


Slopes by the Greenbrier basin that is being landscaped by the homeowner.



Greenbrier Avenue, at the end of the road is the driveway that leads up to the basin. Homeowner is landscaping the area.

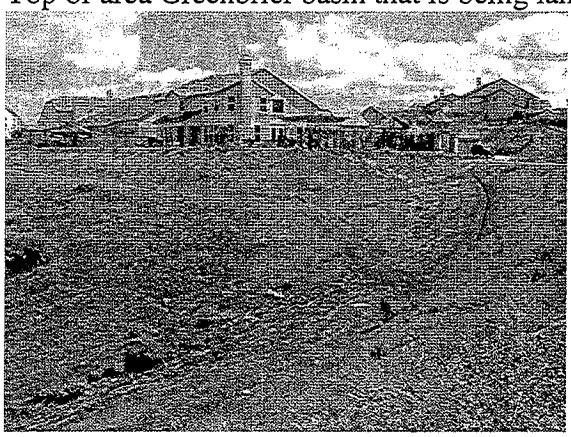




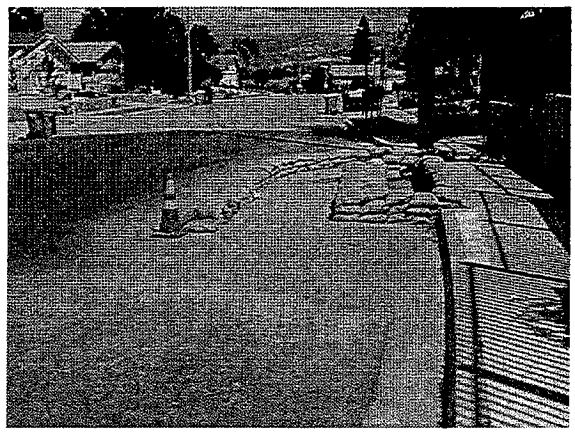
Owner- SouthHills 189 LLC
Inspection Date: 04/02/03
Active Site- North End of Crosby Rd., Simi Valley

Residential- Madleigh of South Hills (Tract 3045)

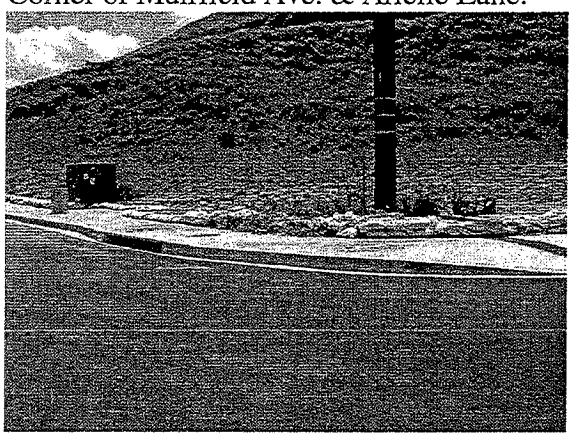
Top of area Greenbrier basin that is being landscaped.



Muirfield Avenue inlet.



Corner of Muirfield Ave. & Arielle Lane.



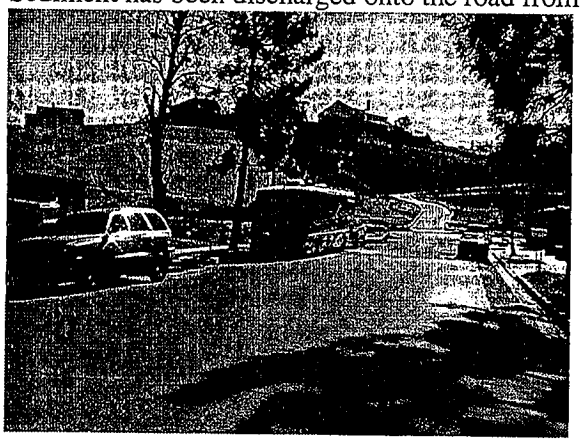
Muirfield Ave. & Arielle Lane basin's filter.

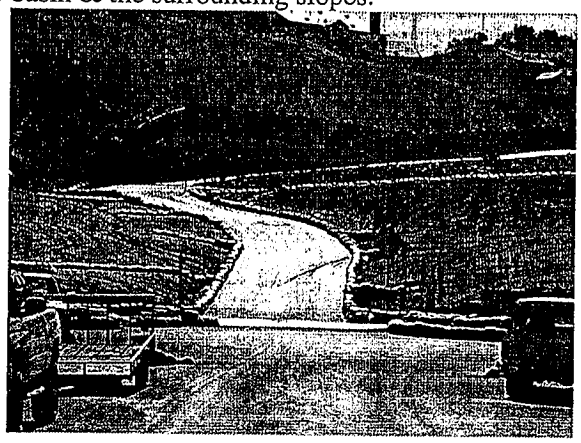
Muirfield Ave. & Arielle Lane basin.

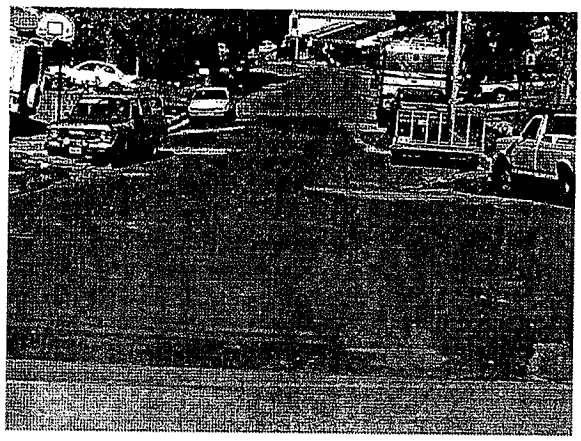
WDID #56S3 06969 (SouthHills 189 LLC)
Owner- SouthHills 189 LLC
Inspection Date: 12/23/02
Active Site- North End of Crosby Rd., Simi Valley

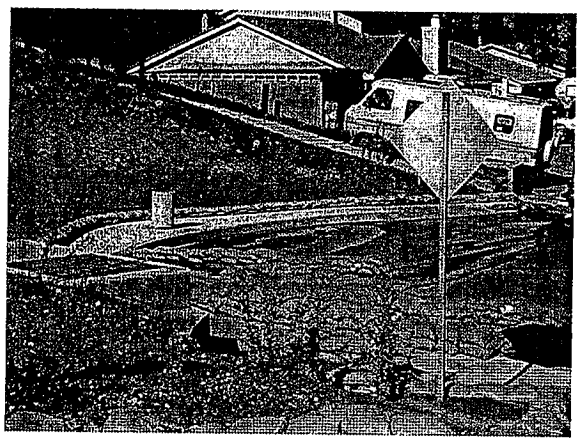
Residential- Madleigh of South Hills (Tract 3045)

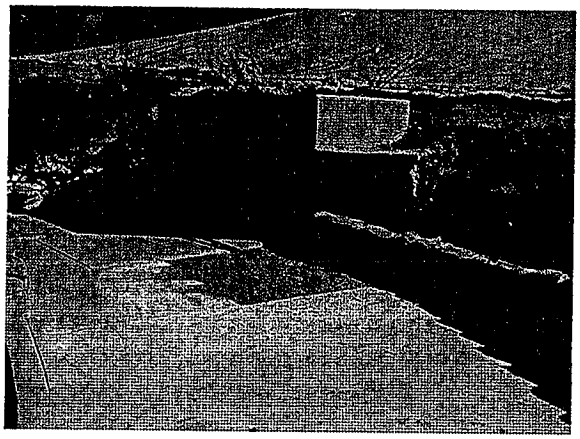
GreenBrier Ave, view towards the outlet of the site's main basin (basin between Greenbriar Ave. & Arielle Ln.). Sediment has been discharged onto the road from the basin & the surrounding slopes.







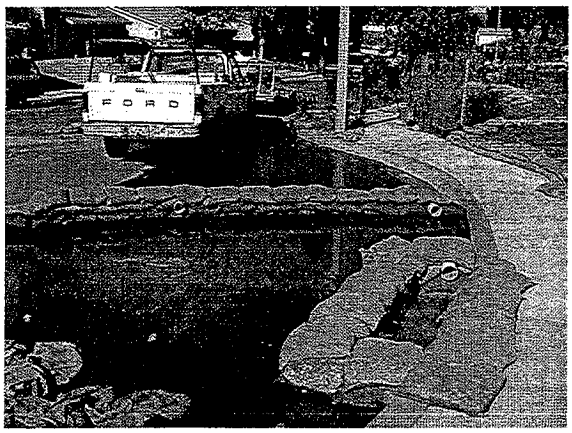


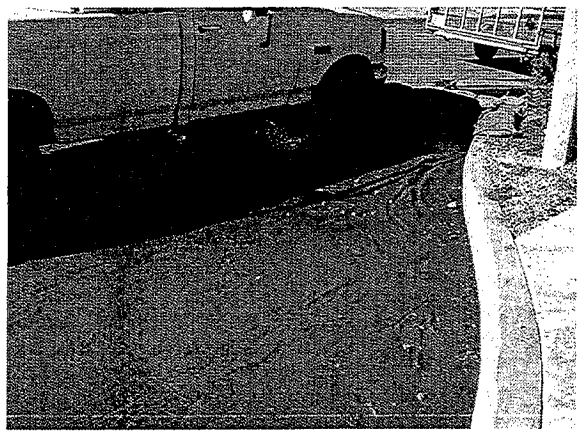


Owner- SouthHills 189 LLC
Inspection Date: 12/23/02
Active Site- North End of Crosby Rd., Simi Valley

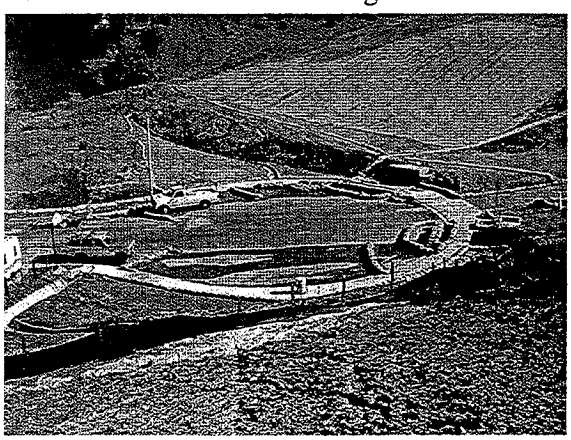
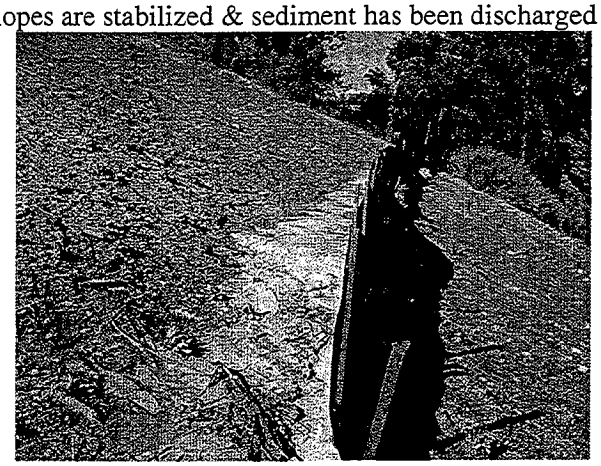
Residential- Madleigh of South Hills (Tract 3045)

Greenbriar Ave, sediment has been discharged onto the road from the basin & the surrounding slopes.



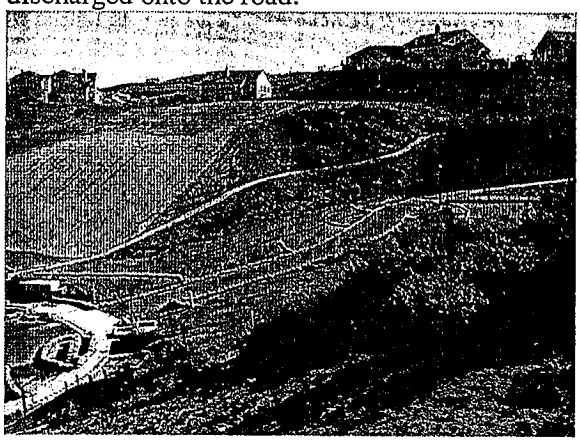


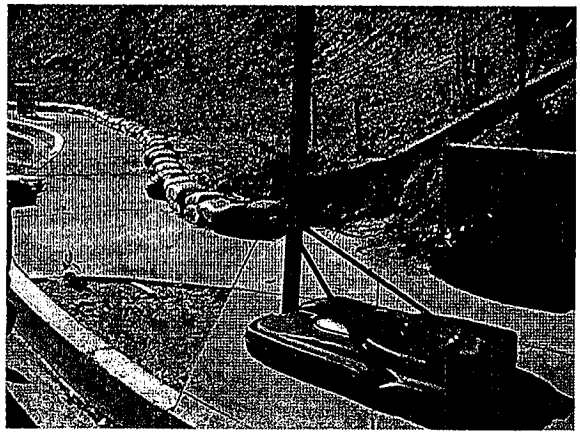
End of Greenbriar Ave. showing that not all of the slopes are stabilized & sediment has been discharged onto the road.

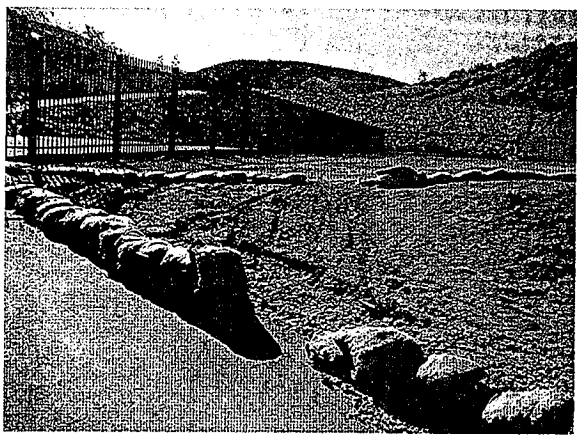



Residential- Madleigh of South Hills (Tract 3045)

End of Greenbriar Ave. showing that not all of the slopes are stabilized, BMPs are not maintained, &sediment has been discharged onto the road.



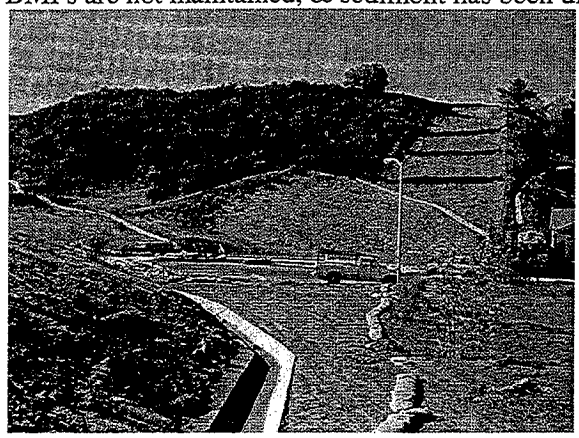




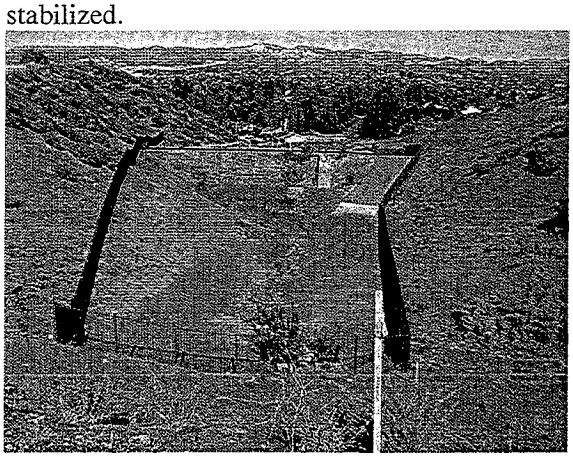
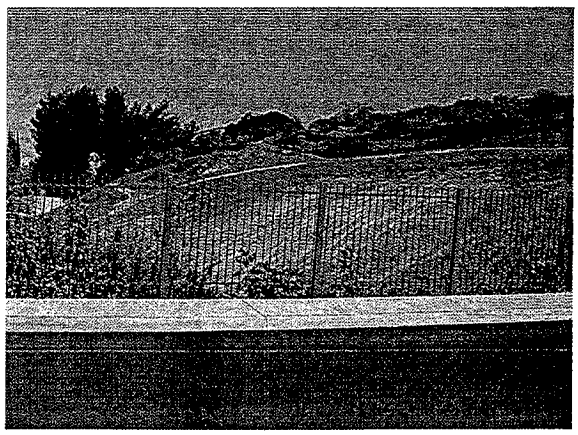
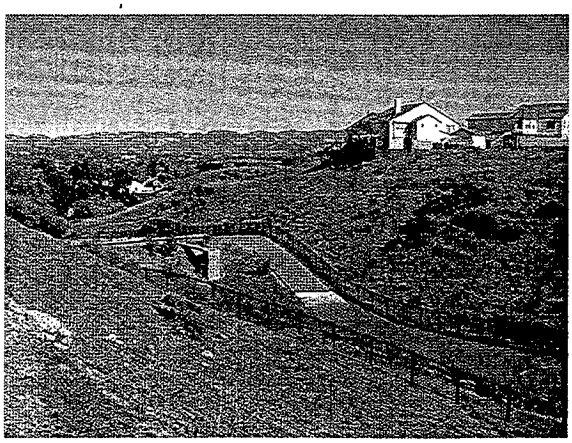
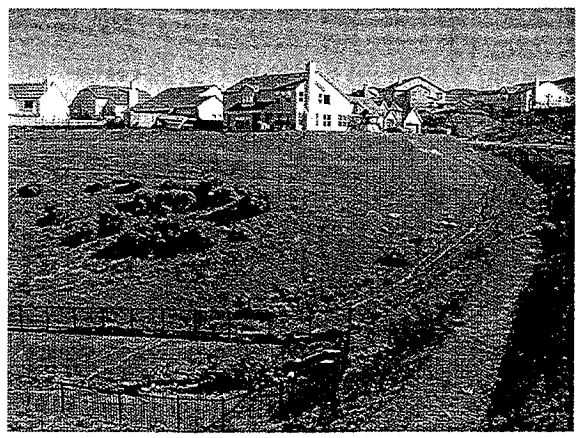
Owner- SouthHills 189 LLC
Inspection Date: 12/23/02
Active Site- North End of Crosby Rd., Simi Valley

Residential- Madleigh of South Hills (Tract 3045)

End of Greenbriar Ave., all slopes are not stabilized, BMPs are not maintained, & sediment has been discharged off site.



View from Arielle Ln., looking down on the main basin towards Greenbriar Ave. Not all of the basin's slopes are stabilized.

Owner- SouthHills 189 LLC
Inspection Date: 12/23/02
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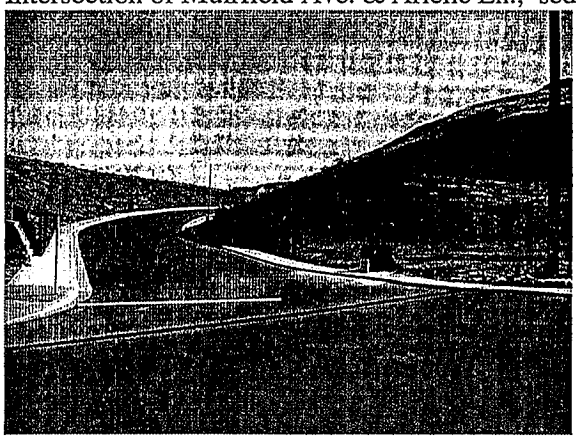
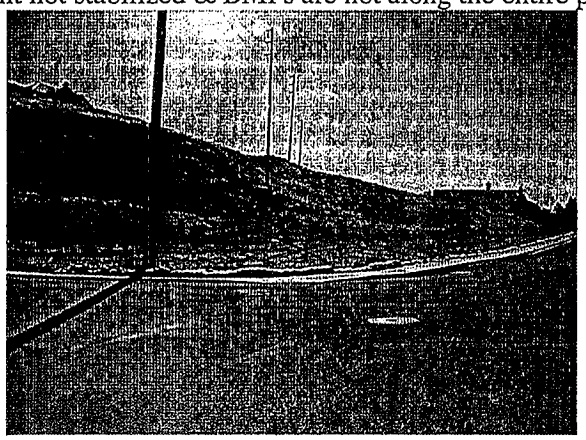
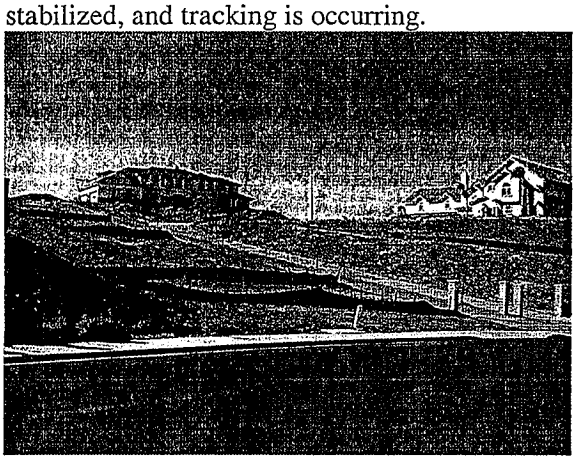
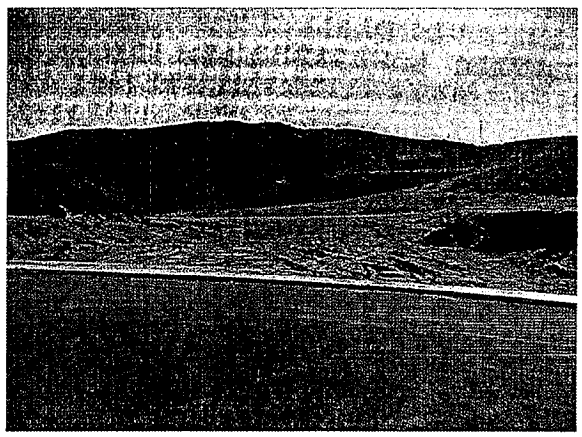
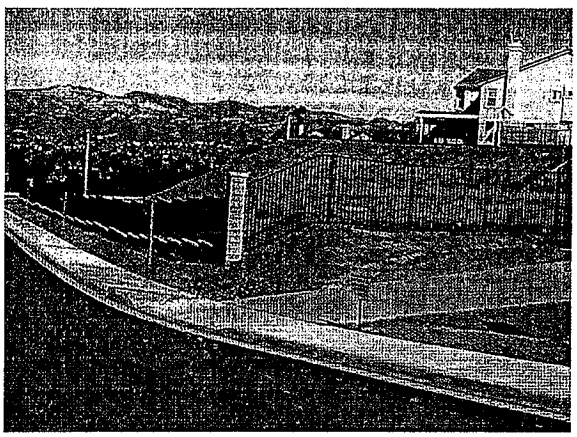
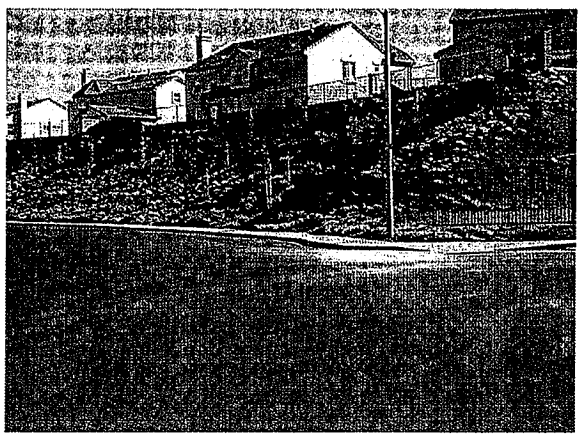
Residential- Madleigh of South Hills (Tract 3045)

Intersection of Muirfield Ave. & Arielle Ln., sediment not stabilized & BMPs are not along the entire perimeter.

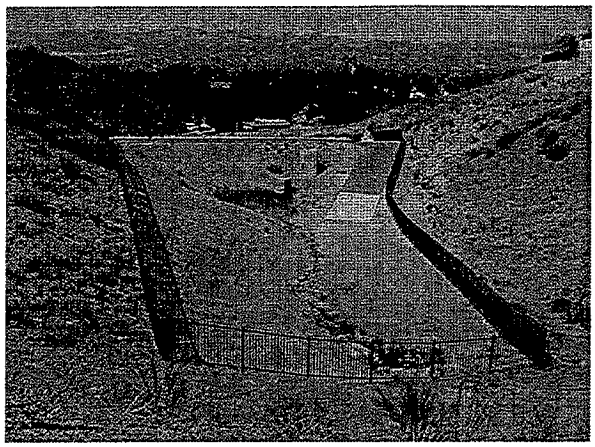



Mainly on the western section of Tract 3045 there are various areas that have no site perimeter BMPs, sediment not stabilized, and tracking is occurring.

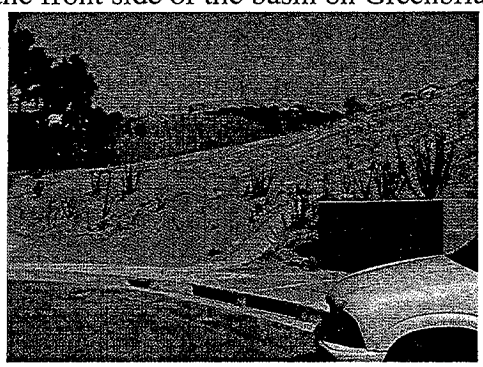





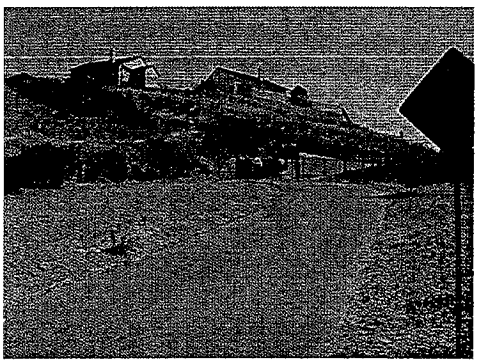
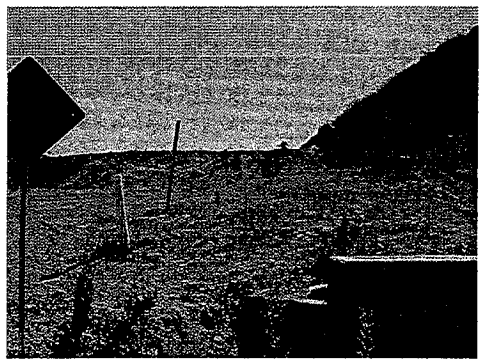
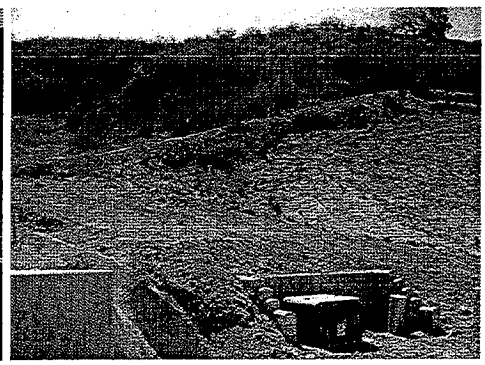
WDID #56S3 06969 (Owner- SouthHills) 189 LLC
Inspection Date: 09/11/02
Active Site- North End of Crosby Rd., Simi Valley
Residential- Madleigh of South Hills (Tract 3045)

Main basin of concern on Greenbriar Ave., it collects all flow from above, including the basins and discharges onto the street.



Photos of the landscape surrounding the front side of the basin on Greenbriar Ave.

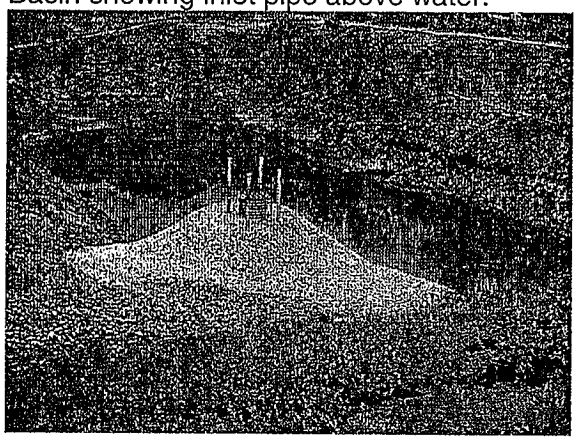


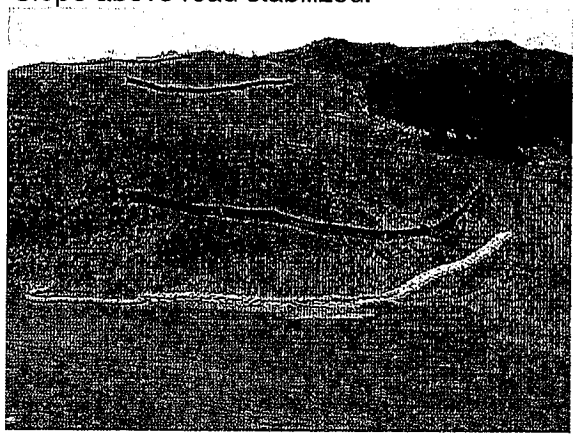
WDID #4A56S3 12080 (Charlemont Partners L.P.)
Developer- New Urban West
Active Site- 300 Long Cyn. Rd., Simi Valley, CA 93065
Inspection Date: 04/15/02

Basin within Tract 4583-16, NPDES or #2 Basin and surrounding area, WDID #4A56S3 12080

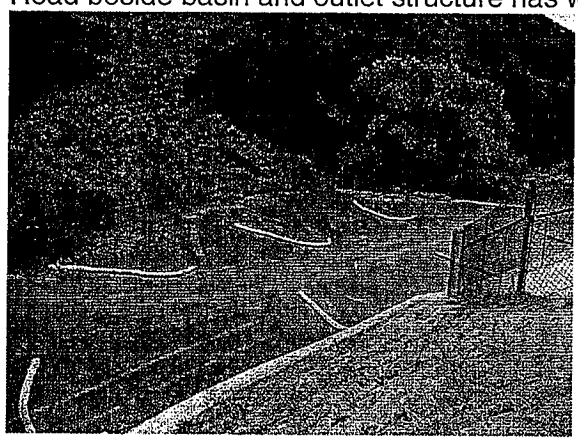
Basin showing inlet pipe above water.

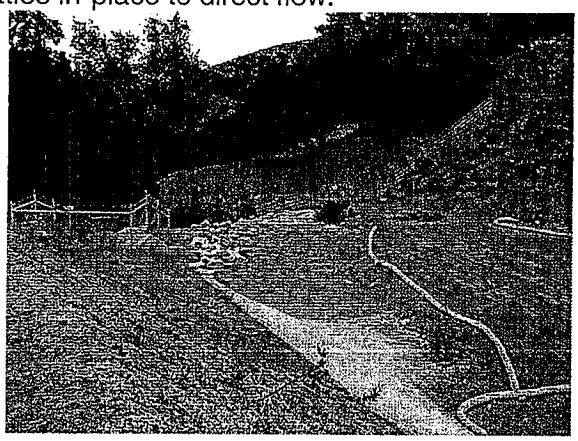


Slope above road stabilized.

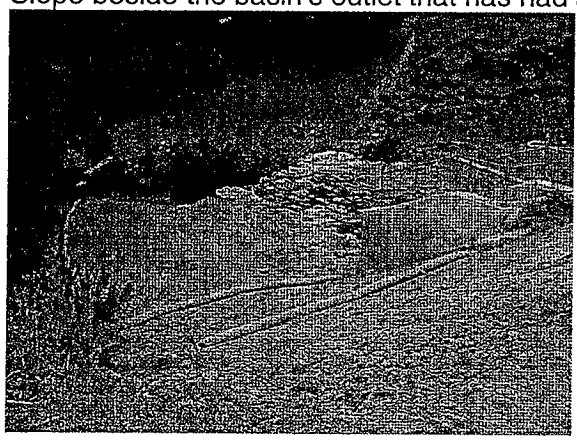


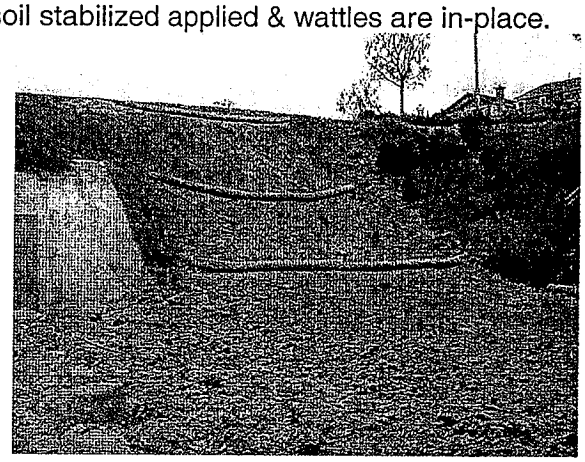
Road beside basin and outlet structure has wattles in-place to direct flow.





Slope beside the basin's outlet that has had a soil stabilized applied & wattles are in-place.

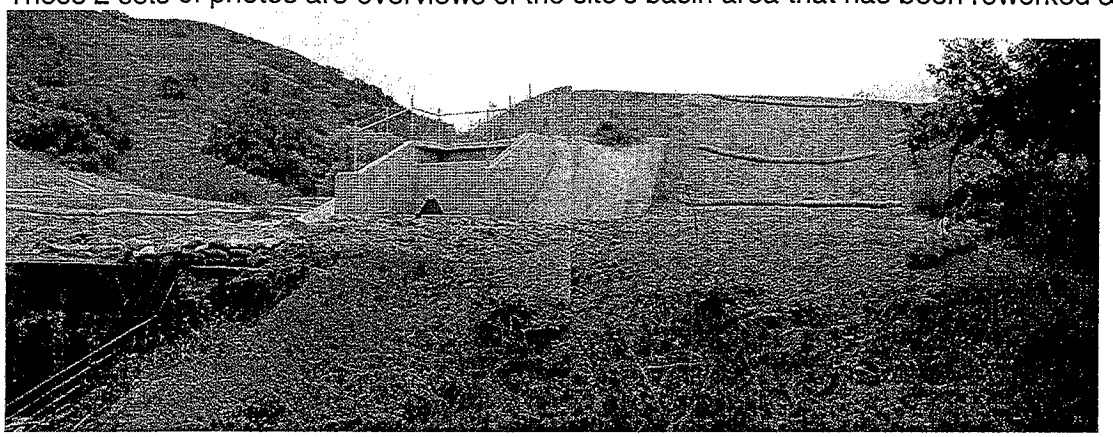




WDID #4A56S3 12080 (Charlemont Partners L.P.)
Developer- New Urban West
Active Site- 300 Long Cyn. Rd., Simi Valley, CA 93065
Inspection Date: 04/15/02

Basin within Tract 4583-16, NPDES or #2 Basin and surrounding area, WDID #4A56S3 12080

These 2 sets of photos are overviews of the site's basin area that has been reworked & stabilized.



This may have to be replaced with a retaining wall.

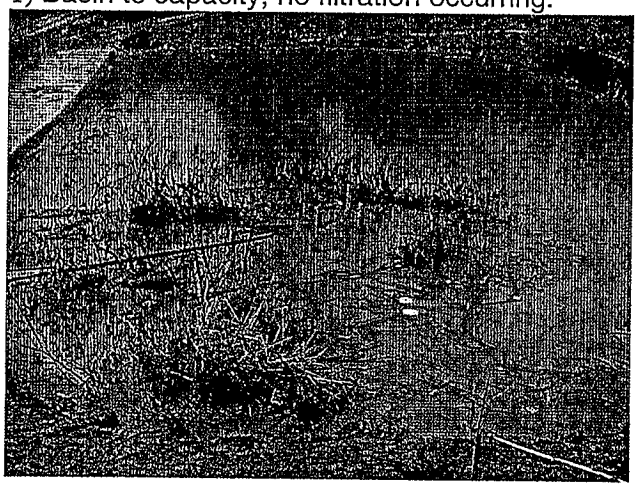
This is the outlet pipe of the site's French Drain System, which appears to have been reworked so, that its discharge is now being deposited farther downstream, away from the basin's outlet.

WDID #4A56S3 12080 (Charlemont Partnes L.P.)
Developer- New Urban West

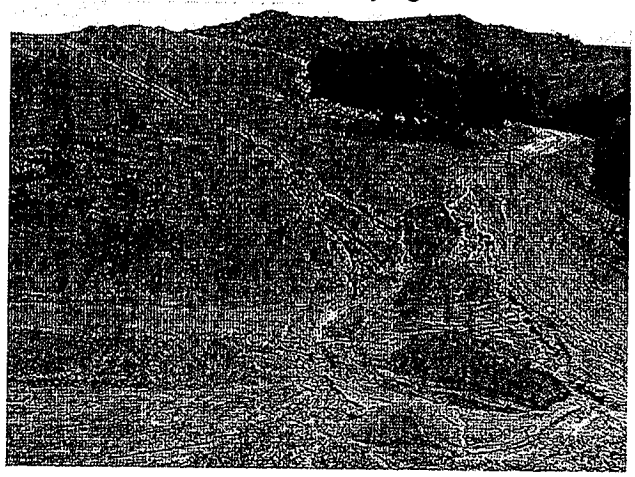
Inspection date: February 13, 2001
Active Site- 300 Long Cyn. Rd. (Tract 4583-16) Simi Valley

Residential- Photos of the basin and area surrounding it were taken during the rain.

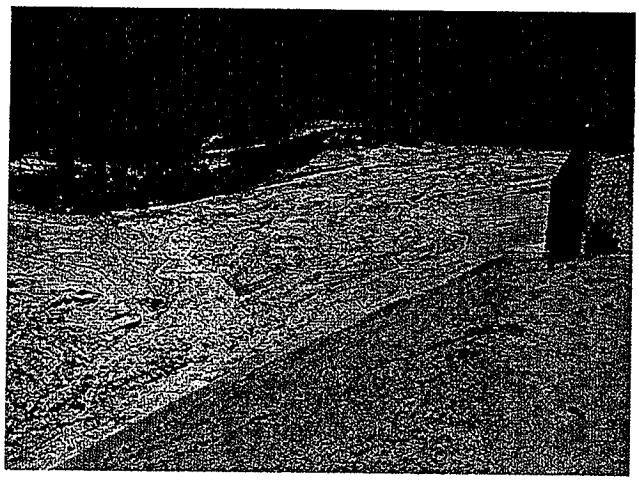
1) Basin to capacity, no filtration occurring.



2) Disposal area, runoff carrying sediment to creek.



3) Runoff flowing into flood plain & creek.

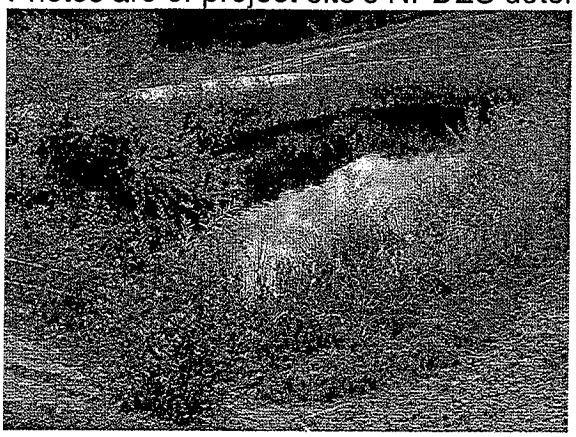
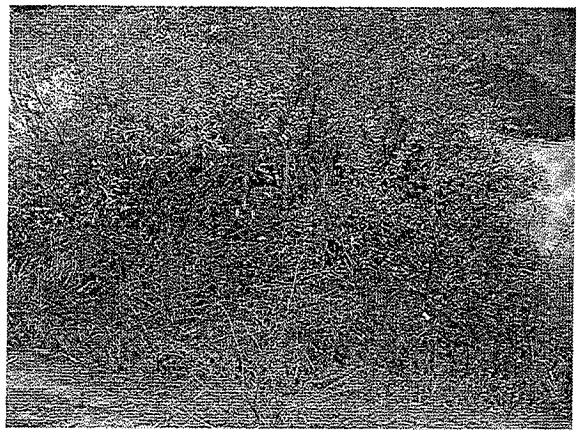


4) Accumulated runoff from above, basin outlet & creek causing erosion.

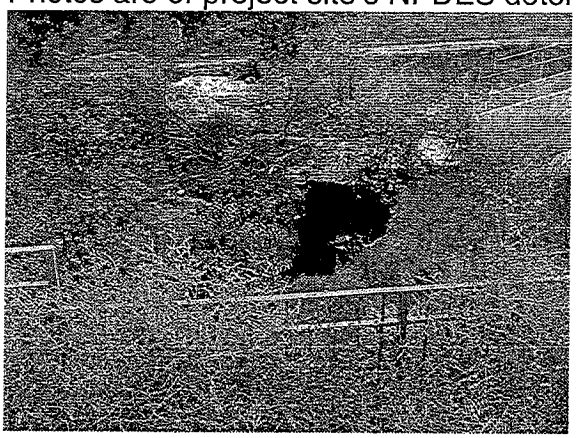
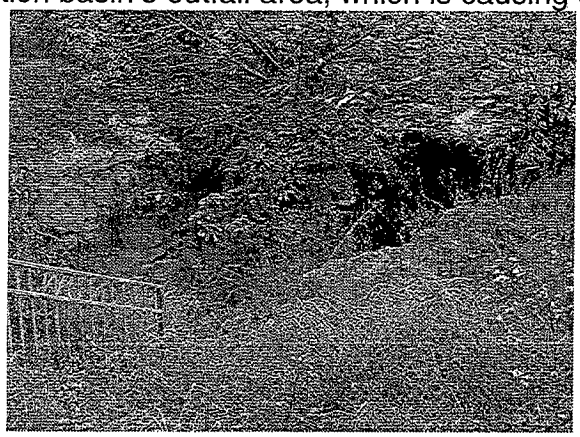
WDID #4A56S3 12080 (Charlemont Partners L.P.)
Developer- New Urban West
Active Site- 300 Long Cyn. Rd. (Tract 4583-16), Simi Valley, CA 93065
Inspection Date: 01/08/02

Residential

Photos are of project site's NPDES detention basin.

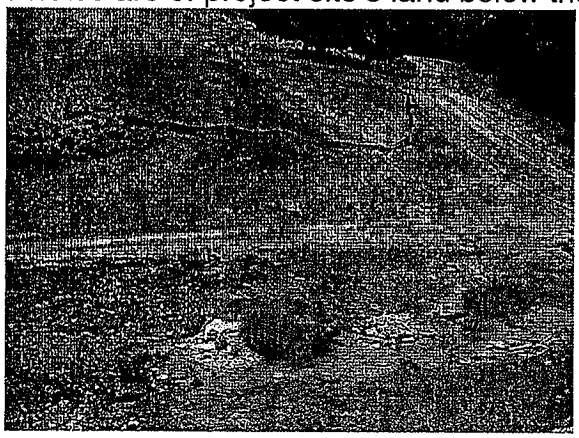
Photos are of project site's NPDES detention basin's outfall area, which is causing erosion.

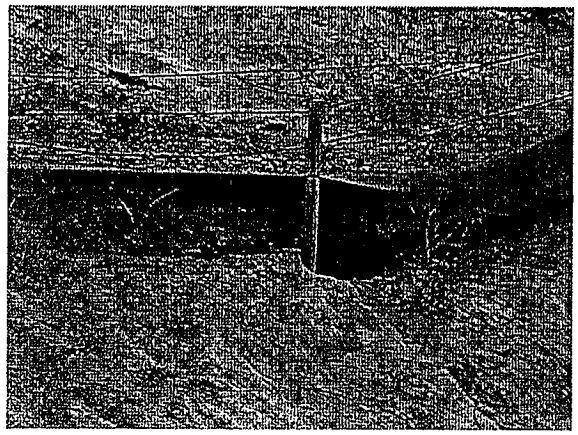



Developer- New Urban West
Active Site- 300 Long Cyn. Rd. (Tract 4583-16), Simi Valley, CA 93065
Inspection Date: 01/08/02

Residential

Photos are of project site's land below the NPDES detention basin.

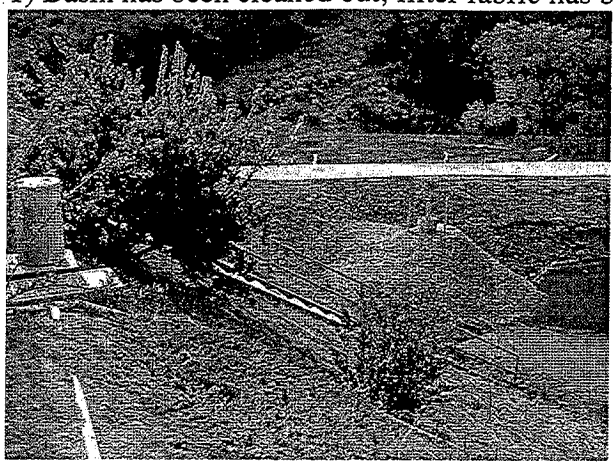




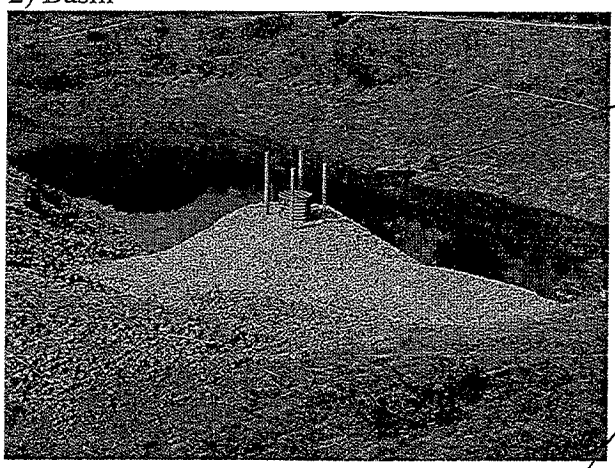
WDID #4A56S3 12080 (Charlemont Partners L.P.),
Developer- New Urban West
Active Site- 300 Long Cyn. Rd. (Tract 4583-16), Simi Valley, CA 93065
Inspection Date: 03/13/02

NPDES or #2 Basin and surrounding area

1) Basin has been cleaned out; filter fabric has been removed. Water level is about a foot in the basin.



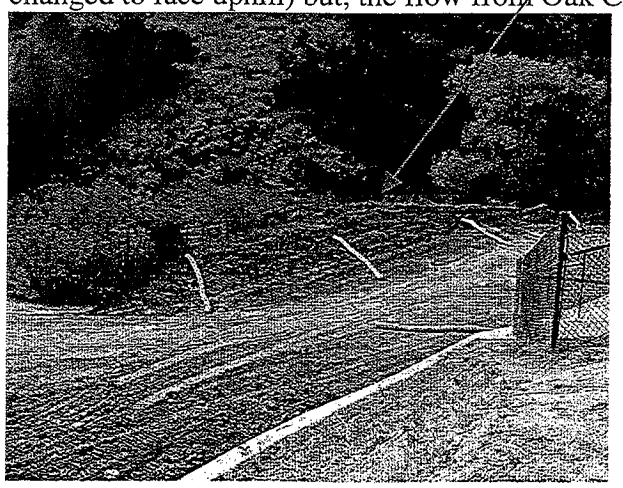
2) Basin

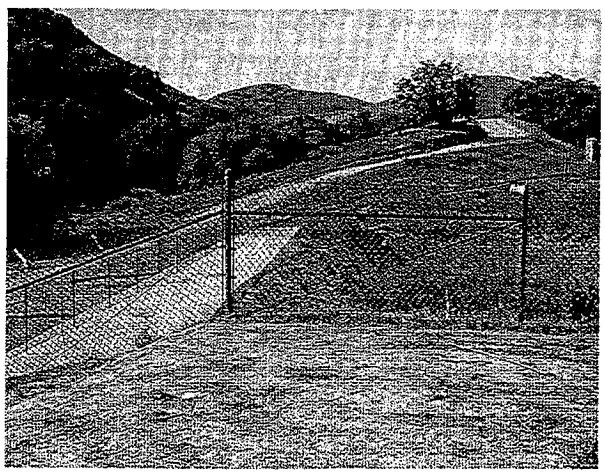


Inlet pipe is underwater presently. The pipe will be cut higher up on the hill, which will make it enter the basin above the water level.

Oak Ck. enters the basin area here during storms. A culvert was to have been installed originally to divert its flows through the basin area but, was never installed. The Oak Ck. flow during storms needs to be addressed with a permanent BMP due to erosion and it will undercut the base of the basin. The cement on the hillside was to have been temporary.

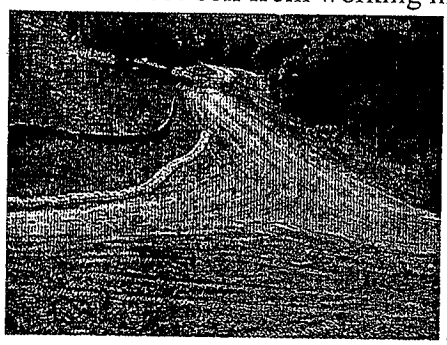
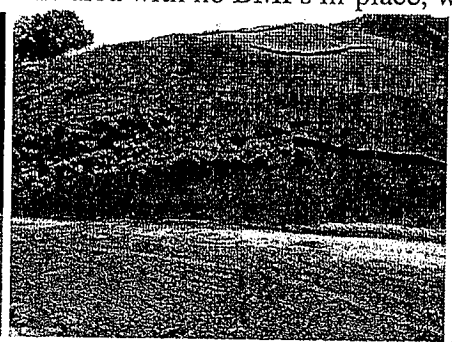
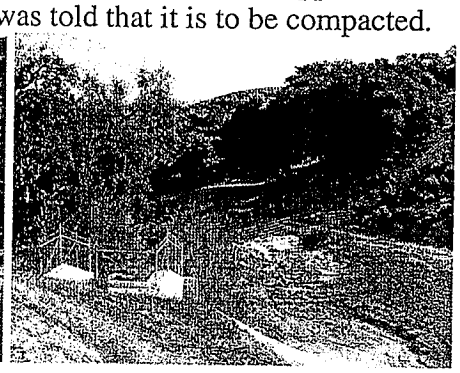
3) Area below basin, wattles are in place to slow the flow coming down the road (their position will be changed to face uphill) but, the flow from Oak Ck. has not been addressed.



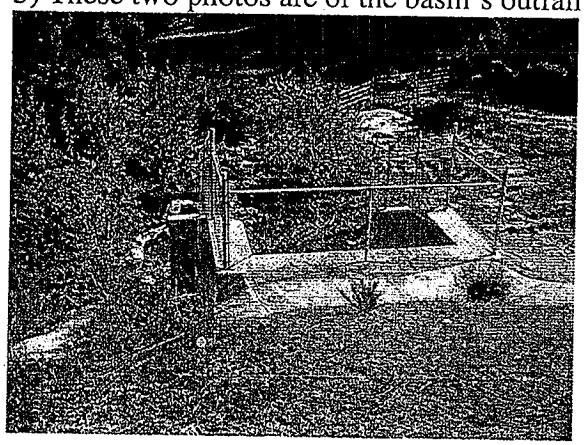
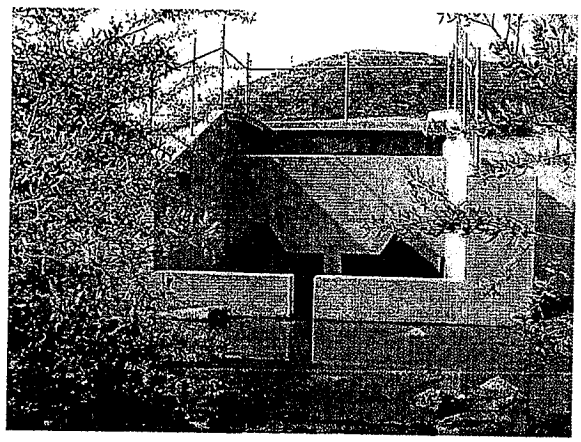


NPDES or #2 Basin and surrounding area

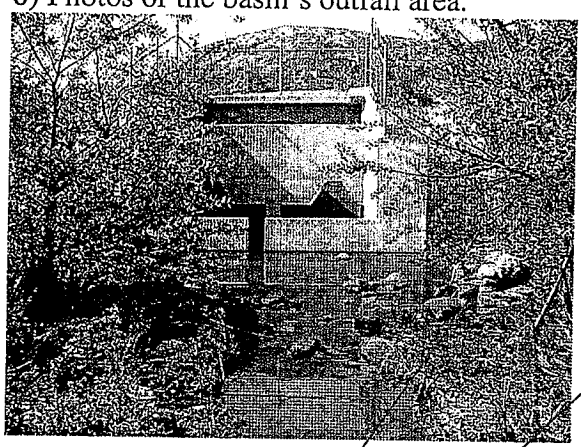
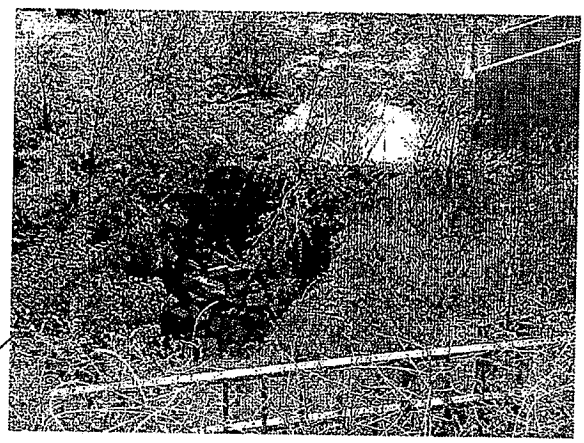
4) Photos are a continuation of the road below the basin. Some sandbags have been put in place & the slit fence has been repaired. The hillside has not been stabilized, was told something would be applied to it. There is loose soil from working in the area with no BMPs in-place, was told that it is to be compacted.

5) These two photos are of the basin's outfall.

6) Photos of the basin's outfall area.

Sandbags placed were water from the outfall has flowed and caused major erosion. A permanent berm is to be placed here.

Rock has been placed in part of the eroded area but, this will not stop it from eroding further. The outfall is being undercut. The City is going to [illegible]ent to be applied to the area.

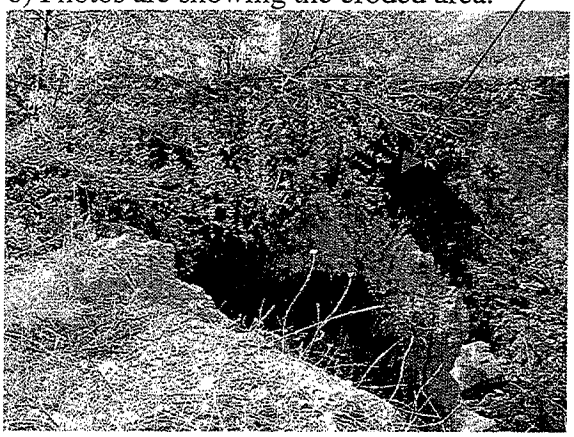
NPDES or #2 Basin and surrounding area

7) Photo is a close-up of the undercutting of the basin's outfall. The site superintendent has said that more rocks will be placed in here with fill dirt. This by itself, will not stop the erosion.

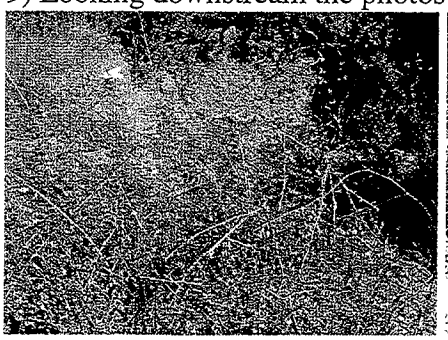
This is the area below the outfall were rocks have been placed.

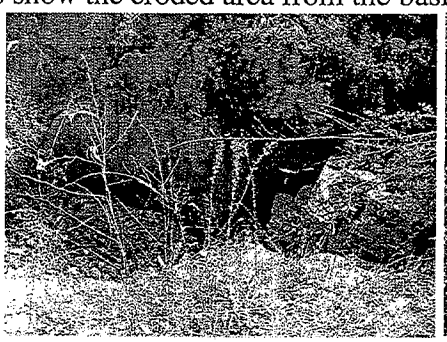
Water has cut into the hillside here to turn and flow downstream.

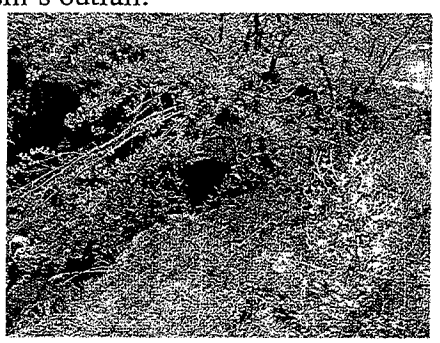
8) Photos are showing the eroded area.



9) Looking downstream the photos show the eroded area from the basin's outfall.



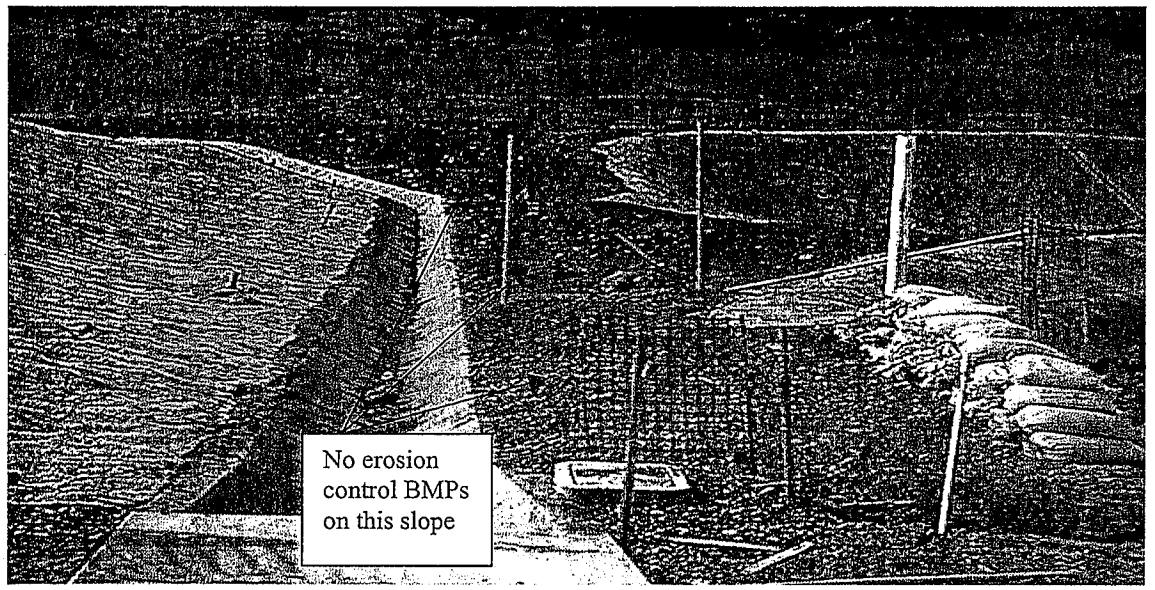




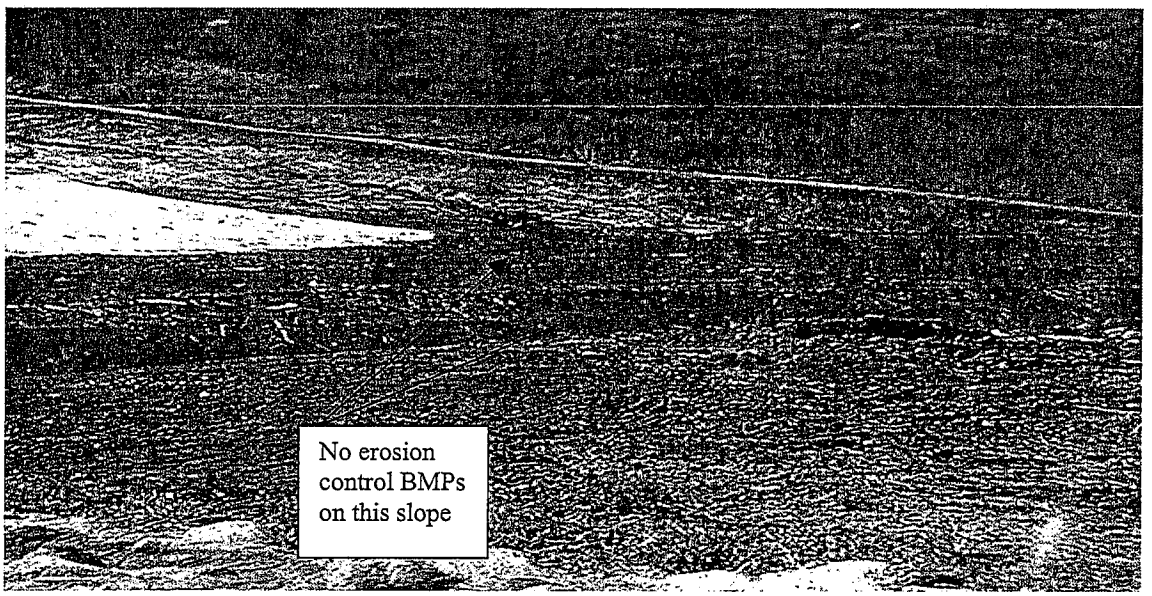
WDID#: 456C 322206
Inspection Date: December 5, 2003
Inspection Site: Centex Homes
Read Rd & Moorpark Rd., Thousand Oaks, CA 91360

Complaint Construction Inspection

1) Showing slope w/o effective erosion control BMPs during rainy season



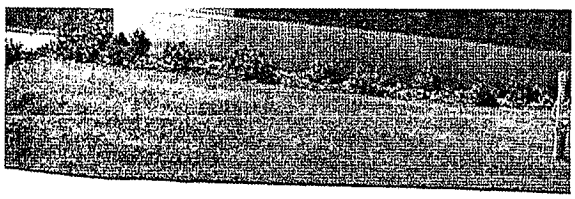
2) Showing slope w/o effective erosion control BMPs during rainy season

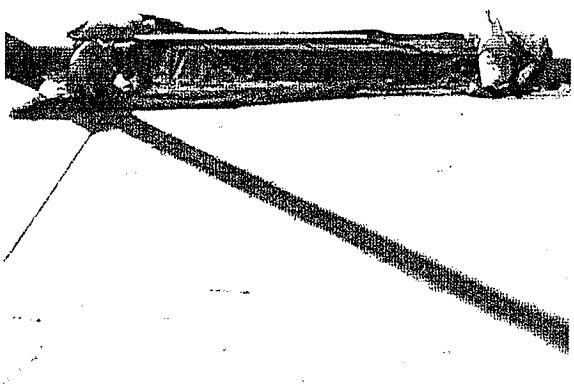


3) Showing no sediment tracking control BMPs on drive way

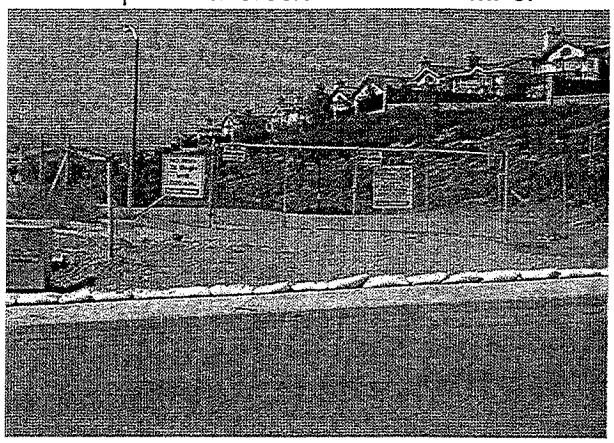
WDID #4A56S 307777 (Pardee Construction Company) 2929 Eagles Claw Ave. & Westlake Blvd. Thousand Oaks, CA
Front part of the construction project has completed homes, and as you go up into the project area there are homes in various stages of completion, as well as grading occurring.

Corner of Eagles Claw Ave. & Westlake Blvd. The filter strip is not fully covering the storm drain on the north side of Eagles Claw Ave., thus allowing sediment-laden water coming down Eagles Claw Ave. to enter storm drain's grate directly and go under the filter strip.

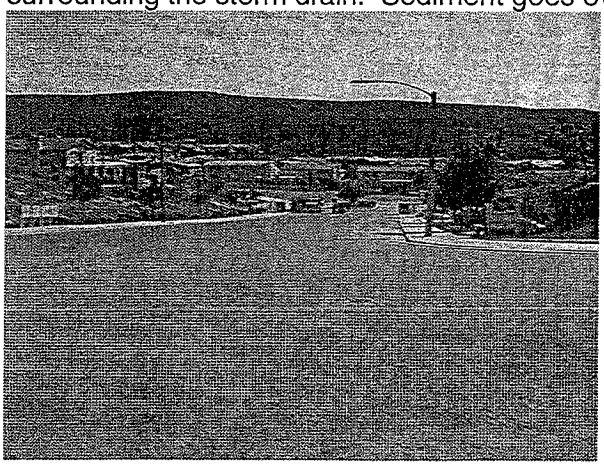


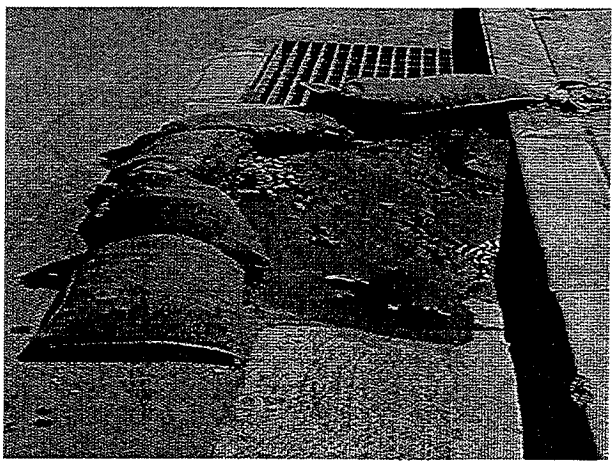


Pictures show the north side of Eagles Claw Ave., looking up Eagles Claw Ave. from Westlake Blvd. There are BMPs at the first area of potential erosion, but as you go up Eagles Claw Ave. areas of potential erosion have no BMPs.

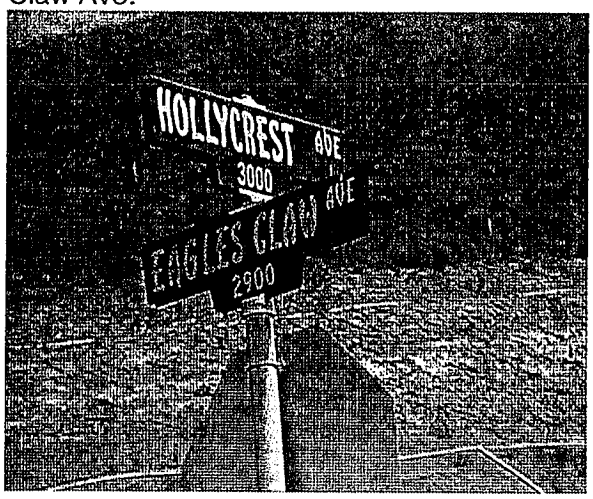


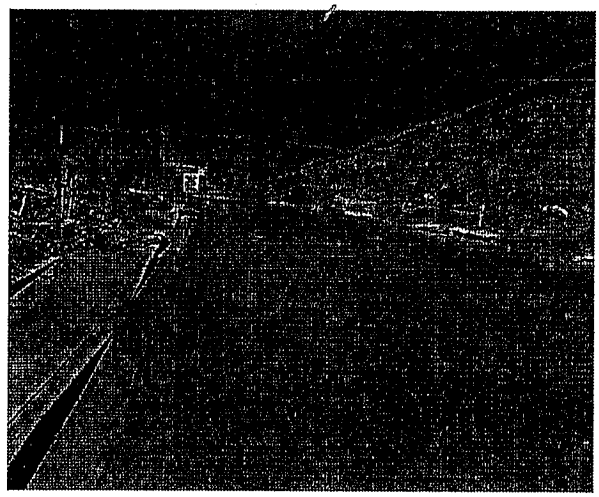
Picture showing a view of looking west (down) on Eagles Claw Ave., corner of Blazing Star Dr. & Eagles Claw Ave. Truck going to Shea Homes development is entering the project area. Sediment-laden water runs down the street from the Shea Homes trucks washing off at the top of Eagles Claw Ave. Storm drain on North side of street shows sediment is on sidewalk and surrounding the storm drain. Sediment goes over sandbags into drain and around sandbags.

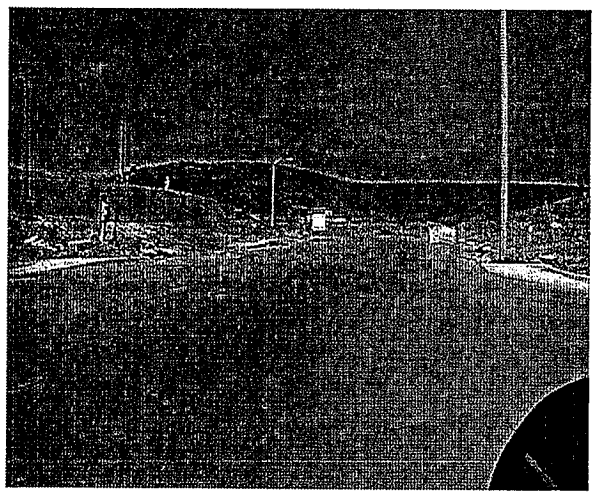




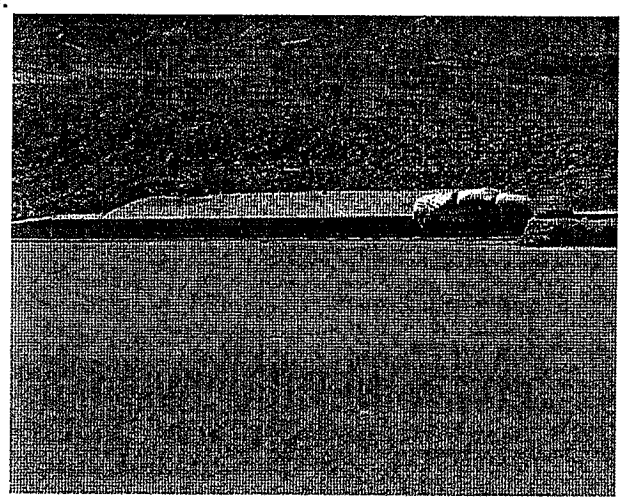
Pictures looking east (up) on Eagles Claw Ave., before gate, corner of Hollycrest Ave. & Eagles Claw Ave.



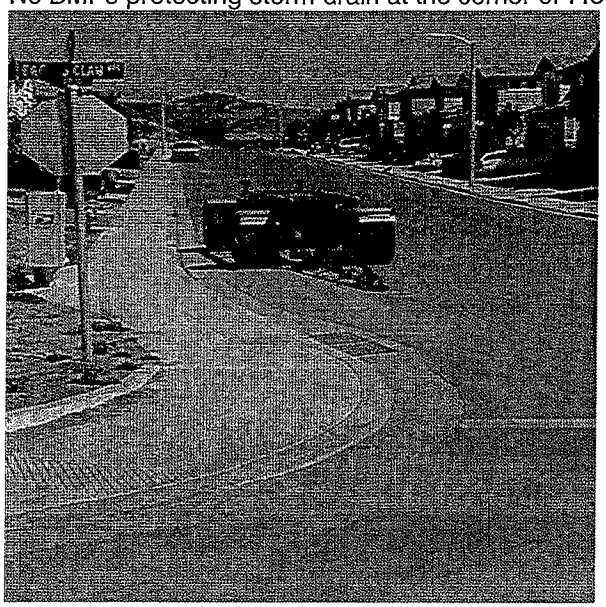




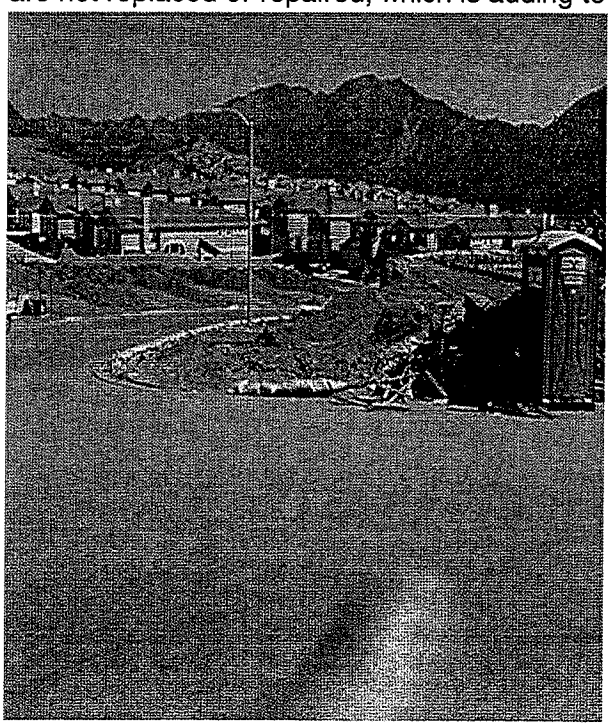
Pictures showing storm drains on East & North sides of Eagles Claw Ave., at the corner of Hollycrest Ave. & Eagles Claw Ave. Sediment is surrounding the storm drains, going over sandbags and down the road. Sediment-laden water runs down the street from the Shea Homes truck washing off at the top of Eagles Claw Ave.

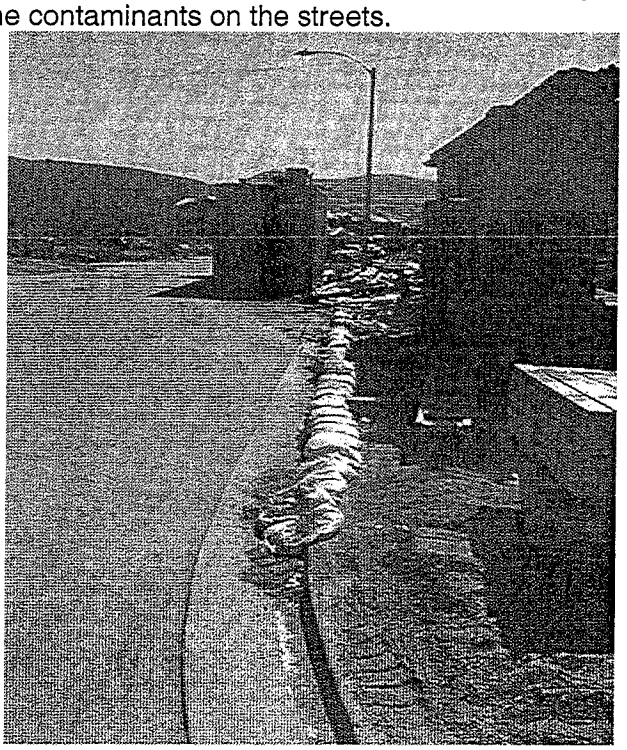


No BMPs protecting storm drain at the corner of Hollycrest Ave. & Eagles Claw Ave.

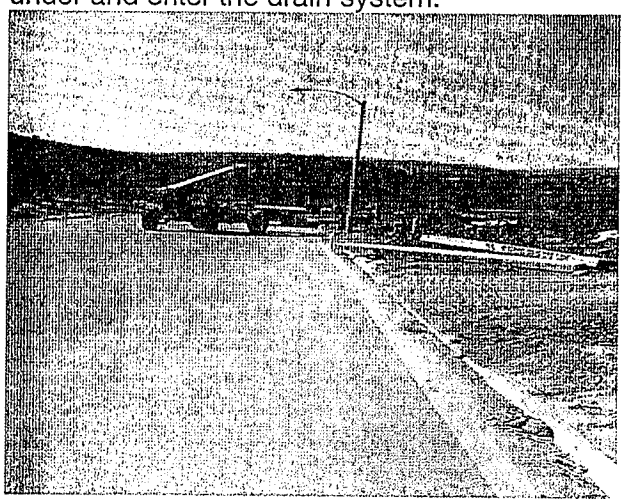


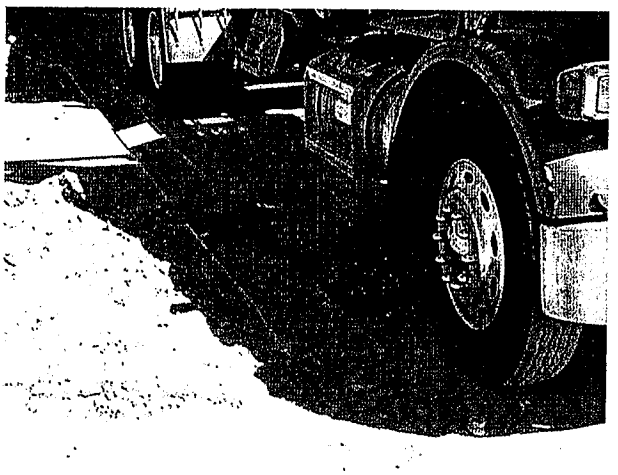
Pictures are showing the corner of Egales Claw Ave. & Arbella Ln. and looking west (down) on Arbella Ln. After entering gate of construction area sandbags are not regularly surrounding perimeter allowing sediment, debris and construction contaminants to leave site area. Sandbags are not replaced or repaired, which is adding to the contaminants on the streets.



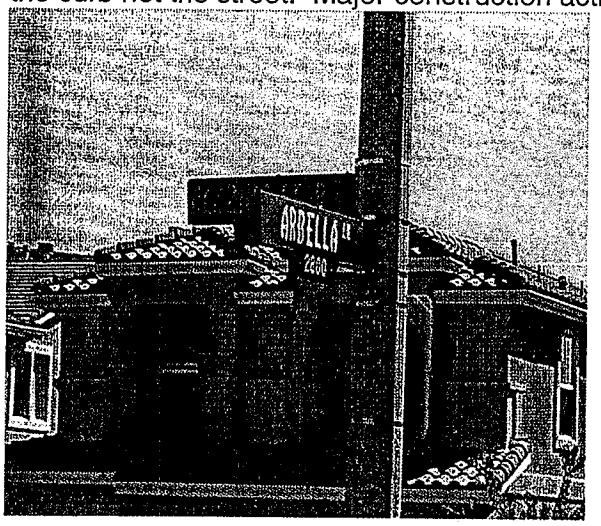


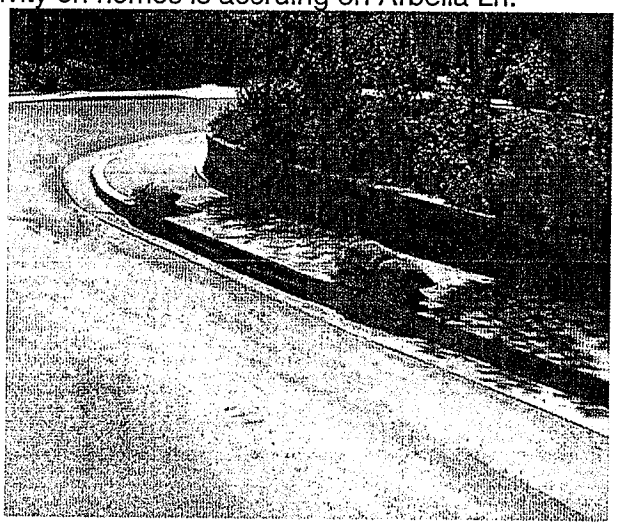
Pictures are after entering gate of construction area. First picture shows the entrance to the active grading operation of Shea Homes and the lack of BMPs to reduce/eliminate sediment runoff. Second picture is showing sand bags by storm drain run over by truck, and the one closest to the drain is not flat on the road , it is partly on the curb creating space under it for contaminants to pass under and enter the drain system.





Pictures are showing corner of Blazing Star Dr. & Arbella Ln. The storm drain has sandbags on the curb not the street. Major construction activity on homes is accruing on Arbella Ln.

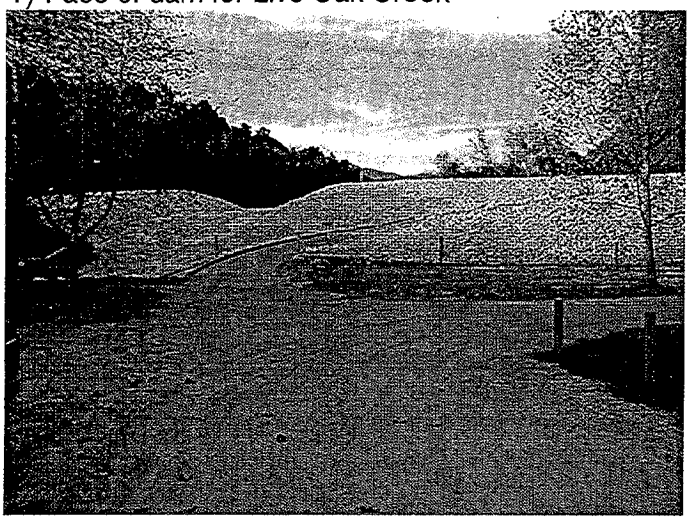




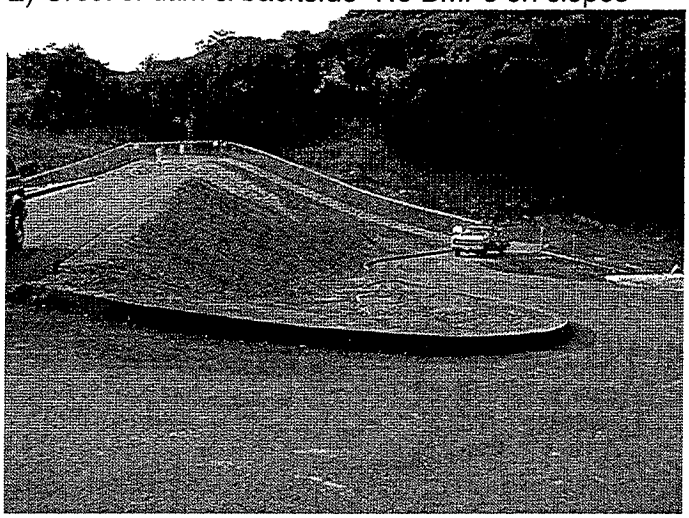
Inspection Date: 12/05/00
Active Site- Rancho Del Rey Park Ojai, CA

Flood Control Project- earthen dam on Live Oak Creek & a water diversion to the Ventura River

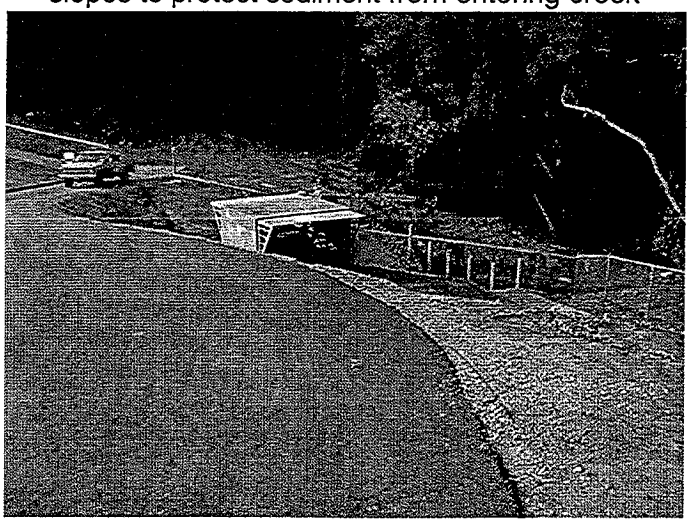
1) Face of dam for Live Oak Creek



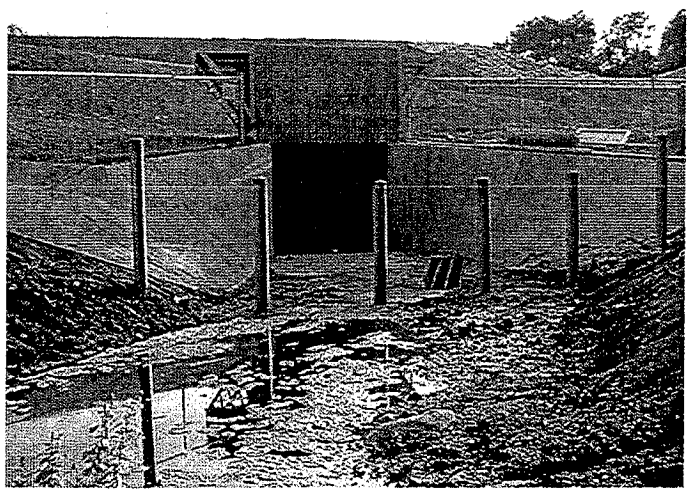
2) Crest of dam & backside- No BMPs on slopes



3) Backside of dam viewing creek.- no BMPs on slopes to protect sediment from entering creek



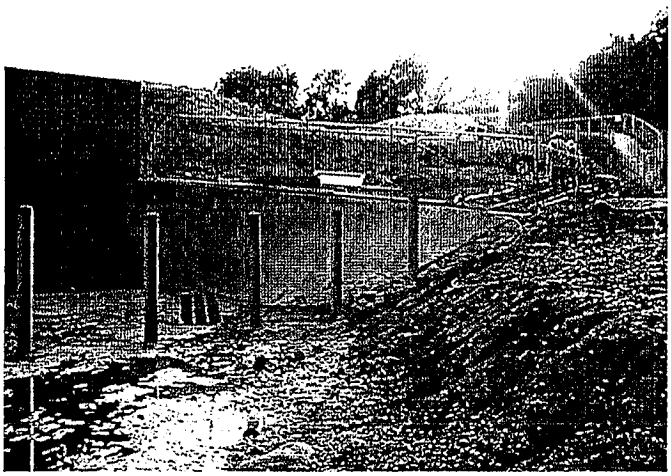
4) Culvert entrance- sediment in creek., no BMPs to protect sediment from entering creek



Inspection Date: 12/05/00
Active Site- Rancho Del Rey Park Ojai, CA

Flood Control Project- earthen dam on Live Oak Creek & a water diversion to the Ventura River

5) Live Oak Ck.- Erosion, sediment in Ck., no BMPs on active disturbed soil areas protecting creek



6) Live Oak Ck.- Erosion, sediment in Ck., no BMPs on active disturbed soil areas protecting creek

A new modeling approach for estimating first flush metal mass loading

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Abstract The purpose of this study was to investigate pollutant mass loading from major highways in Southern California, with emphasis on interpretation of event mean concentrations and first flush effects. The results of monitoring eight sites during the 1999-2002 storm seasons found that metal contaminants had higher concentrations at the early stages of storm events compared with other stages of rain storms. A new washoff model was developed to predict the event mean concentrations of metal contaminants taking first flush effect into account. Model variable parameters included average daily traffic, antecedent dry period, rain intensity, total runoff volume, and runoff coefficient. The results obtained using the washoff model were compared with measured values and found to fit well for heavy metals with R^2 ranging from 0.8 to 0.95.

Keywords Event mean concentration (EMC); first flush; mass loading; metal contaminants; washoff model

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Introduction

Large amounts of heavy metals in road surfaces are from wear and tear of various vehicle components such as tires, engine parts, brake pads; auto body rusting; lubricants; and fuel combustion (USEPA, 1995). In general, metals accumulate during dry days and wash from highways during storm events, usually absorbed by soil particles and move to receiving waters. The California Department of Transportation engaged in various storm water characterization studies throughout the state (Kayhanian *et al.*, 2001). One of these was first flush (FF) characterization, carried out jointly by the Department of Civil and Environmental Engineering at the University of California, Davis (UCD) and Los Angeles (UCLA) campuses. The FF characterization study has been ongoing since 1998 and several aspects of FF characterization have been published in Ma *et al.* (2002); Lau *et al.* (2002); Kayhanian *et al.* (2002).

Often the pollutant concentrations decline over time, which tends to create greater emission rates at the beginning of runoff. This phenomenon is often called a "first flush," and the existence of a first flush can influence the selection of best management practices (BMPs). The existence of first flush is debated and many defining criteria exist. It is most often observed in small watersheds, particularly if the amount of imperviousness area is proportionally high.

Models are often used to predict pollutant concentrations. Different models have been used, including regression, stochastic, and deterministic simulation (Irish Jr. *et al.*, 1998). The main difference between these models is the assumption of the origin of pollutants. Most of the models commonly use concentrations or loads of pollutants as variables that are dependent upon runoff volume, rainfall intensity, traffic intensity, antecedent dry days, surrounding land use, etc. Generally, it is difficult to consider all factors because many different site-specific conditions exist, such as the presence or absence of street

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sweeping, soil saturation, wind direction, etc. Regression models have been criticized as poor predictors of future events or for different regions (Driscoll *et al.*, 1990). No model, however, is available to take first flush into account as part of the mass loading computation. This paper will provide a new approach defining first flush criteria and its application for EMCs and mass loading calculations.

Methods

All eight monitoring were selected to include primarily highway runoff. Samples have been collected since the 1999 rainy season. Table 1 summarizes the monitoring periods and partial characteristics of each site. Monitoring was performed by collecting 4L grab samples. Generally, five samples were collected in the first hour. The first sample was collected at the very beginning of runoff. Additional samples were collected each hour until the end of the runoff. Rainfall and runoff rates were also measured with automated monitoring equipment. Additional information on sample collection, equipment, analytical constituents and other related items can be found in Kayhanian *et al.* (2002) and Ma *et al.* (2002).

Washoff model development

Because of random characteristics of runoff quality and quantity, the EMCs cannot be determined by simple statistical averages of measured pollutant concentrations in stormwater runoff. The sources of uncertainty are generally caused by uncertainties in magnitude of rainfall intensity, experimental errors, and lack of sufficient data. Gupta and Saul (1996) used multiple linear regression analysis for data interpolation and Larsen *et al.* (1998) calculated EMCs using the medium point method. Many researchers (Charbeneau and Barrett, 1998; Deletic and Mahsimivic, 1998; Irish Jr. *et al.*, 1998; Osuch-Pajdzinska and Zawilski, 1998; Deletic *et al.*, 2000) used mass emission rates from the exponential washoff model to estimate EMCs.

The exponential model ignores many different trends in concentrations normally observed during monitoring. For instance, it is not possible to predict dilution with an exponential model. Concentration reduction occurs whenever a particular quantity of pollutants mixes with a large runoff volume. The dilution in stormwater occurs essentially as a continuous process and varies with rainfall rate. It is generally assumed that a pollutant has an initial mass on the watershed area that existed before the rainfall and a remaining mass that still exists after the rainfall. The washoff mass is the difference between total and remaining mass. The total mass on the watershed changes with time due to inputs from wet or dry deposition, automobiles, and other sources. During the storm event, the mass input from automobiles can be high and can affect runoff concentrations during the storm (Shaheen, 1975).

As mentioned earlier, the mechanism affecting the concentration changes with time is the dilution of initial pollutant mass. However, the mass from air and automobiles during a storm event can create the opposite trend, continuously adding to the washoff mass.

Table 1 Monitoring site descriptions

Site name	Freeway location	ADT (cars/day)	Watershed area (m^2)	Monitoring period
UCLA 1	101	328,000	12,800	1999-current
UCLA 2	405	260,000	16,900	1999-current
UCLA 3	405	322,000	3,900	1999-current
CDM7-10	210	176,000	48,100	1999-2000
CDM7-185	91 & 605	220,000	2,300	1999-2000
URS23	210	122,000	29,100	2000-current
URS6-20F	60	216,600	1,700	2000-current
URS8-23C	605	229,000	2,500	2000-current

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The washoff rate can be described such as Eq. (1).

$$\frac{d[C(t)]}{dt} = -\alpha \cdot \frac{Q_{Ru}(t) \cdot C(t)}{V_{TRu}} \tag{1}$$

where

α = washoff rate coefficient
$C(t)$ = Pollutant concentration at time t
Q_{RU} = Runoff volumetric rate (m^3/s)
V_{TRu} = Total runoff volume = $\int_0^T Q_{Ru}(t)dt(m^3)$

Rearranging and integrating Eq. (1), we can obtain:

$$C(t) = \beta \cdot exp[-\alpha \cdot V_{nRu}(t)] \tag{2}$$

where, $V_{nRu}(t)$ = Normalized Cumulative Volume, $0 \leq V_{nRu}(t) \leq 1.0$.

The mass input during a storm event can be considered as another concentration term (γ), which originates from automobiles, air and other factors. Thus,

$$C(t) = \beta \cdot exp[-\alpha \cdot V_{nRu}(t)] + \gamma \tag{3}$$

where, the concentration can also be defined from mass emission rate:

$$M(t) = C(t) \cdot Q_{Ru}(t) \tag{4}$$

with $M(t)$ = Pollutant mass emission rate at time, t

$$C(t) = \frac{\Delta M(t)}{\Delta Q_{Ru}(t)} = \frac{\int_{t-1}^{t} M(t)dt}{\int_{t-1}^{t} Q_{Ru}(t)dt} = \frac{\int_{t-1}^{t} M(t)dt}{\int_0^t Q_{Ru}(t)dt - \int_0^{t-1} Q_{Ru}(t)dt} \tag{5}$$

from which can be obtained

$$C(t) = \frac{1}{\beta_1 \cdot V_{nRu}(t)} \cdot \frac{\int_{t-1}^{t} M(t)dt}{V_{TRu}} \tag{6}$$

The right side of Eq. (6) has units of mass/volume or concentration. This new concentration term is a key premise of the model. Let $\int_{t-1}^{t} M(t)dt/V_{TRu} = C^*[V_{nRu}(t)]$, where C^* is defined as new concentration.

Equation 6 now can be expressed as follows:

$$C(t) = \frac{1}{\beta_1 \cdot V_{nRu}(t)} \cdot C^*[V_{nRu}(t)] \tag{7}$$

By equating Eqs. (3) and (7), we obtain:

$$\beta \cdot exp[-\alpha \cdot V_{nRu}(t)] + \gamma = \frac{1}{\beta_1 \cdot V_{nRu}(t)} \cdot C^*[V_{nRu}(t)] \tag{8}$$

Summarizing and letting $\beta \cdot \beta_1 = \beta^*$ and $\gamma \cdot \beta_1 = \gamma^*$, the new washoff model is expressed as follows:

$$C^*[V_{nRu}(t)] = \beta^* \cdot V_{nRu}(t) \cdot exp[-\alpha \cdot V_{nRu}(t)] + \gamma^* \cdot V_{nRu}(t) \tag{9}$$

In Eq. (9), a parameter is needed to describe the initial condition (δ), which ideally should be related to antecedent dry periods. The new washoff model is finally expressed as follows:

$$C^*[V_{nRu}(t)] = \delta + V_{nRu}(t) \cdot \{\gamma^* + \beta^* \cdot exp[-\alpha \cdot V_{nRu}(t)]\} \tag{10}$$

In order to use the model as a predictive tool, it is necessary to predict the total runoff volume, which must be based upon weather forecast or other information. Eq. (10) has four parameters that are related to antecedent dry periods, rainfall intensity and runoff coefficient. The δ is an initial concentration related to antecedent dry periods.

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changes with time is
automobiles during
e washoff mass.

Monitoring period
1999-current
1999-current
1999-current
1999-2000
1999-2000
2000-current
2000-current
2000-current

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The parameters α and γ^* are related to total runoff. The β^* is related to rainfall, runoff coefficient and storm duration.

Results and conclusions

Runoff coefficient

The runoff coefficients are shown in Figure 1 as a function of total rainfall. The average is 0.87. Events with less rainfall have lower runoff coefficients, and lie below the regression line. This phenomenon is well established in the literature and is related to saturation of the site.

Statistical summaries of measured metal concentrations

Figure 2 shows the box plots of measured concentration for seven metals. The box plots show minimum, median, maximum, standard deviations, upper/lower 95 percent confidence intervals and outliers for each metal. For example, the concentration ranges

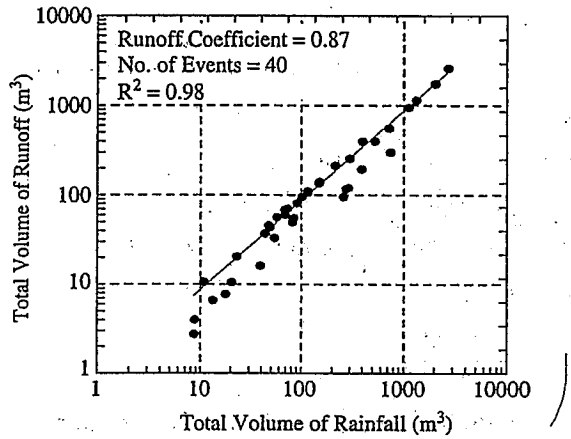

Figure 1 Runoff coefficient plot

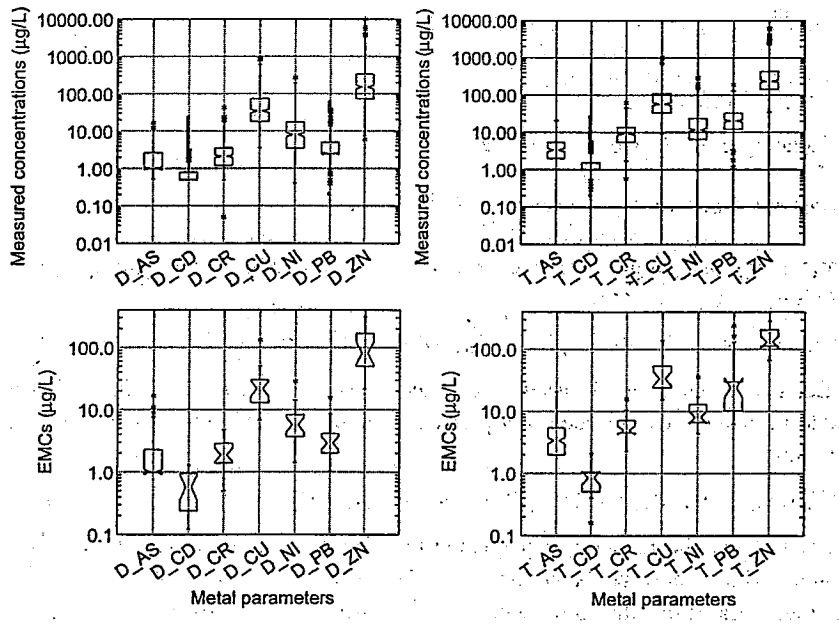

Figure 2 Box plots for dissolved and total concentrations and related EMCs for seven metals

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0.7–1.2 μg/L, 27.3–51.7 μg/L, 15.6–70.1 μg/L, 126–208.6 μg/L for total Cd, Cu, Pb, and Zn, respectively under 95 percent confidence intervals. These plots clearly showed that there are large differences between minimum and maximum concentrations. These differences are assumed to be partially due to variations in rainfall intensity and antecedent dry periods. In most cases it was determined that large fraction of metal contaminants is in dissolved phase. However, the ratios of total to dissolved fraction for all metal contaminants were not the same. For example, as shown in Figure 2, the ratio of T-Pb and D-Pb is substantially higher than other metal pollutants.

Because of these extreme variations of pollutant concentrations from event to event, the use of medium concentration in modeling effort can introduce large error, particularly when only a few samples are collected. Similarly, because the EMC values are affected by rainfall and antecedent dry periods the exponential model may not fit the observed data and that can result in large errors. The new modeling approach introduced in this paper will delineate some of these errors.

First flush criteria

It is important to know the probabilities and magnitude of the first flush. True estimation of the first flush magnitude is difficult, due to random characteristics of runoff quality and quantity, uncertainties in rainfall intensity and magnitude, experimental errors, and lack of sufficient data. Models to predict first flush of metal pollutants are rare. Therefore, the existence and importance of first flush has been debated. If first flush exists, it is more practical and cost effective to capture and treat more of the earlier runoff volume and bypass the remaining runoff volume.

Figure 3 shows the example of displaying first flush in the case of total Zn. The results were obtained by fitting the model to each storm event and then using the model results to calculate mass emission rates. The left side of Figure 3 shows total Zn mass emission rates for successive normalized runoff volumes ranging from 10 to 100 percent with the increment of 10 percent. This method of plotting shows that the first 10 percent of the normalized volume carries the greatest mass of pollutants. The right side of Figure 3 shows mass first flush ratio (MFF). For example the MFF_{10} for total Zn is 2.2, which means that 22 percent of the normalized total Zn mass is washed off in the first 10 percent of normalized runoff. The MFF ratio declines as the storm proceeds and the MFF_{20} and MMF_{30} decline to 1.6 and 1.4, respectively.

These analyses were performed on seven metal parameters and we concluded that metal first flush peaked at about 30 percent of the normalized flow. This means that the first flush usually occurred in the first 30 percent of total runoff volume.

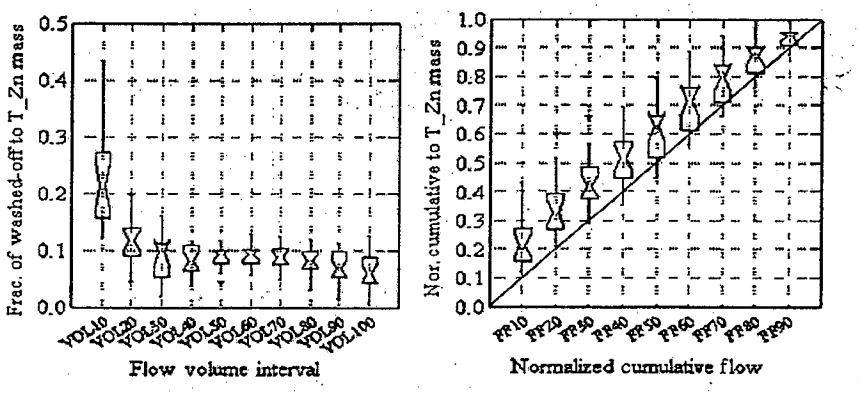

Figure 3 Washoff pollutant mass and volume

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Metal pollutographs

Figure 4 shows the measured metal concentration profiles against time and rainfall and flow rate in the background (this type of plot is known as a pollutograph). As shown, the concentrations of Cu and Zn were consistently greater than Ni and Pb.

The concentrations of both dissolved and total Cu and Zn also showed a general declining pattern as storms progress. As previously discussed, the monitoring results also showed that Cu and Zn are predominantly present in the dissolved phase. This observation was consistent during the entire monitoring periods. For example, the dissolved Cu concentration for storm event 1/8/01 was approximately 10 times greater than those present in the particulate phase. For the same storm event, the concentration of dissolved Zn was approximately 36 times more than the particulate Zn concentration. Contrary to Zn, the concentration of dissolved Pb in most of the 2000-2001 samples was below the detection limits (5 μg/L) and most of the Pb concentration in runoff samples was found to be in the particulate phase. This phenomenon was also observed in studies performed by Sansalone and Buchberger (1997), and Legret and Pagotto (1999). Unlike Pb, the amount of dissolved Ni found in runoff samples was approximately the same as those found in the particulate phase.

Factors affecting EMCs and mass loadings

Table 2 shows the effects of parameters such as average daily traffic (ADT), watershed area, antecedent dry days (ADD), storm duration (STORM-DUR), volume of total rainfall (T-RAIN), volume of total runoff (T-RUN), runoff coefficient (RC) and average rainfall intensity (ARI) on total Pb mass loadings. The constant value for each predictor is summarized in Table 2. As indicated, average daily traffic, antecedent dry periods, total rainfall, and average rainfall intensity are among the parameters that affect total Pb mass

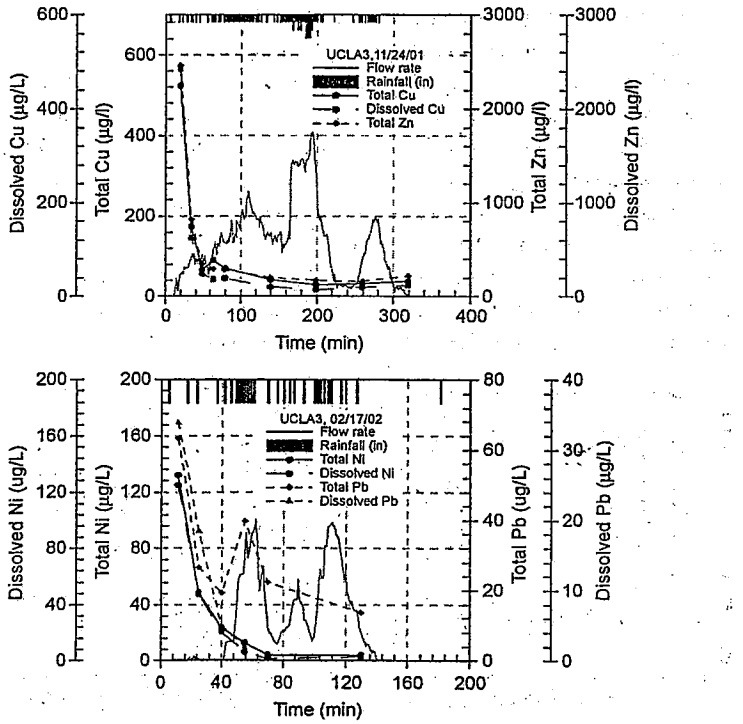

Figure 4 Typical pollutographs for total and dissolved Cu, Pb, Ni, and Zn during two representative storm events

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Table 2 Summary of predicting variables used in washoff model to compute total Pb mass loading

Factors	ADT	AREA	ADD	STORM-DUR	T-RAIN	T-RUN	RC	δ	γ*	β*	α	ARI
ADT	1.00	−0.65	0.02	0.16	−0.10	−0.41	0.40	−0.13	0.04	0.12	−0.32	−0.08
AREA	0.00	1.00	0.02	0.05	0.26	0.76	−0.07	0.11	−0.41	−0.17	0.69	0.15
ADD	0.92	0.93	1.00	−0.11	0.26	0.05	−0.12	0.87	−0.27	−0.04	−0.06	0.12
STORM-DUR	0.42	0.82	0.61	1.00	0.29	0.12	0.40	−0.16	−0.25	0.30	0.35	−0.21
T-RAIN	0.63	0.19	0.20	0.15	1.00	0.61	0.14	0.40	−0.54	−0.38	0.52	0.67
T-RUN	0.04	0.00	0.81	0.57	0.00	1.00	0.17	0.15	−0.42	−0.31	0.80	0.55
RC	0.05	0.75	0.56	0.05	0.51	0.41	1.00	−0.13	−0.40	0.00	0.21	0.35
δ	0.52	0.60	0.00	0.43	0.04	0.47	0.52	1.00	−0.25	−0.06	0.01	0.22
γ*	0.86	0.04	0.19	0.21	0.01	0.03	0.05	0.21	1.00	0.19	−0.48	−0.42
β*	0.57	0.40	0.84	0.14	0.06	0.12	0.98	0.78	0.35	1.00	−0.07	−0.46
α	0.11	0.00	0.78	0.08	0.01	0.00	0.30	0.97	0.01	0.75	1.00	0.30
ARI	0.72	0.48	0.56	0.31	0.00	0.00	0.08	0.28	0.03	0.02	0.14	1.00

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loading more than the other parameters. It is important to note that δ value is highly dependent on antecedent dry periods, α and γ^* are related to total runoff, and β^* is related to rainfall, runoff coefficient and storm duration. From our collected data, however, no significant correlations among EMCs, mass loading and storm characteristics could be observed.

Model performance and implications

The washoff model is capable of predicting metal concentrations based on linear, exponential, and gamma function using defined parameters. Figure 5(a) shows examples of measured and predicted metal concentrations for total and dissolved Cu and Zn for storm events during 14 December 2001. The predicted results by washoff model agree well with measured results. Figure 5(b) compares the measured and predicted (model) results for total Cu. As shown, a good fit for measured and model results was obtained for total Cu with R^2 ranging from 0.80 to 0.95. The residuals, not shown in the figure, are unbiased.

Metal pollutant concentrations predicted by the washoff model can be used to predict event mean concentrations for different stages of storm events. This new modeling approach will enable engineers to compute metal pollutant mass loadings for a specific portion of a storm event (i.e., early stage) that may be more practical to treat than by treating the entire runoff volume.

Conclusions

A new washoff model was developed to predict mass emission rates of metals from highway runoff during first flush. Several predictor parameters were introduced in this model to estimate rapidly declining concentrations in the early part of the storm as well as slowly declining concentrations in the later part of the storm. This new model can be calibrated based on predicted stormwater runoff using estimated rainfall volume and is not dependent on continuous flow measurement. The model can be used to estimate EMCs and mass loading rates. Major findings of this study were the following.

- Most metal pollutants showed first flush on concentration and mass basis. The range of metal concentrations from early stages of a storm compared to the final stages of the storm can be tenfold. This large variation can introduce rare error that is normally associated with other modeling approaches. Mass first flushes were also observed and classified as: high, medium and non-first flush cases. Approximately 80 percent of the storm events exhibited a high or medium first flush.

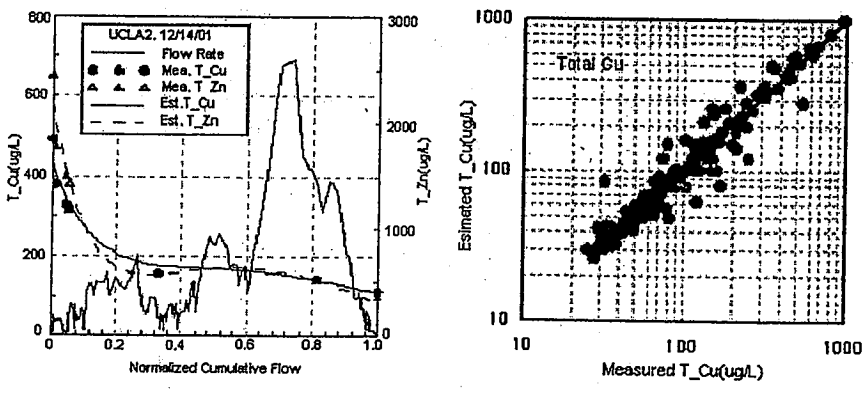

Figure 5 (a) Measured and predicted concentrations of total Cu and Zn versus normalized flow; (b) Correlation between measured and predicted total Cu

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- Among the predictor variables, initial conditions (δ) and runoff coefficient have the strongest influence on the metal washoff mass loading estimation. Other important variables are average daily traffic, antecedent dry period, total runoff volume and average rainfall intensity.
- The results were compared with measured values and fitted well for heavy metals with R^2 ranging from 0.8 to 0.95.

Acknowledgements

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Trace Metal Pollutant Load in Urban Runoff from a Southern California Watershed

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Abstract: In order to implement efficient and effective management strategies for coastal water quality in Southern California, it is important to consider the relative pollutant contributions from urban dry-weather flow (DWF) and wet-weather flow (WWF). This study uses both historical flow coupled with water quality monitoring data and computer modeling to characterize the annual DWF and WWF discharges from an urban catchment in Los Angeles, Calif. The DWF and WWF pollutant loading of the trace metals copper, lead, nickel, and chromium for 6 water years dating from 1991 to 1996 is predicted. The results indicate that DWF contributes a considerable amount of flow and pollutants. Approximately, 9–25% of the total annual Ballona Creek flow volume is DWF. The simulations indicate DWF accounts for 54, 19, 33, and 44% of the average annual load of total chromium, copper, lead, and nickel, respectively. In the dry season, the simulations indicate DWF accounts for 89, 59, 58, and 90% of the load of total chromium, copper, lead, and nickel, respectively. This research suggests DWF controls may be an important part of pollution mitigation plans for urban stormwater drainage systems in Southern California.

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CE Database subject headings: Watershed management; Nonpoint pollution; Urban runoff; Stormwater management; Water quality; California.

Introduction

Increased human populations in coastal areas have placed increased pressure on coastal ecosystems. In 1960, approximately 80 million people lived in coastal areas of the United States. As of 1990, 112 million people lived in United States coastal areas. The Southern California Coast was one of the regions of highest population change during this period (Culliton et al. 1990). The influx of people was accompanied by increased urban development; Los Angeles, Orange, and San Diego counties were among the top ten counties in the nation in construction of new single and multifamily homes and commercial and industrial buildings in the period from 1970 to 1989 (Culliton et al. 1992). The increased urban development in Southern California coastal watersheds, as in other coastal watersheds, changed the natural drainage of those systems, increased the amount of impervious area, and altered watersheds such that they became exporters of anthropogenically produced contaminants in urban runoff (United States Environmental Protection Agency 1993; Santa Monica Bay Restoration Project 1994). As a result of this urban runoff loading and other sources, the water quality in many Southern California coastal systems is impaired as evidenced by their placement on the California list for Total Maximum Daily Load (TMDL) development (California Environmental Protection Agency, State Water Resources Control Board, 1999).

Urban runoff in Southern California's Mediterranean climate can be divided into wet-weather flow (WWF) or dry-weather flow (DWF). In our study, we define WWF as the surface runoff produced by precipitation events. The DWF is the baseflow resulting from groundwater inflow, permitted discharges, illicit connections to the storm sewer system, excess irrigation, automobile washing, and other residential and commercial uses. The WWF discharges from urban storm drains into receiving waters have long been recognized as a significant source of pollutants and cause of water-quality degradation (APWA 1969; Field and Turkeltaub 1981; Athayde et al. 1983; Heaney and Huber 1984). In the Los Angeles area, historical creeks and rivers have been modified into concrete-lined storm drains (e.g., Los Angeles River and Ballona Creek). These massive concrete channels direct flow to the ocean throughout the year and the WWF from these systems has been shown to be a significant source of toxic and conventional contaminants to downstream coastal receiving waters (Suffet et al. 1997; Wong et al. 1997; Los Angeles Department of Public Works 1998; Suffet and Stenstrom 1999).

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The impact of urban DWF discharges is less understood. The relative importance of DWF load compared to WWF load is dependent on many factors, but is most likely related to the amount of annual precipitation, frequency of precipitation events, the degree of urbanization (i.e, alteration of land use to commercial, residential, and industrial purposes), the pollutant concentrations in each flow type, and the extent of DWF production due to illicit connections, excess irrigation or other nuisance flows. Southern California has several characteristics that may make DWF an important pollutant source. Southern California has a dry Mediterranean climate characterized by a distinct wet season and low annual precipitation. Annual average rainfall in Los Angeles is 300–330 mm, and the majority of the rainfall occurs in the winter (Santa Monica Bay Restoration Project 1994). Many coastal Southern California watersheds are highly urbanized and these densely populated areas import a large amount of water that is used for residential, commercial, and industrial uses. The City of Los Angeles, for example, imports approximately 80% of its water (Los Angeles Department of Water and Power 1999). Although the majority of this water is discharged to the sanitary sewer system, a considerable proportion may be discharged to storm drain systems following use.

The DWF in the Ballona Creek watershed has also been found to contain elevated concentrations of toxic contaminants. Lau et al. (1994) determined that the DWF effluent from the Ballona Creek system and several other storm drains in the Santa Monica Bay watershed was equivalent to secondary sewage effluent for some parameters including chemical oxygen demand (COD), total suspended solids (TSS), and turbidity and that it exerted a toxic effect on tested marine species. In an associated study, Suffet et al. (1993) found elevated concentrations of organic contaminants in Ballona Creek DWF and noted the potential importance of suspended solids in the transport of polychlorobiphenyl and polynuclear aromatic hydrocarbons. While much of the current regulatory strategies are concerned with nonpoint source contamination of water bodies from WWF, results from the studies mentioned above indicate the toxic potential of DWF in Southern California. Understanding the magnitude of the contaminant load in DWF and WWF allows the appropriate allocation of resources between water quality management alternatives.

An important contaminant in storm drain effluent is heavy metals (Athadye et al. 1983; United States Environmental Protection Agency 1998). Metals in DWF and WWF come from permitted or illicit discharges, surface runoff from industrial facilities, atmospheric deposition, releases due to dissolution from water pipes, or releases during wear of machine parts especially automobiles. Once in receiving waters, metals can accumulate in bottom sediments, bioaccumulate in animal tissues, and affect ecological systems.

There have been no detailed studies comparing the relative importance of DWF and WWF pollutant loads of metals from urban Southern California coastal watersheds. Duke et al. (1999) statistically compared concentrations of select water quality parameters in DWF to concentrations in WWF at locations throughout California including two stations in Ballona Creek. Those researchers found no statistically significant differences between DWF and WWF concentrations in Ballona Creek for total and dissolved copper, lead, and zinc, but indicated the strength of the conclusion was not strong due to low sample sizes. Stephenson and Green (1988) calculated DWF and WWF loads for two urban South African catchments determining that WWF pollutant loads were 3.6–5.3 times DWF loads, but they only calculated DWF and WWF loads for total dissolved solids in a region with greater annual rainfall than Southern California. This paper compares the heavy metal load in DWF and WWF in the Ballona Creek watershed. We simulate the WWF load of total heavy metals using the Storm Water Management Model (SWMM) (Huber and Dickinson 1988). We estimate the DWF load of total heavy metals using an empirically based DWF load model. The model is developed as part of this research.

Methods

This study uses historical data, field sampling protocols, and modeling results to characterize long-term average DWF and WWF discharges from the Ballona Creek watershed. Total suspended solids, chromium (Cr), copper (Cu), lead (Pb), and nickel (Ni) were selected for this study because of their importance in relation to the protection of Ballona Creek and Santa Monica Bay beneficial uses and the availability of the necessary data to create the models. The Ballona Creek system was chosen for this study because it has been placed on the California list for TMDL development for several of the metals studied (California Environmental Protection Agency, State Water Resources Control Board, 1999) and has been determined to be a major source of contaminants to Santa Monica Bay, a National Estuary Program estuary.

Ballona Creek Watershed Description

Fig. 1 shows the major features of the Ballona Creek Watershed. The watershed is located in Southern California, and includes a significant portion of Los Angeles, Calif. Approximately 85% of the 330 km^2 watershed is covered by urban land uses (Wong et al. 1997). The watershed extends north into the Santa Monica Mountains, west into Beverly Hills and Culver City, east into downtown Los Angeles and south to the Westchester Bluffs. The drainage of the watershed can be divided into three subcatchments: the Ballona Creek catchment, Sepulveda Channel catchment, and the Centinela Creek catchment. Ballona Creek, Sepulveda Channel, and Centinela Creek are concrete-lined channels fed by a complex network of storm drains. Sepulveda Channel feeds into Ballona Creek and Ballona Creek flows into the Ballona Creek Estuary. Centinela Creek flows directly into the Ballona Creek Estuary. The Ballona Creek Estuary is an area of significant tidal influence from Santa Monica Bay. The Ballona, Sepulveda, and Centinela catchments account for the majority of the flow into the Ballona Creek Estuary.

Dry-Weather Flow Load Calculation

An empiric model to predict the seasonal DWF pollutant load from the Ballona Creek watershed for the 1991–1996 water years was developed. The model development began with analyzing the historical flow record for Ballona Creek. Flow rates in Ballona Creek have been recorded at 15 min to hourly increments since 1928 at station F38C-R, located at the Sawtelle Avenue Bridge just upstream of the confluence with Sepulveda Channel. The data were obtained as the mean daily flow rates from the Los Angeles Department of Public Works for the 1991 to 1996 water years. Historical flow records for Sepulveda and Centinela are not available; therefore, flow measurements of the three catchments were included in a field project during the summer of 1999. The goal was to develop a relationship between the DWF rate in Ballona Creek and the DWF rates in Sepulveda Channel and Centinela Creek. The measured ratios of flow between Sepulveda Channel

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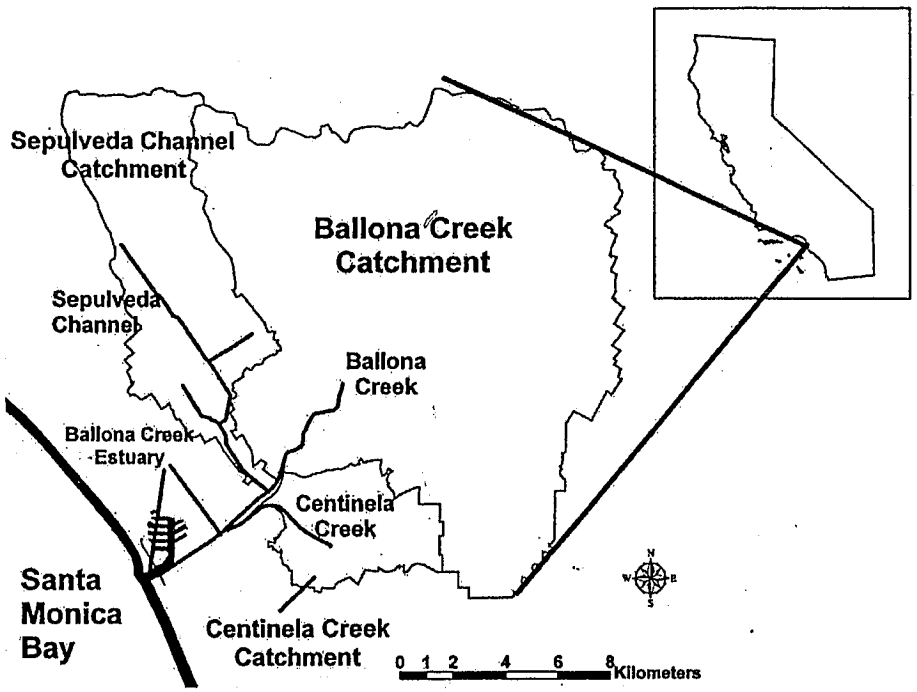

Fig. 1. Ballona Creek Watershed

and Ballona Creek and Centinela Creek and Ballona Creek had an average and standard deviation of 0.27±0.07 and 0.04±0.02, respectively.

In order to determine the yearly load from dry weather runoff conditions, the LADPW mean daily flow data had to be adjusted to remove wet weather conditions. Wet weather flows were removed using the sliding interval base flow separation method (Pettyjohn and Henning 1979). The DWF reduction procedures were partly verified by comparing the estimated 1997 water year wet season WWF volume to an estimate based on the more detailed 15 min flow record. The DWF reduction approach estimated the 1997 WWF volume to be 36×10^6 m^3, which was less than 7% different than the 33.7×10^6 m^3 value produced from the more detailed 15 min flow record.

The water quality characteristics of the DWF were established using two sources of water quality data. One source was the Santa Monica Bay Urban Runoff Database (SMBURD) compiled by Dr. Michael K. Stenstrom of the University of California, Los Angeles (UCLA). The other source was the results of water quality monitoring in the Ballona Creek watershed during the summer of 1999. The SMBURD database contains water quality data collected over a period of 20 years by 15 different agencies with responsibility for local water quality in Southern California. The 1999 summer water quality monitoring effort was organized to supplement the SMBURD database and account for current conditions in the system.

During the summer 1999 effort, samples were collected on 6 days in June, July, and August. Samples were collected from three sites within the Ballona Creek watershed at 6 h intervals: (1) Ballona Creek upstream of the Sepulveda Channel and Centinela Creek confluences; (2) Sepulveda Channel immediately upstream of its confluence with Ballona Creek; and (3) Centinela Creek upstream of its confluence with Ballona Creek (Fig. 2). These three sites were chosen to represent the outlets from the Ballona, Sepulveda, and Centinela catchments and to correspond to previous sampling efforts (Suffet et al. 1993, 1997; Lau et al. 1994; Suffet and Stenstrom 1999). By placing the sampling locations at the outlet of the three catchments the total DWF pollutant contributions from each catchment can be characterized. Each sample was analyzed for TSS and dissolved and suspended solids concentrations of Cr, Cu, Pb, and Ni. Analytical methods were similar to those used in Suffet and Stenstrom (1999) in a 1998 sampling protocol of WWF. Samples were collected in the field in amber glass bottles, placed in an ice chest until they were brought to the laboratory where they were stored at 4°C until filtration. Samples were filtered using a stainless steel, Teflon-lined Millipore 142 mm Hazardous Waste Filtration System with an integral 1.5 L reservoir. Samples were filtered in 1 L increments using pressure filtration through preweighed 142 mm, 0.7 μm pure glass Toxicity Characteristic leaching procedure (TCLP) filters. The second liter of each sample was collected as filtrate for water quality analyses. Thirty milliliters of each filtrate were placed with 3 drops of trace metal grade concentrated HNO_3 in 30 mL Nalgene low density polyethylene (LDPE) bottles for trace metal analysis. Filters were then dried according to the methods of Capangapangan and Suffet (1998) in which the filter paper is placed on top of folded weighing paper that rests on anhydrous calcium chloride desiccant in a precleaned glass jar. Following drying, each filter was cut into pieces and placed into 250 mL beakers with 20 mL of HCl and 5 mL of HNO_3 for 20 min. After the initial digestion the samples were transferred to a Whatman Number 41 filter paper and washed with 5 mL of hot HCl followed by 20 mL of hot water. The resulting filtrate was collected in a 100 mL volumetric flask. The remaining digestate and filter were then transferred back into the beaker with 10 mL of HCl and digested for another 10 min. This second digestion was then transferred to another Whatman Number 41 filter and washed with 25 mL of hot water. The resulting filtrate was collected in the same 100 mL volumetric flask. The final solution was then diluted to 100 mL total volume. From this solution a 15 mL aliquot was transferred

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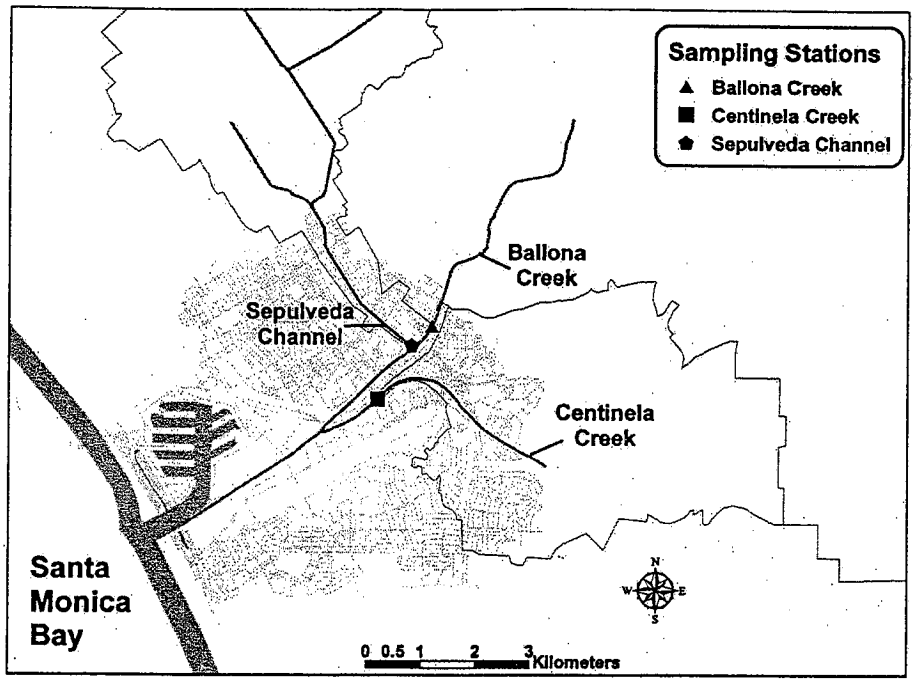

Fig. 2. Sample sites within Ballona Creek Watershed

with 15 mL of water to a 30 mL Nalgene LDPE bottle for trace metal analysis. The filtrates and suspended solids samples were analyzed for trace metals by inductinely coupled plasma–atomic emission spectroscopy according to *EPA Method 3120.B*. The metals concentrations in the filtrate represent the dissolved phase. Total recoverable metals were calculated as the sum of dissolved and suspended solids concentrations of metals.

The SMBURD database was queried for TSS and total Cu, Cr, Pb, and Ni data for the Ballona Creek, Sepulveda Channel, and Centinela Creek catchments. Total metal concentrations were used as the parameter of study due to the low amount of dissolved metals concentration data in the SMBURD database. The sample sites used from SMBURD matched the sites sampled in the summer of 1999. Data retrieved from SMBURD were defined as wet weather or dry weather using the available rainfall record, and the dry-weather data were then combined with the summer 1999 monitoring data to calculate the contaminant concentrations in each catchment. Samples reported below the detection limit were transformed to half the detection limit. As in other urban runoff studies (Athayde et al. 1983), the data were assumed to follow a log-normal distribution. In this study, a log-normal distribution was used for each parameter to minimize the considerable errors generated in load calculations by using the improper probability distribution for urban runoff concentrations from a censured dataset as discussed in Van Buren et al. (1997). Table 1 shows the average, median, and standard deviation of each metal in the dataset. Median concentrations of Cu, Pb, and Ni are similar in Ballona Creek and Sepulveda Channel but lower in Centinela Creek. Median Cr concentrations are similar in Centinela Creek and Ballona Creek but lower in Sepulveda Channel. Because the DWF in Centinela Creek is less than 3% of the combined DWF in Ballona Creek and Sepulveda Channel and the concentrations for the majority of parameters studied are lower in Centinela Creek, the Centinela DWF was considered negligible and was not included in subsequent analyses.

The DWF load from each catchment was calculated according to

$$W = \sum C_m \times V_j / 10^6 \quad (1)$$

where W=load over a prescribed period of time (kg); C_m=median concentration at the site of interest (mg/L); and V_j=DWF volume for the period of interest (L). This approach is similar to the sample mean approach listed in Mukhopadhyay and Smith (2000) in which the mean concentration and the average flow on each given day are multiplied and then summed over the period of interest. Because our goal was an estimate of long-term pollutant loadings, the median concentration at each location was used with the total volume of flow for the dry and wet season to characterize the seasonal and annual loading in the system. Fur-

Table 1. Mean, Median, and Standard Deviation of Dry-Weather Flow Total Metal Concentrations (μg/L) in Ballona Creek Watershed Catchments

Location	Total Cr	Total Cu	Total Ni	Total Pb
Ballona Creek				
Mean	38	23	16	21
Median	15	16	10	10
Standard deviation	87	28	19	28
Sepulveda Channel				
Mean	4	16	37	8
Median	5	14	9	8
Standard deviation	3	13	103	4
Centinela Creek				
Mean	11	12	16	11
Median	10	5	5	5
Standard deviation	5	9	28	20

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Table 2. Total Area and Assigned Percent Imperviousness for Each Land Class Included in Ballona Creek Watershed Storm Water Model

Land use	Area (ha)	Percent imperviousness (%)
Commercial	3,843	92
High-density single family residential	13,033	68
Mixed residential	1,577	75
Multifamily residential	3,675	80
Industrial	1,272	91
Institutional	993	30
Urban vacant	4,744	0
Water	177	0
Transportation	726	92
Other/unknown urban	145	80

thermore, daily concentration data were not available for the period of our simulation.

Wet-Weather Flow Simulation

Stormwater models of the Ballona Creek watershed were developed as part of a larger environmental modeling project performed at Los Alamos National Laboratory (Heiken et al. 1999). These models were developed using the U.S. Environmental Protection Agency (EPA) SWMM (Huber and Dickinson 1988). Separate stormwater models were developed for the Ballona, Sepulveda, and Centinela Catchments (Burian et al. 2000). The development of the stormwater models required digitizing 3,000 storm drains and delineating over 2,000 subcatchments using information obtained from microfiche as-built construction drawings of the storm drainage system and drainage maps stored at the LADPW. Other data necessary to develop the models included United States Geological Survey digital elevation models and 1993 land use data from the Southern California Association of Governments (SCAG). The land use data obtained from SCAG were categorized according to the Modified Anderson Level III/IV classification. This classification was aggregated into ten land use classes selected for inclusion in the stormwater quality simulation. The breakdown of land use for the three catchments is shown in Table 2.

The WWF quality was simulated in SWMM by attributing an event mean concentration (EMC) to each of the land uses simulated. The EMC procedure was used because the goal of this research is a long-term prediction of seasonal and annual loads, not an intrastorm evaluation, which would require a more complicated modeling approach such as the use of buildup washoff coefficients. Under these circumstances, the event load is more important than the exact contaminant concentrations during the storm event. Furthermore, the total load estimated with EMCs for a long-term simulation can be as accurate as that obtained from more complex models, e.g., buildup washoff in most cases (Charbeneau and Barrett 1998).

The Runoff Block of SWMM was used to simulate the runoff quantity and quality from each catchment to a specified inlet. Runoff quality simulation with the EMC procedures requires the input of appropriate flow-weighted EMCs for each of the pollutants for each of the land classes being simulated. The EMCs used in this study were obtained from the LADPW stormwater monitoring program (LADPW 2000). Part of the LADPW stormwater monitoring program is the monitoring of runoff from predominantly single land use catchments. The number of storms monitored at each site ranged from 24 to 67. The median concentrations for each constituent of concern from the single land use catchments were used in the SWMM model. These EMCs were not specific to the watershed studied. The EMCs were specific to Los Angeles County and the study watershed resides in that county. Simulating stormwater quality using land use specific EMCs in SWMM produces constant concentrations from each land use during each storm event. Concentrations at the outlet of the watershed are variable because different catchments with different land uses contribute flow throughout the runoff event.

Table 3. Ballona Creek Storm Water Management Model Model Relative Error

Parameter	Relative error
Runoff volume	10.6
Total copper	49.7
Total lead	75.9
Total nickel	68.3
Total chromium	57.5

Model Calibration

Calibration is a crucial step in stormwater quality modeling. Calibration of the Ballona Creek SWMM model was performed using data from a mass emission monitoring station at the downstream end of the Ballona catchment. The Ballona Creek SWMM model was calibrated for water quality and quantity for four storms in the 1997 water year using flow and concentration data from the mass emission station. Percent imperviousness was modified globally in the model until runoff volumes and estimated total pollutant loads were comparable to observed data. Table 3 shows the results of the model calibration. The cumulative relative error for the simulated runoff volumes in the four calibration storms was 10% indicating good agreement with observed data. The performance of the model was less for metals loads. All constituents simulated had a cumulative relative error for mass loading of 50–75%.

Results

The DWF in Ballona Creek ranged from 8×10^{-2} to 2 m^3/s, while the DWF in Sepulveda Channel and Centinela Creek ranged from 2×10^{-2} to 5.5×10^{-1} m^3/s and from 3×10^{-3} to 8×10^{-2} m^3/s, respectively. Fig. 3 compares the annual DWF and WWF volumes with the annual precipitation volume for the Ballona Catchment for the 1991–1996 water years. The DWF volume was consistent at levels greater than 10^7 m^3 for every year of the study except the 1991 water year. Because of its dependence on the stochastic rainfall process, WWF volume was highly variable from year to year and showed no general trend. The WWF volume ranged from a low of 3.6×10^7 m^3 to a high of 10.6×10^7 m^3. The DWF accounted for 9–25% of the total annual discharge from the Ballona catchment in this period. The annual DWF volume was fairly consistent. Therefore, the variation in the DWF contribution to the total annual volume of flow was dependent on the highly variable volume of WWF (i.e., in relatively low precipitation years the DWF contribution was higher and in relatively high precipitation years the DWF contribution was lower).

While the DWF produced less than 25% of the average annual

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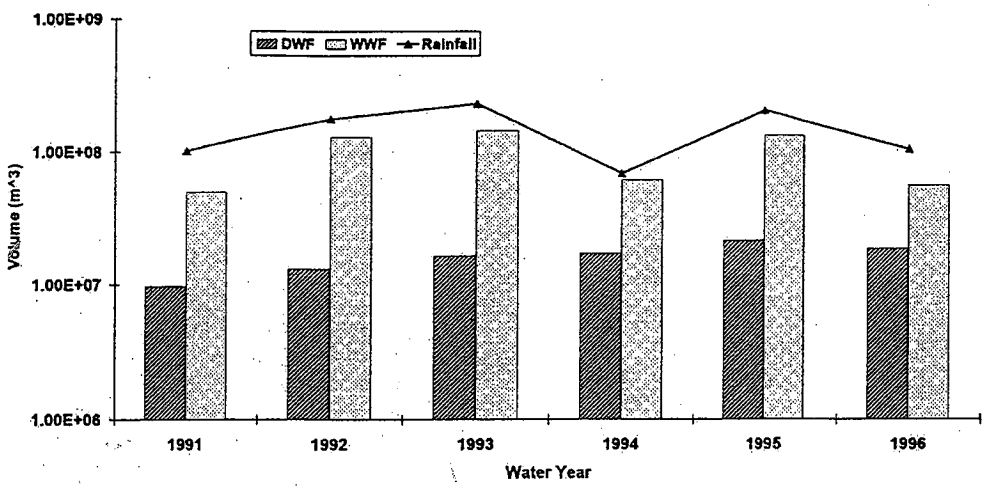

Fig. 3. Dry-weather flow and wet-weather flow volumes (m^3) 1991–1996

runoff volume, it produced a higher proportion of the average annual pollutant loading. Table 4 details the annual trace metal pollutant load from DWF and WWF in the Ballona Creek watershed. WWF still produces the majority of the average annual pollutant load of TSS, Cu, Pb, and Ni, but DWF contributes 19–44% of the annual total metals load of those constituents. The average DWF contribution to the annual average load of Cr was greater than the WWF contribution. Although WWF accounts for between 41 and 81% of the average annual load for each metal, precipitation occurs on average only 37 days/year. Therefore, the majority of the annual load is being discharged from Ballona Creek during relatively short time periods occurring during the wet season.

Although WWF is the dominant source annually for most metals, DWF is responsible for the majority of the pollutant load during the dry season. In this study, the definition for the dry season, April 1–September 30, is same as that used by LADPW (Los Angeles Department of Public Works 1998). Fig. 4 shows the percentage of the total annual load that is contributed by DWF and WWF seasonal pollutant loads. Greater than 70% of the pollutant loading of all metals from this watershed occurs in the wet season. The WWF is responsible for the majority of the pollutant load during that season. During the dry season, DWF accounts for 60–90% of the load of the metals. The seasonal results were expected because precipitation totals are very low during the dry season and high during the wet season. The DWF load for each pollutant was nearly the same during the dry season as it was during the wet season suggesting that DWF is not influenced by season. This is not an unexpected result in the Mediterranean climate of Southern California where outdoor water use may not change considerably throughout the year.

The contribution from DWF relative to WWF becomes more significant when the individual catchments within the watershed are considered. Fig. 5 shows the WWF and DWF loads for the Ballona, Sepulveda, and Centinela Catchments as a percentage of the average annual load for the entire Ballona Creek watershed. The predominant source of each contaminant, except Cr, is still WWF from Ballona Creek, but DWF from Ballona Creek is largest source of Cr and the second largest source of Pb and Ni. DWF from Ballona Creek is also a greater source of all metals than Centinela Creek WWF, but is a lower source than Sepulveda Channel WWF for Cu. DWF from the Ballona and Sepulveda catchments are minimal sources of TSS. Nearly 95% of the TSS annual average load is from Ballona catchment WWF. Overall, the results from the analysis define the importance of the Ballona Catchment in the annual pollutant load discharge from the Ballona Creek watershed.

Table 4. Average Annual Total Trace Metal Pollutant Load in Dry-Weather Flow (DWF) and Wet-Weather Flow (WWF) from Ballona Creek Watershed

Contaminant	Average annual DWF load (kg)	Average annual WWF load (kg)	Percent of annual load from DWF
TSS	91,940	4,944,380	2
Chromium	220	190	54
Copper	250	1,060	19
Lead	150	300	33
Nickel	160	200	44

Note: TSS=total suspended solids.

Discussion

This study evaluated DWF and WWF heavy metal loads from the Ballona Creek watershed for the 1991–1996 water years. The goal

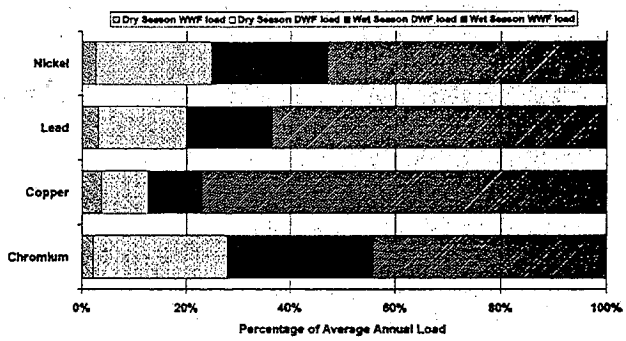

Fig. 4. Dry-Weather Flow and Wet-Weather Flow seasonal pollutant load contributions

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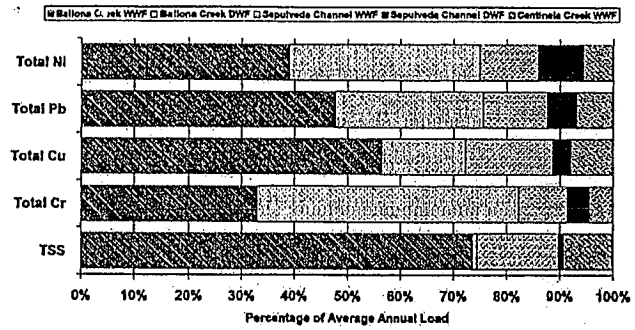

Fig. 5. Dry-Weather Flow and Wet-Weather Flow catchment pollutant load contributions

was to compare the relative contributions of TSS and the total metal loads of Cu, Pb, Ni, and Cr in DWF and WWF from the watershed and its catchments. The WWF was found to be the largest nonpoint source of metals from the Ballona Creek Watershed. The DWF was also an important source, contributing 9–25% of the flow volume and 19–54% of the annual pollutant load.

The ultimate toxic effect of DWF and WWF pollutant loads depends on the physico-chemical properties of the receiving water and the constituents of concern. The Ballona Creek Watershed has two potential receiving water systems: (1) the Ballona Creek Estuary, and (2) Santa Monica Bay. This research does not address the receiving water impacts on either of these systems, but assesses the relative pollutant contribution from DWF and WWF in each catchment. This assessment therefore provides baseline information for effective decisions on reducing the effects of urban runoff pollutant loads to these receiving waters. Both DWF and WWF eventually reach Santa Monica Bay and the toxic effect within that waterbody of the contaminant load in each flow type should be considered. Bay et al. (1999) found stormwater plumes discharged from Ballona Creek into Santa Monica Bay caused toxicity in tested species. Lau et al. (1994) came to a similar conclusion for DWF samples from Ballona Creek, but the effect of DWF following discharge to and dilution in the Ballona Creek Estuary or Santa Monica Bay is unknown. Due to the channelization of the Ballona Creek Estuary and the high flowrates of WWF, it is unlikely that the full toxic effect of the WWF pollutant load is exhibited in that system. Average base flow from the Ballona Creek catchment was approximately 41×10^{-2} m^3/s from 1991 to 1996. During wet weather, the flow in the channel drastically increases with flows greater than 283 m^3/s having been recorded at the F38C-R gauging station.

While the tidal nature of this system was noted by Suffet et al. (1997) to retain the WWF at high tide, the system also was noted to flush the visible contaminants (i.e., trash) during the ensuing low tide. The low flowrates within DWF suggest that much of its contaminant load may remain within the Ballona Creek Estuary for a significant period of time. This is potentially of concern as the Ballona Creek Estuary will be used as the source water for the Ballona Creek wetlands, a wetland restoration effort in that watershed. To assess the ultimate receiving water impacts of DWF and WWF a further understanding of the chemical properties of each receiving water and their interactions with both DWF and WWF loads is necessary.

The results of this study indicate that in the Ballona Creek Watershed the effects of pollutant loading from dry weather nuisance flow may be significant. This phenomenon may be true in other urbanized Southern California watersheds where the annual rainfall is low. The significance of DWF as shown by the results indicates the need to consider its control or treatment. Integrated DWF and WWF management would likely be the most cost-effective plan, but the infrequent and unpredictable nature of the WWF presents management difficulties. DWF on the other hand is a fairly consistent flow in quantity and quality in this watershed, which would permit the easier development and implementation of management practices. Several treatment practices are already in place in the Los Angeles area. For example, DWF has been pumped from some storm drains to a centralized wastewater treatment plant (*Civil Engineering* 1999), and, in December 2000, the City of Santa Monica opened a treatment facility designed to treat DWF from residential and commercial areas (Antich et al. 2002). Only considering the results of this study (neglecting feasibility studies, cost/benefit analyses, and environmental impact assessments) the treatment of DWF in Ballona Creek would seem to be a logical option to protect water quality in the Ballona Creek Estuary and Santa Monica Bay.

Conclusion

In this study, we compared the relative pollutant contributions of the trace metals copper, lead, nickel, and chromium in urban DWF and WWF from a Los Angeles, Calif. watershed using historical flow data, water quality monitoring data, and computer modeling. The results indicate DWF contributes a considerable amount of flow and pollutants. The DWF accounted for up to 25% of the total annual Ballona Creek flow volume in the years studied and a considerable portion of the annual contaminant load for the metals studied. In the dry season when precipitation is infrequent, the simulations indicate DWF accounts for an even larger fraction of the pollutant load. Therefore, this research suggests DWF controls may be an important part of nonpoint source pollution mitigation plans for urban stormwater drainage systems in Southern California.

Acknowledgments

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Loading estimates of lead, copper, cadmium, and zinc in urban runoff from specific sources

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Abstract

Urban stormwater runoff is being recognized as a substantial source of pollutants to receiving waters. A number of investigators have found significant levels of metals in runoff from urban areas, especially in highway runoff. As an initiatory study, this work estimates lead, copper, cadmium, and zinc loadings from various sources in a developed area utilizing information available in the literature, in conjunction with controlled experimental and sampling investigations. Specific sources examined include building siding and roofs; automobile brakes, tires, and oil leakage; and wet and dry atmospheric deposition. Important sources identified are building siding for all four metals, vehicle brake emissions for copper and tire wear for zinc. Atmospheric deposition is an important source for cadmium, copper, and lead. Loadings and source distributions depend on building and automobile density assumptions and the type of materials present in the area examined. Identified important sources are targeted for future comprehensive mechanistic studies. Improved information on the metal release and distributions from the specific sources, along with detailed characterization of watershed areas will allow refinements in the predictions. © 2001 Elsevier Science Ltd. All rights reserved.

Keywords: Runoff; Stormwater; Loadings; Metals; Lead; Copper; Cadmium; Zinc

1. Introduction

As point source inputs of pollutants continue to be addressed, the fraction of the pollutant burden to local waterways contributed by non-point sources becomes increasingly important. Less is known about non-point sources and control is much more difficult. Urban stormwater runoff is being recognized as a major source of pollutants to receiving waters and a number of recent investigations have evaluated stormwater runoff quality characteristics and best management technologies to minimize pollutant input to receiving waters.

Heavy metals are of particular interest in stormwater runoff due to their toxicity, ubiquitousness, and the fact that metals cannot be chemically transformed or destroyed. A number of investigators have found various levels of metals in runoff from urban areas and in highway runoff (Wu et al., 1996, 1998; Sansalone and Buchberger, 1997; Barrett et al., 1998). Generally levels follow the order: Zn (20–5000 μg/l) > Cu ≈ Pb (5–200 μg/l) > Cd (< 12 μg/l). The sources of metals in urban stormwater runoff are numerous and the metal release mechanisms are complex. Metal fluxes depend on land use characteristics, specific materials and components employed within the drainage area, hydrometeorological effects, and others. It is expected that major

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contributors of metals in non-industrial areas are automobiles and structures that use metallic constituents in various components.

The goals of this work are to estimate metal loadings from individual components of automobiles and buildings utilizing information available in the literature, in conjunction with controlled experimental and sampling investigations. Specifically, sampling has been initiated on automobile brake areas and building siding and roofs. Controlled laboratory studies have been completed on automobile tire shavings and used vehicle motor oil. With this information on specific metal levels produced from these sources, assumptions of building and automobile densities and characteristics for a typical developed residential area are employed to produce an estimate of the pollutant loading for each source. Dominant sources are identified. These results are compared with published estimates of metal loadings for residential land use areas. This study is designed as a preliminary investigation to identify important sources of metals from a broad array of possible inputs. These principal sources should be targeted for fundamental mechanistic investigations of metal origin and release. Knowledge of the sources of these pollutants allows decisions to be made targeting metal reduction plans and evaluating changes in pollutant loading due to modifications in development and land use.

2. Experimental methodology

All labware was soaked in HCl bath for at least 24 h and rinsed thoroughly with de-ionized water to prevent metal contamination. The water used for sampling and laboratory studies was a synthetic rain water, unless otherwise specified. The synthetic rain water contained 23 μM NaCl (Baker), 18 μM HNO_3 (EM Science), and 18 μM H_2SO_4 (Baker) and was based on the chemical makeup of rainfall in Maryland (Maxwell and Mahn, 1987). De-ionized water was from a Hydro-Service reverse osmosis/ion exchange apparatus, Model LPRO-20. Synthetic rain water was prepared in bulk volume in a 20-l plastic container. After preparation, the pH of the solution ranged from 4.2 to 4.4.

2.1. Automobile and building sampling

Plastic spray bottles (400 ml) filled with the synthetic rain water were used to collect samples. Usually 120 to 160 ml of synthetic rain water was sprayed at a medium intensity (spray diameter = 7 to 10 cm at a spray distance of 30 to 40 cm) on automobile front wheels or building walls and then collected using sheets of aluminum foil. The collected water was transferred from the foil to a 125-ml acid-washed polyethylene sample bottle. The surface area of the wash part was determined, ranging from 180 to 300 cm^2. All samples were brought to the University of Maryland, Environmental Engineering Laboratory for analysis.

2.2. Used engine oil sampling

Used engine oil was obtained from 13 automobile repair shops near the University of Maryland campus. In each case, 5 ml of oil was mixed with synthetic rain water in 125-ml plastic bottles to produce a total volume of 100 ml for the oil/water mixture. The sample bottles were shaken at a medium speed for 24 h. After shaking, samples were placed in the refrigerator, which helped to separate the water from the oil phase. After chilling, the water was carefully separated from the oil, collected in a clean plastic bottle, and acidified. In addition, a single virgin automobile motor oil was purchased and evaluated in the same manner.

2.3. Tire sampling

Automobile tires were also obtained from repair shops near the University of Maryland campus. All dirt and sand were removed from the tire surfaces, they were washed with hot water and soap, and air dried at room temperature. The clean tread surface of each tire was abraded using a steel brush. The small particles of tire (tire powder) were collected on clean white paper.

Samples of 100 mg tire powder were placed in 125-ml plastic bottles and 100 ml of synthetic rain water was added. The sample bottles were shaken for 24 h. After shaking, the tire powder/water mixture was filtered using a syringe filter holder with a 0.2 μm Gelman Supor Modified Polysulfone filtration membrane, discarding the first few ml of filtrate. The filtrate was then acidified with HNO_3 to pH < 2 and stored at 4°C.

2.4. Roof rain water sampling

Only in the case of roof sampling was runoff from an actual rain event was employed. Just before the start of a rain event, a plastic bag with a drawstring was placed at the exit point of a roof downspout. Approximately 500–1000 ml of first flush rain was collected in a few minutes.

Along with the roof samples, a rain water blank was also taken. To collect the blank, a pan covered with an identical plastic bag was placed in an open area at the beginning of the rain event and the rain was collected for approximately 20 min. The collected roof rain water samples and the blank were transferred to 125-ml plastic bottles and transported to the laboratory. The samples were acidified and stored.

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2.5. Instrumentation and analytical procedure

Metals standards were prepared with HNO_3 (EM Science, reagent grade) from a 1000 mg/l solution of lead as $Pb(NO_3)_2$, a 0.1 M copper solution as $Cu(NO_3)_2$, a 1000 mg/l solution of cadmium as $CdCl_2$ and a 100 mg/l solution of zinc as $ZnCl_2$ (all from VWR). A Varian Techtron Model 61 AA-5 atomic absorption spectrophotometer equipped with a graphite furnace (GFAAS) and a chart recorder were used for approximately the initial 25% of the metals analysis work. With the Varian GFAAS, standards and samples were pipetted manually with a 10 μl Eppendorf pipette into the graphite furnace. The measured sample absorbances were employed with linear calibration curves to calculate the metal concentrations in the samples. The practical quantitation limits were found to be 1 μg/l for Pb and Cu, and 0.2 μg/l for Cd.

In the later portion of the study, a Perkin-Elmer Model 5100 ZL atomic absorption spectrophotometer with autosampler was used for all metal analyses. The quantitation limits (QL) for lead, copper, cadmium, and zinc were 1, 1, 0.2, and 0.3 μg/l and the linear ranges for these metals were 0–50, 0–50, 0–5, and 0–2.5 μg/l, respectively. Most of the zinc samples had concentrations high enough for measurement using flame AAS. If the sample metal concentration exceeded the highest standard concentration, the sample was diluted with de-ionized water. For sample metal concentrations below the quantitation limits, the concentrations greater than the quantitation limit in that data set were fitted using a log distribution. Values for the concentrations less than the QL were predicted using the fitted distribution (Helsel, 1990); statistical analyses were then completed on the entire data set.

2.6. QA/QC

Standard practices for the handling of trace metal samples were implemented. This included the soaking of all plastic sample bottles in HCl for >24 h, followed by thorough rinse in de-ionized water. Field blanks were collected with each sampling excursion. These blanks were obtained by spraying the synthetic runoff onto bare foil, and otherwise carrying these samples completely through the sampling procedure, including transportation and storage of samples, acidification, and analysis of metals. In all cases, concentrations of lead, copper, cadmium, and zinc detected in the field blanks were below the respective quantitation limits. Trace metal grade HNO_3 was used for sample acidification to $pH < 2$ and all samples were stored at 4°C. GFAAS analyses followed instrument manufacturer's recommendations and ultrapure Ar was used for the inert carrier gas. All metal standards were synthesized from dilution of commercial standards, prepared using Standard Methods (APHA, 1985). Only linear calibrations meeting preset criteria were accepted. Usually r^2 values for linear calibrations were greater than 0.99; in no case was the $r^2 < 0.96$. Analytical reproducibility was checked using duplicate or triplicate analysis of each sample.

A study of multiple washings of the same building area allowed an estimate of the reproducibility of measurements. A single area was washed using the synthetic runoff 12 consecutive times. All samples were collected, handled, and analyzed as previously described. Initially, metal concentrations declined as they were washed off the wall. This was also seen in our lead washing study (Davis and Burns, 1999). However, relatively constant concentrations were found after the initial removal of metals. Therefore, considering the last six samples as being constant, the results found metal concentrations as (mean ± S.D., range): Pb (51 ± 15, 37–76 μg/l), Cu (18 ± 3.3, 12–20 μg/l), Cd (1.2 ± 0.1, 1.0–1.2 μg/l), and Zn (1600 ± 230, 1200–1800 μg/l) suggesting good precision and reproducibility of results.

3. Results and discussion

3.1. Sampling results

It should be stressed that in all cases, the sampling results do not represent the total amounts of metals that may be present on the target areas, but only represent metals washed/extracted by the synthetic rain water wash under the specific conditions employed. A more vigorous mechanical agitation or chemical digestion process would likely produce higher metal levels.

3.1.1. Building siding samples

Table 1 displays summary information on metal values from building siding, presented as metal removed per wall surface area for six siding materials. Among the different types of building materials, the highest lead concentrations were found from brick and painted wood buildings; consequently, sampling from these siding types was emphasized. The lowest lead concentrations were found from unpainted wood, metal, and vinyl siding, although fewer samples were taken from these materials.

The highest lead levels were found from painted wood (mean 520 μg/m², median 110 μg/m²) and likely result from releases of lead from lead paint (Sutton et al., 1995; Davis and Burns, 1999). Painted wood structures have higher lead concentrations than those not painted. Decades ago, lead-based paint was commonly used for painting building exteriors and trim. The most common form of lead used in paints was basic lead carbonate ($Pb_3(CO_3)_2(OH)_2$). This lead compound is weathered over time and lead can be released from the paint, either in particulate form, or through dissolution mechanisms

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Table 1
Results of building siding sampling for metals

	Metal concentration (μg/m²)					Samples < QL
	Geometric mean	Median	Mean	Min.	Max.	
Brick: 30 samples						
Lead	94	76	300	7	4500	0
Copper	25	23	47	6	280	0
Cadmium	0.6	0.4	1.4	<0.2	6.8	6
Zinc	630	720	2100	26	23 000	0
Painted wood: 13 samples						
Lead	73	110	520	<1	3000	2
Copper	28	34	80	<1	280	2
Cadmium	1.4	1.7	3.4	<0.2	15	3
Zinc	1400	1600	2800	36	8400	0
Concrete: seven samples						
Lead	14	20	26	<1	89	1
Copper	12	16	35	<1	170	1
Cadmium	<0.2	<0.2	0.3	<0.2	0.6	3
Zinc	900	1400	1200	220	1900	0
Metal: four samples						
Lead	2.7	4.0	9.8	<1	31	1
Copper	<1	<1	1.6	<1	4.6	3
Cadmium	0.3	0.3	0.4	<0.2	1.1	1
Zinc	170	120	690	26	2500	0
Unpainted wood: three samples						
Lead	9.0	8.9	93	<1	270	1
Copper	31	23	120	4	320	0
Cadmium	0.5	0.7	0.6	<0.2	0.9	1
Zinc	200	200	330	56	730	0
Vinyl: three samples						
Lead	11	7.6	11	7.6	17	0
Copper	11	7.6	16	4.3	35	0
Cadmium	0.3	0.4	0.4	<0.2	0.5	1
Zinc	52	66	60	24	91	0
All siding: 60 samples						
Lead	45	50	270	<1	4500	5
Copper	18	19	51	<1	320	6
Cadmium	0.6	0.4	1.5	<0.1	15	15
Zinc	590	820	1900	24	23 000	0

(Barnes and Davis, 1996). Details on lead release in runoff from painted structures have recently been presented by Davis and Burns (1999).

Copper concentrations from brick (47 μg/m², mean; 23 μg/m², median) and wood (80 μg/m², 34 μg/m²) were higher than from concrete, metal, and vinyl building sidings (1.6–35 μg/m², < 1–16 μg/m²). Paint does not seem to be a major factor in producing high copper concentrations. Values for unpainted wood siding were not significantly different from copper levels from painted materials. A possible source would be copper used as a wood preservative. Overall, copper concentrations from buildings were equal to or lower than that of lead.

Zinc was found at levels one or two orders of magnitude higher than the other three metals examined from all types of siding. The highest levels were from brick, concrete, and painted wood structures with typical values near 1000 μg/l. Sampling results of all siding types show low cadmium concentrations, in many instances below the quantitation limit (<0.2 μg/m²).

Overall results from Table 1 clearly indicate the higher metal levels resulting from brick and painted wood buildings. Also, the clear differences among different types of buildings suggest that the building material itself is the metal source, and not that the buildings are collecting atmospheric emissions. It can be suggested that deposited metals are responsible for the lower

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concentrations from metal and vinyl sidings. Additionally, the metal levels found from all buildings follow the trend: Zn > Pb > Cu > Cd, mirroring the trend noted in actual stormwater runoff measurements, as discussed above.

3.1.2. Roof samples

Totally, 38 roof runoff samples, divided into three different building types, plus 4 blanks (rainfall only) were collected. A summary of the sample results from the capture of first-flush runoff from roofs during actual rain events is presented in Table 2. The results are summarized as the difference between the roof sample and the corresponding blank. One blank sample showed relatively high levels of metals – 6 μg/l Pb, 18 μg/l Cu, and 130 μg/l Zn. The three other rain water blanks for different rain events showed zinc levels that were much lower. A test of metal leaching from the plastic bag used to collect the rain water blanks indicated that the addition of synthetic rain water and subsequent shaking produced levels of all metals less than quantitation limits. The reason that the one sample was particularly high in metals is not known.

The quality of runoff from roof catchments varied considerably. Zinc concentrations were high (>100 μg/l) in most samples with several greater than 1000 μg/l. With the exception of zinc, metal levels from residential roofs were small. However, all metal levels from commercial and institutional buildings were significantly larger than those from residences. For lead and zinc, this difference was approximately an order of magnitude. With cadmium, the increase was less; copper levels were two or more orders of magnitude greater than in the residential sampling. Yaziz et al. (1989) found Pb and Zn concentrations in runoff from tile roofs to range from 102–271 and 49–193 μg/l, respectively; Zn levels similar, but Pb levels higher than those documented in the current study.

In some cases, the type of roof was known. Generally, fiberglass and asphalt roof catchments demonstrated better runoff quality than those constructed using slate tile, rubber, and galvanized metal, in terms of lead and copper levels. Not surprisingly, the highest zinc concentration (7600 μg/l) resulted from a galvanized metal roof sample. Both zinc and copper are commonly used in materials in roof areas. Zinc is easily corroded and the appearance of zinc in the roof runoff is not unexpected. Copper is more noble, but will weather nonetheless. Copper sheeting is common in flashing and other trim in roof areas, and rain gutters. Its prevalence in commercial/institutional buildings likely produces the high copper levels found from roofs of these structures.

3.1.3. Automobile brakes

An estimate for copper release from automobile brake abrasion has been given as 1.5 mg/km-vehicle (Malmqvist, 1983). Linking this with an estimate that 5% of brake particles are copper (Hewitt and Rashed, 1990) produces a discharge estimate of 75 μg Cu/km-vehicle. Brake pad material can contain copper, zinc, and brass (which contains several percent lead), contributing other metals to the environment during brake wear. Since estimates for the other metals were not available, releases of lead, cadmium, and zinc were estimated by normalizing concentrations found to those for copper during the sampling of automobile front wheels. Obviously, the static testing will not collect all brake material released during automobile use, but metal ratios from the accumulated brake dust can be employed to construct useful estimates for these numbers. When obtaining samples, it was noticed that front wheels usually had brown or gray dust accumulated on the metallic components of front wheels, while back wheels were generally cleaner. Fifty-four samples were analyzed, with metal levels ranging over about 1.5 orders of magnitude. Results of the sampling program are summarized in Table 3. In all cases, a distribution of metal concentrations was found. Zinc was found at higher levels than copper, with a ratio of 1.18 for the population means, producing an estimated zinc contribution of 89 μg/km-vehicle. Lead and cadmium were found at lower levels with ratios to the copper mean of 0.04 and 0.0066, respectively, resulting in estimated loadings of 3 and 0.5 μg/km-vehicle.

3.1.4. Tire samples

Results were obtained from four different brands of automobile tires. In one tire, 65 μg/g lead and 17 μg/g

Table 2
Net metal concentrations from roof sampling

	Roof runoff sampling					
	Residential: 13 samples		Commercial: 13 samples		Institutional: 12 samples	
	Median (μg/l)	Mean (μg/l)	Median (μg/l)	Mean (μg/l)	Median (μg/l)	Mean (μg/l)
Lead	2	1.5	12	62	64	64
Copper	7	7.5	29	200	2100	5000
Cadmium	0.1	0.12	0.7	1.3	0.4	0.6
Zinc	110	100	760	1100	460	1100

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Table 3
Metal concentrations from automobile front brake areas and used oil extraction

	Metal concentration (μg/l)			Metal:Cu (mean)	μg/km-vehicle[a]	Samples < QL
	Geometric mean	Median	Mean			
Brakes: 54 samples						
Lead	5.9	7	11	0.04	3	1
Copper	37	26	280	1	75	0
Cadmium	0.3	0.2	1.9	0.0066	0.5	5
Zinc	160	150	330	1.18	89	0
Used oil: 13 samples (μg/l-oil)						
Lead	270	400	1100			
Copper	770	1400	2100			
Cadmium	20	20	100			
Zinc	9×10^4	1.6×10^5	1.25×10^5			

[a] Value for copper estimated from Malmqvist (1983) and Hewitt and Rashed (1990). Other metals estimated from ratios to copper.

copper were detected. Lower lead, copper, and cadmium concentrations were generally found in the remaining tire samples; the mean metal levels found were 17 μg/g Pb, 5 μg/g Cu, and 1 μg/g Cd. However, zinc was found at greater than 1000 μg/g in all four tire samples, with a mean value of 3400 μg/g. Zinc is added to automobile tires as a filler, which is released by tire wear and subsequent water contact. For comparison, mean levels in 29 tire samples as found by Sadiq et al. (1989) for Pb and Cu were 57 and 7 μg/g, respectively. The metal levels of Sadiq et al. result from nitric/perchloric acid digestion at 120°C. These values should represent total metals present in the tire matrix. Thus, these lead and copper values are generally higher than in the present study, which employed the less aggressive synthetic rain water.

3.1.5. Engine oil samples

Summary results for the water/oil mixtures converted to metal mass per liter of oil are also shown in Table 3. Again, the metal concentrations varied significantly. Zinc is the heavy metal of most concern in the engine oil. The zinc concentration was always greater than the other metals, and was usually significantly greater. A zinc concentration as high as 1.9×10^5 μg/l-oil was found in the water extract of one used engine oil. The mean zinc concentration for the 13 used engine oils was 1.25×10^5 μg/l-oil, with a median value of 1.6×10^5. Concentrations of the other metals were two or more orders of magnitude lower.

One virgin oil was also investigated, which contained 1.8×10^5 μg/l-oil. The high zinc concentration apparently results from the use of zinc additives in formulating the oil to provide wear protection for the engine. These components also act as antioxidants for the oil in the combustion chamber. Some lead was also found in the virgin oil (460 μg/l-oil), but negligible amounts of copper and cadmium (<10 and <4 μg/l -oil, respectively). These limited results suggest that at least Cu and Cd are accumulated in the oil during use. For comparison, Chen et al. (1994) studied one type of engine oil, new and used, and evaluated water-soluble metals. Their results indicated no detectable concentrations for lead, cadmium, and copper in the water-soluble fractions of new engine oil. In the used oil, cadmium was not found; unspecified lead concentrations were detected. Copper was detected at unspecified "low" concentrations. The average zinc concentration was 21900 μg/l-oil for new oil and 45500 μg/l-oil for used oil.

3.2. Estimates of metal annual loadings

In order to utilize the metal levels determined from the sampling in annual loading estimates, a number of assumptions are necessary to characterize building and vehicle densities and relationships to other parameters. Typical and reasonable values are employed for demonstration purposes. These densities can be appropriately modified as more accurate estimates become available or if specific information for a developed area is given. The loading estimate is made for a low density residential area with an assumed density of 5 houses per hectare. For calculation of metals from these homes, assumptions for size are necessary, along with rainfall event estimates; necessary information includes exterior wall and roof area per house, number of rainfall events per year (60) (Urbonas, 1999), and total rainfall per year. Mean metal values for brick buildings and residential roofs are utilized. Loadings for siding must be handled differently from roofs because the source data were collected using different techniques.

For these surfaces, simplifying assumptions are employed. These include the fact that all vertical walls are assumed to be washed evenly in each storm. Also, "first flush" considerations were not included. In the former case, walls that are not washed during an event may continue to accumulate metal and at some point, will be washed; annually, the loading is the same as a continu-

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ous wash. Further research is necessary to understand these accumulation and washoff mechanisms better.

The metal loadings from automobiles require an assumption for vehicles per household (2) and the distance driven per year (24 000 km). Finally, tire wear/km and oil leaked/km assumptions are necessary. All assumptions are summarized in Table 4. A value of 48 l-oil/ha-yr corresponds to 43 kg oil/km^2-cm rainfall, somewhat higher than the value for oil and grease calculated by Stenstrom et al. (1984) for residential areas, but much lower than the value for parking properties. With oil, only rainwater-extractable metals are employed. It is assumed that not all oil will be mobilized during a rain event and that a portion of the oil will partition with sediments and not enter the runoff stream.

The density assumptions are combined with the environmental sampling data of Tables 1–3 to produce the annual loading calculations of Table 5. Mean values are employed from the sampling results. The mean value must be used to calculate total loadings appropriately (Parkhurst, 1998) and in cases where the mean is significantly greater than the median, a few sources contribute the majority of the metal load. To these specific building and automobile loadings are included "background" rainfall metal levels from Chesapeake Bay wet deposition estimates (Scudlark et al., 1994). Finally, values for metals in dry atmospheric deposition, estimated to occur uniformly over the area, are added based on Chesapeake Bay studies by Wu et al. (1994).

3.2.1. Lead

A total annual loading of 0.069 kg Pb/ha-yr is estimated from the sources of lead. Most of the lead results from building walls, making up 79% of the total. The sampling program found high levels of lead on brick walls. Wet deposition, at 10%, was the second largest source of lead.

Estimates of yearly pollutant loadings resulting from different land use, for utilization in GIS analyses have been published by Wong et al. (1997). These loadings were calculated from stormwater monitoring data in the Santa Monica Bay (CA) watershed. The annual loading for lead presented by Wong et al. (1997) for a low density residential area is presented in Table 5 for comparison. Only 11% of the Wong et al. value of 0.6 kg/ha-yr is accounted for here by the specific sources. Both values are much less than the 1.5 kg/ha-yr found by Bryan (1972) from a North Carolina residential area when leaded gasoline was used.

3.2.2. Copper

The largest contributor to the calculated copper loading of 0.038 kg/ha-yr was brake emissions from automobiles, at 47%, followed by building siding at 21%. This loading represents 15% of the annual loading of 0.2 kg/ha-yr suggested by Wong et al. (1997).

3.2.3. Cadmium

Little cadmium was found from any of the sources evaluated. The estimated annual loading was 0.0012 kg/ha-yr. The largest contributor was wet deposition, at 41%, followed by building walls (21%) and dry deposition (19%). No annual loading for comparison is available, but to produce an average runoff concentration of 1 μg/l in 90 cm/yr rainfall, 70% runoff, a loading of 0.0063 kg/ha-yr is required, equal to five times the value calculated.

3.2.4. Zinc

The largest metal loading was found for zinc at 0.646 kg/ha-yr. This represents 108% of the 0.6 kg/ha-yr loading estimated for zinc by Wong et al. (1997). However, this latter value may be a low estimate as it corresponds to a runoff concentration of approximately 95 μg/l, which is quite low as compared with stormwater values recently measured. The largest contributor was runoff from the brick walls, at 58%, followed by tire wear at 25%. Four of the five sources evaluated gave significant contributions to zinc levels, with only oil being small, at 1%.

3.2.5. Specific sources

The distribution of total metals among the seven sources examined is shown in Fig. 1. The most significant overall contributor of metals was building siding, which was the highest source for lead and zinc, and the second largest for copper and cadmium. Atmospheric deposition was very important in the cadmium loading

Table 4
Assumptions used to estimate total annual metal loadings from various sources[a]

Source	Assumptions			Result
Siding	600 m^2/house		60 rainfall events/yr	180 000 m^2/ha-yr
Roof	100 m^2/house		0.9 m rain/yr	450 000 l/ha-yr
Brakes	2 autos/house	24 000 km/auto-yr		240 000 km/ha-yr
Tires	240 000 km/ha-yr	0.05 g/km/tire	4 tires	48 000 g tire/ha-yr
Oil	240 000 km/ha-yr	0.2 l-oil/1000 km		48 l-oil/ha-yr

[a] Residential density is 5 houses/ha.

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Table 5
Metal loadings in urban stormwater runoff

		Lead			Copper			Cadmium			Zinc		
		Unit value	Loading (kg/ha-yr)	% of Total	Unit value	Loading (kg/ha-yr)	% of Total	Unit value	Loading (kg/ha-yr)	% of Total	Unit value	Loading (kg/ha-yr)	% of Total
Buildings													
Siding	180 000 m^2/ha-yr	300 μg/m^2	0.054	79	47 μg/m^2	0.0085	22	1.4 μg/m^2	0.0003	21	2100 μg/m^2	0.378	58
Roof	450 000 l/ha-yr	1.5 μg/l	0.007	1	7.5 μg/l	0.0034	9	0.12 μg/l	5×10^{-5}	5	100 μg/l	0.045	7
Total			0.055	80		0.0118	31		0.0003	26		0.423	65
Autos													
Brakes	240 000 km/ha-yr	3 μg/km	0.0007	1	75 μg/km	0.018	47	0.5 μg/km	0.0001	10	88 μg/km	0.021	3
Tires	48 000 g tire/ha-yr	17 μg/g	0.0008	1	5 μg/g	0.0002	0.6	1 μg/g	5×10^{-5}	4	3400 μg/g	0.163	25
Oil leakage	48 l-oil/ha-yr	1100 μg/l	5×10^{-5}	<0.1	2100 μg/l	0.0001	0.3	100 μg/l	5×10^{-6}	0.4	1.25×10^5 mg/l	0.006	1
Total			0.0016	2		0.0183	48		0.0002	15		0.19	29
Total buildings and autos			0.0563	82		0.0302	79		0.0005	41		0.0613	95
Wet deposition[a]			0.0056	8		0.0026	7		0.00048	41		0.013	2
Dry deposiotion[b]			0.0069	10		0.0055	14		0.00022	19		0.020	3
Total			0.069			0.038			0.0012			0.646	
Value from Wong et al. (1997)			0.6			0.2			–			0.6	
% of Value from Wong et al. (1997)			11%			19%			–			108%	

[a] From Scudlark et al. (1994).
[b] From Wu et al. (1994).

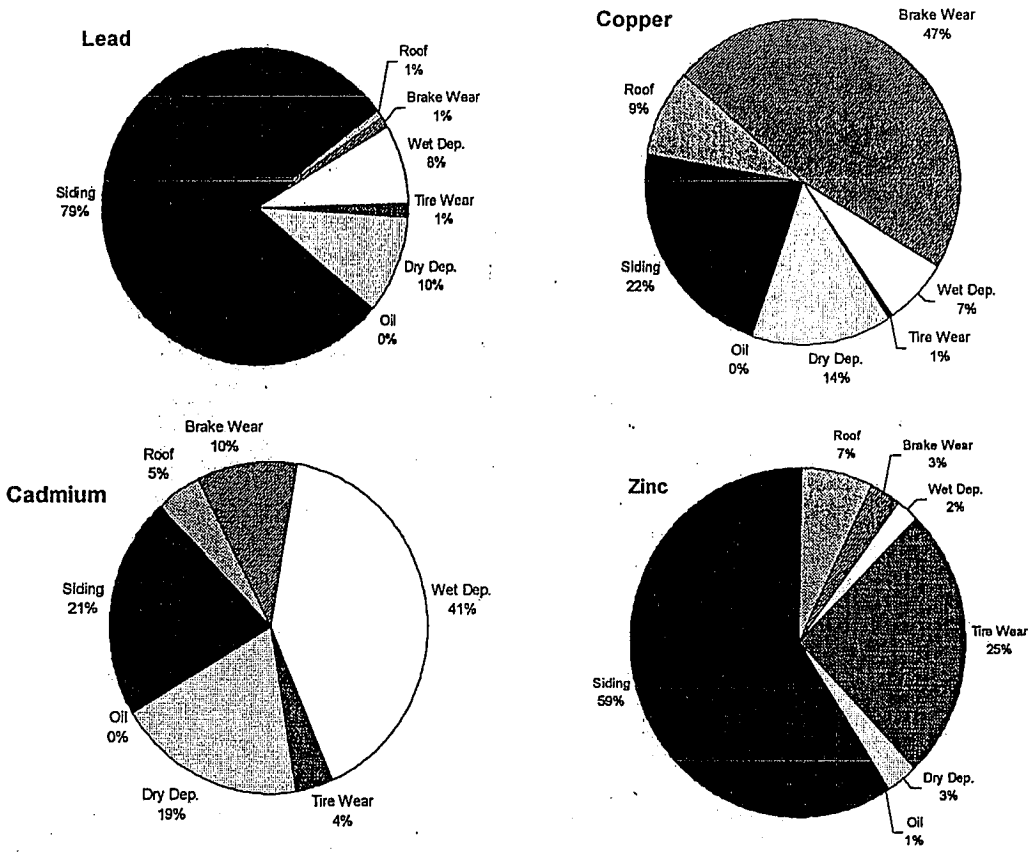

Fig. 1. Estimated contributions of various sources of metals in urban residential stormwater runoff. Brick buildings. Total metal loadings: Pb = 0.069 kg/ha-yr, Cu = 0.038 kg/ha-yr, Cd = 0.0012 kg/ha-yr, Zn = 0.646 kg/ha-yr.

and to a lesser extent for copper and lead. Brake emissions were significant for copper and tire wear only for zinc. Oil leakage contributed less than 1% of the total for all four metals. This agrees with the 4 mg/l values for oil and grease noted in residential stormwater runoff (Stenstrom et al., 1984), which corresponds to <1 μg/l Zn at 1.25×10^5 μg Zn/l-oil. Metals from oil should only be of concern should illicit disposal of large volumes occur. Roof runoff was also small compared with other sources.

Since the annual loadings calculations are based on an idealized watershed area, an analysis was preformed to evaluate how the previous conclusions would be modified if some characteristic of the input was changed. The first situation evaluated is the assumption of housing density. Doubling this value to 10 units per ha doubles the metal input from siding and roofs. Also, since automobile density is linked directly to housing density, values for brakes, tires, and oil are doubled as well. Wet and dry deposition are not affected. Results are presented in Table 6.

The total loadings for Pb, Cu, and Zn were essentially doubled, bringing Pb and Cu loadings closer to the estimates by Wong et al. (1997). However, the distributions among sources were not significantly affected and the dominant category did not change for any of these three metals. Since depositions were the dominant sources for Cd, doubling the housing density slightly affected the distribution of this metal. Building siding became the dominant source, at 30% of total. Wet deposition followed at 29%, which was followed by brakes at 14%.

A second scenario doubled only the automobile density, which corresponded to a doubling of the automobile mileage traveled in the drainage area. Accordingly, metal loadings from brakes, tires, and oil were doubled. Pb, which did not have these three sources as major contributors, saw negligible impact from this modification. With copper, this doubling just strengthened the dominance of brakes as a source of the metal. Brakes increase to the third most dominant Cd source (18%), behind wet deposition (36%) and siding (29%). Tires became a major source of Zn (39%), just below siding at 45%.

The final scenario tested was to double atmospheric deposition. Zinc and lead source distributions were not significantly impacted by this modification. Dry depo-

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Table 6
Effects of watershed density assumptions on metal loadings

	EMC (μg/l)[a]	Building		Roof		Brakes		Tires		Oil		Wet deposition		Dry deposition		Total
		Ldg[b]	% of Total	Ldg [b]	% of Total	Ldg [b]	% of Total	Ldg [b]	% of Total	Ldg [b]	% of Total	Ldg [b]	% of Total	Ldg [b]	% of Total	Loading (kg/ha-yr)
Standard																
Lead	7.7	0.054	79	0.007	1	0.0007	1	0.0008	1	5×10^{-5}	<1	0.0056	8	0.0069	10	0.069
Copper	4.2	0.0085	22	0.0034	9	0.018	47	0.0002	0.6	0.0001	0.3	0.0026	7	0.0055	14	0.038
Cadmium	0.13	0.0003	21	5×10^{-5}	5	0.0001	10	5×10^{-5}	4	5×10^{-6}	0.4	0.00048	41	0.00022	19	0.0012
Zinc	72	0.378	58	0.045	7	0.021	3	0.163	25	0.006	1	0.013	2	0.020	3	0.646
2x Housing density																
Lead	14	0.108	87	0.014	1	0.0014	1	0.0016	1	0.0001	<1	0.0056	4	0.0069	6	0.125
Copper	7.6	0.0169	25	0.0068	10	0.036	53	0.0005	0.7	0.0002	0.3	0.0026	4	0.0055	8	0.0685
Cadmium	0.19	0.0005	30	0.0001	7	0.0002	14	0.0001	6	1×10^{-5}	0.6	0.00048	29	0.00022	13	0.0017
Zinc	140	0.756	60	0.09	7	0.042	3	0.326	26	0.012	1	0.013	1	0.020	2	1.26
2x Auto density																
Lead	7.8	0.054	77	0.0007	1	0.0014	2	0.0016	2	0.0001	<1	0.0056	8	0.0069	10	0.0703
Copper	6.2	0.0085	15	0.0034	6	0.036	64	0.0005	0.9	0.0002	0.4	0.0026	5	0.0055	10	0.0566
Cadmium	0.15	0.0003	19	5×10^{-5}	4	0.0002	18	0.0001	7	1×10^{-5}	0.7	0.00048	36	0.00022	16	0.00135
Zinc	93	0.378	45	0.045	5	0.042	5	0.326	39	0.012	1	0.013	2	0.020	2	0.837
2x Atmospheric deposition																
Lead	9.0	0.054	66	0.007	1	0.0007	1	0.0008	1	5×10^{-5}	<1	0.0112	14	0.0138	17	0.0813
Copper	5.2	0.0085	18	0.0034	7	0.018	39	0.0002	0.5	0.0001	0.2	0.0052	11	0.011	24	0.0464
Cadmium	0.21	0.0003	13	5×10^{-5}	3	0.0001	6	5×10^{-5}	3	5×10^{-6}	0.3	0.001	51	0.00044	23	0.00188
Zinc	75	0.378	56	0.045	7	0.021	3	0.163	24	0.006	1	0.026	4	0.040	6	0.679

[a] Event mean concentration at 90 cm/yr total precipitation.
[b] Loading (kg/hr-yr).

sition increased to the second greatest source of copper. Since deposition was the dominant Cd source under the baseline conditions, the doubling reinforced the importance of these sources. The total Cd loading increased by more than 50% to 0.0019 kg/ha-yr and 74% of the Cd loading was attributed to deposition.

Overall, these changes did not alter the major conclusions discussed previously. In all scenarios, buildings are the major sources of lead and zinc, and brake emissions is the major source of copper. Atmospheric wet deposition remains the dominant source of Cd, except when housing density is doubled, where siding becomes just slightly higher. Absolute loading values are impacted and become closer to the published values for urban areas at higher housing densities.

This analysis leads to two conclusions. First, the source results are not particularly sensitive to the assumptions made. A 100% variation in any of the sources would not impact the conclusions. Second, the same basic conclusions drawn based on the simple model drainage area can also be used for other, somewhat different watersheds. The analysis is not particularly sensitive to the housing density of the watershed.

3.2.6. Alternate land uses

Two variations related to the land use and building characteristics were also investigated. In the first case, the dominant building type was changed from brick to vinyl. In the sampling study, the metal levels from vinyl siding were found to be considerably lower than from the brick. Metal distributions are graphically presented in Fig. 2. This modification produces profound changes in the loadings and source distribution for most of the metals. The total lead and zinc loadings are drastically reduced, falling to 0.017 and 0.28 kg/ha-yr, respectively, with the respective contributions from siding decreasing from 79% to 12% and from 58% to 4%. The dominant sources shifted to dry and wet deposition for lead and tire wear for zinc. Less-drastic reductions were found in copper and cadmium since siding was not such an important source. The percentages of the other five sources increased accordingly.

In the second analysis, the building density was doubled and the roof concentrations were selected from the commercial sampling data set (Table 2) in order to simulate a commercial land use. The metal levels from commercial roofs were much higher than from residences.

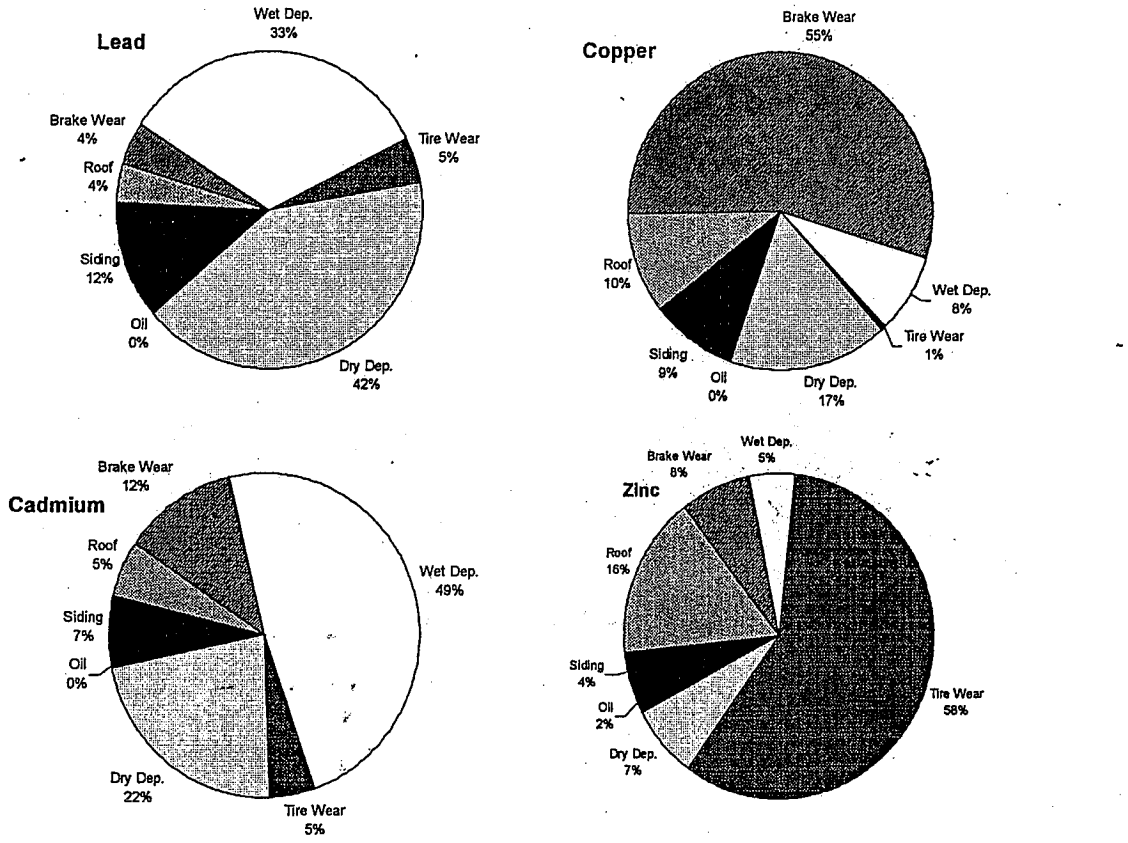

Fig. 2. Estimated contributions of various sources of metals in urban residential stormwater runoff. Vinyl buildings. Total metal loadings: Pb = 0.017 kg/ha-yr, Cu = 0.033 kg/ha-yr, Cd = 0.0010 kg/ha-yr, Zn = 0.279 kg/ha-yr.

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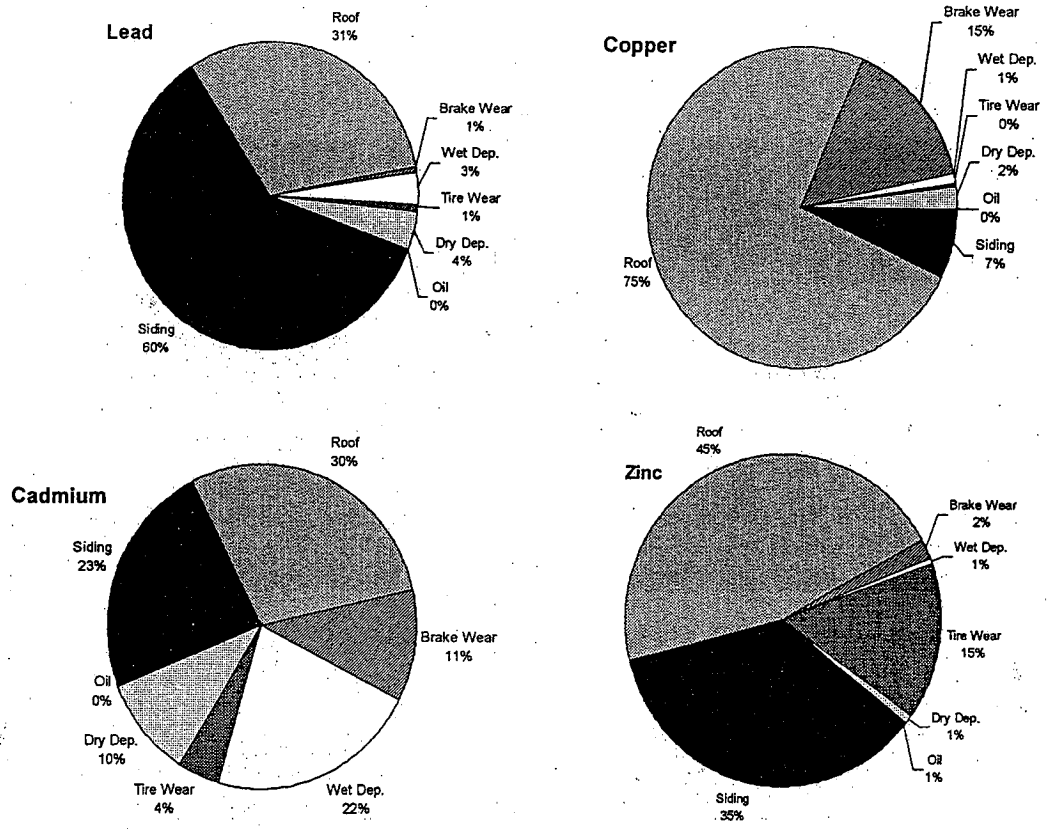

Fig. 3. Estimated contributions of various sources of metals in urban commercial stormwater runoff. Total metal loadings: Pb = 0.180 kg/ha-yr, Cu = 0.243 kg/ha-yr, Cd = 0.0022 kg/ha-yr, Zn = 2.16 kg/ha-yr.

Naturally, the yearly loadings were significantly increased (lead, 0.18; copper, 0.24; cadmium, 0.0022; and zinc, 2.2 kg/ha-yr). This change made a substantial impact on the source distribution for all metals – especially with copper, where the roof percentage went from 9% to 74% (Fig. 3). The other metals also saw major increases from roof runoff (lead: from 1% to 31%, cadmium: from 5% to 29%, zinc: from 7% to 46%).

In all of these estimates, any attenuation of metals during overland travel is neglected. However, in a steady state, any attenuated metals may also be a metal source to the runoff. Additionally, the importance of roadways on the metal estimates should be noted. This analysis assumes that all vehicle travel is done throughout the area of residence, or that travel outside the area is matched by non-resident travel inside. The location of a major traffic thoroughfare with non-resident traffic would significantly increase vehicle metal loadings. Concurrently, the presence of only low traffic density residential streets would produce lower loadings, dominated by resident vehicle travel outside the resident area.

The results presented and described depend on the various values and assumptions employed in the analyses. For several of the parameters used from the sampling program, sample populations were low and mean values can be biased by one large or small value. With a larger database and more focused mechanistic studies, information on metal distributions can be employed to refine the results presented here, increasing the utility and confidence of the output. The work by Davis and Burns (1999) represents one attempt in this direction. In many cases, rather than deterministic values, stochastically distributed inputs could be employed to produce distributed ranges of loadings from various sources. Obviously, mechanisms of metal release, transport, and fate will depend on a number of factors, including hydrometeorological considerations.

4. Summary and conclusions

Sources of lead, copper, cadmium, and zinc in urban stormwater runoff have been quantitatively evaluated. Sources examined included building siding and roofs; automobile brakes, tires, and oil leakage; and wet and dry deposition. A controlled sampling program, along

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with assumptions on residence and automobile densities and use allow the estimation of annual loadings for each metal from each source. Important sources identified are building siding for all four metals, vehicle brake emissions for copper and tire wear for zinc. Atmospheric deposition is also important for cadmium, copper, and lead. Future research should target these sources to advance the mechanistic understanding of each metal source contribution. Loadings and source distributions depend on density assumptions and the type of materials present in the area examined. This work was designed as an introductory study to estimate metal loadings. Improved information on the metal release and distributions from specific sources with focused subsequent research, along with detailed characterization of drainage areas will allow refinements in the predictions.

Once significant sources of metals are identified and confirmed, reducing these inputs to receiving waters must be addressed. Public education can play an important role in this endeavor. Reducing metal inputs from vehicle and building materials may require modifications or elimination of metal parts. The removal of lead paint may have a significant impact on lead in urban runoff (Davis and Burns, 1999). The alternative is to design and install stormwater treatment systems that address metal pollution. With detailed information on pollutants from various sources, environmental impacts of land development can be more accurately quantified, decisions on the needs of stormwater treatment can be made, and pollutant loadings entering receiving waters can be estimated.

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EVALUATION OF LEAD CONCENTRATION IN RUNOFF FROM PAINTED STRUCTURES

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Abstract—Urban stormwater runoff is considered to be a major input source of heavy metals to surface waterways. In this study, lead runoff from painted structures in an urban setting was assessed. In many cases, high lead concentrations were found. Lead concentrations (100 ml over 1600 cm^2) from 169 different structures followed the order (geometric mean, median, Q10–Q90): wood (40, 49, 2.6–380 μg/l) > brick (22, 16, 3.3–240 μg/l) > block (9.7, 8.0, < 2–110 μg/l). Lead concentration depended strongly on paint age and condition. Lead levels from washes of older paints were much higher than from freshly painted surfaces, which were demonstrated quantitatively as: paint age [> 10 y] (77, 88, 6.9–590 μg/l)≫[5–10 y] (22, 16, < 2–240 μg/l) > [0–5 y] (8.4, 8.1, < 2–64 μg/l). Lead from surface washes was found to be 70% or greater in particulate lead form, suggesting the release of lead pigments from weathered paints. High intensity washes were found to liberate more particulate lead than lower intensities. Old surface paints can contribute high masses of lead into a watershed, targeting these structures for source preventive actions to curtail future lead input into the environment. © 1999 Elsevier Science Ltd. All rights reserved

Key words—lead, urban stormwater runoff, paint

INTRODUCTION

Despite numerous actions that have been implemented to curtail lead hazards and to decrease the use of lead in consumer products, elevated levels of lead in the environment are still pervasive. Currently, much of the lead in the environment is residual material remaining from historic uses. Because of the prevalence of lead use, lead is accumulating to levels that are of concern in environmental sinks such as large water bodies. For example, a study of lead in the Chesapeake Bay has indicated concentrations close to the U.S.EPA chronic criterion (Chesapeake Bay Water Column Contaminants Critical Issue Forum, 1993). As pollutants from point sources continue to decline, urban stormwater runoff is now considered to be one of the major sources of heavy metals into receiving waters (Hogland *et al.*, 1993). Granier *et al.* (1990) detected a flow-weighted mean lead concentration of 140 μg/l in the stormwater runoff of Créteil, France. A 'first flush' appearance of lead was noted. In 1993, the U.S.EPA required cities and municipalities to determine pollutant levels, including lead, in stormwater runoff. Results from Prince George's County, Maryland showed lead concentrations from 9 to 72 μg/l from composite sampling and ND (not detected) to 62 μg/l from grab samples of residential areas. Lead concentrations of 14–39 μg/l (composite) and 54–230 μg/l (grab) were found for commercial land use areas (Department of Environmental Resources, 1993). Many of these results are above the EPA fresh water chronic and acute criteria of 3.2 and 83 μg/l, respectively.

A recent study has implicated brick and wood buildings and possibly building roofs as major contributing sources of lead to urban stormwater runoff (Ni *et al.*, 1995). Lead paint remaining on the exterior of many buildings is suggested as the source of this lead. Specifically, lead is thought to be mobilized as it is contacted by rainfall. Additionally, paint collected on adjacent soils due to natural or forced removal may act as a lead source. Paints produced in and prior to the 1970s characteristically had very high lead contents. Many structural surfaces are still coated with leaded paints of this era. Typical lead paint pigments used in the U.S. from 1804 until they were banned by the Consumer Product Safety Commission in 1977 included basic lead carbonates, basic lead sulfates, lead oxides and lead chromates (Gooch, 1993).

According to a survey by the U.S. Department of Housing and Urban Development, 41% of all structural exterior walls, or 31,940 million square feet,

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have been painted (Tasaday, 1995). Many of these painted surfaces predate the lead paint ban. In fact, it has been estimated that 27% of the homes in California have exterior paint lead concentrations greater than 5000 mg/kg (Sutton *et al.*, 1995). As they age and weather, paints tend to chalk, chip, flake and otherwise deteriorate, resulting in an accumulation of lead pigment material on and within soils surrounding painted structures. Deterioration of a paint is a direct result of the failure of the binder. Chalking, the normal and preferred process of paint deterioration involves the gradual destruction of paint binder by the photolytic attack of UV radiation. This reaction oxidizes the binder and leads to the release of colloidal-size pigment particles from the paint matrix (Hare, 1995). Also, lead can be quickly dissolved (in minutes) from a lead paint matrix at acidic pH values or in the presence of strong chelating agents (Barnes and Davis, 1996). At pH values closer to typical environmental conditions, lead release is not as rapid, but measurable lead levels are still found.

Transport of lead away from the immediate vicinity of its originating painted surface via storm water runoff is dependent upon whether it is particulate or dissolved. Once lead is dissolved and released from painted structures, it can be attenuated via interactions with surrounding soil and other media. Generally, soils have a high affinity for lead and other metals and dissolved lead can be adsorbed by the soil. Studies indicate that the residence time of lead adsorbed onto soil can be as high as several thousand years and lead accumulation in soils near lead-painted structures can be significant (Snyder and Bendersky, 1983). For example, in Mt. Pleasant, MI, soil surrounding buildings built after 1972 have lead concentrations at background levels whereas soil near buildings built before 1972 have higher levels (Francek, 1992; Francek *et al.*, 1994).

In areas without soil contact, dissolved lead and lead paint particulates are transported away from lead-painted structures directly to storm drains. Leaded paint particles will continue to dissolve as they are being transported, releasing lead into solution. The ultimate concentration of lead in solution is controlled by the solubilities of lead carbonate and basic lead carbonate (Barnes and Davis, 1996). The lead paint dissolution rate can be enhanced by complexing agents commonly found in natural waters, such as humic acid (Guy and Chakrabarth, 1976) and chloride (Barnes and Davis, 1996).

The purpose of this study was to identify and quantify categories of painted structures as possible sources that contribute lead to stormwater runoff. Random building surfaces located in the Washington DC-metropolitan area were systematically washed with a synthetic rainwater. Structural and paint characteristics which contribute higher levels of lead have been identified. Also, the effect of varying intensity and storm (wash) duration on lead flux have been determined. Additionally, first flush roof rain water has been collected from building roof downspouts during actual rain events and lead concentrations in roof runoff have been determined. Information gathered as a result of this study may be utilized to understand and minimize lead input into the environment through stormwater.

MATERIALS AND METHODS

Nalgene 125 ml wide mouth polyethylene sampling bottles and all other laboratory vessels and utensils were washed prior to use by scrubbing with Alconox detergent, followed by a 24 h soak in 0.1 N reagent grade HCl, triple rinses with deionized (DI) water and drying in a dust free area. DI water (18 MΩ) was from a Hydro Service Model LPRO-20 ion exchange/reverse osmosis system.

Study area

Wash samples from painted brick, painted block and painted wood exterior wall surfaces were obtained from structures at the University of Maryland, College Park Campus and in surrounding commercial and residential neighborhoods in Prince George's and Montgomery Counties, Maryland and the District of Columbia. Structures were chosen from the study area with an attempt to provide equal sampling populations for all structures/paint ages. The collection period extended from May 1995 to March 1996.

Washing sample collection and preparation

A synthetic rain water (SRW) was synthesized as 23 μM NaCl (Baker), 18 μM HNO_3 (EM Science) and 18 μM H_2SO_4 (Baker). This SRW had a pH in the range of 4.2–4.4, typical of natural rain water in Maryland (Maxwell and Mahn, 1987). For sampling, a measured volume of SRW was sprayed on a structure wall using a 1.4 l plastic pressure spray bottle (Delta Industries) over a 1600 cm^2 area (20 cm width, 80 cm height) from a distance of 30 cm. An envelope fashioned from aluminum foil served to collect the SRW runoff for one minute after its application. The SRW runoff was then carefully transferred from the aluminum foil envelope into a 125 ml Nalgene bottle. Sample name, location, temperature and date since last precipitation event were recorded. An estimation of paint age was made utilizing a method similar to that described by Sutton *et al.* (1995). Table 1 indicates the characteristics observed to estimate paint age. Field blanks were collected daily by spraying SRW directly into an aluminum foil envelope. From the foil, the SRW blanks were transferred to sample bottles and carried through all sample analyses as with wall surface samples.

The effect of varying wash intensity was examined by sampling three adjacent locations on the same wall surface and varying the diameter of spray exiting the spray bottle at each location. Weak, medium and strong intensities were simulated in this manner. Table 2 further describes spray intensities. All samples, other than differing intensity samples, were collected using the medium intensity method. The effect of spray duration was evaluated using an iterative procedure where ten 100 ml SRW washing samples were consecutively collected from the same 1600 cm^2 area.

Roof runoff samples were collected during an actual rain event. Immediately previous to a rain event, a sample bottle was placed under the outlet of a building rain gutter. Normally, in 3 min, the sample bottle captured 100–120 ml of first flush rainfall runoff, depending on the rain-

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Table 1. Criteria used to estimate paint age on surfaces (Sutton *et al.*, 1995)

Painted surface	Water absorbed by wall	Collected volume/spray volume	Age (y)
Smooth	small	above 40%	0–5
Little peeling	medium	20–40%	6–10
Much peeling and chipping	large	0–20%	> 10

fall intensity, surface area of the roof and the number of gutters. Also immediately prior to each event, a pre-washed plastic beaker was set out in a nearby open area to collect a rainfall blank. A longer time was required to collect the blank sample due to the differences in collection areas. The roof and rain water samples were then processed in the same manner as the SRW samples. Sample name, building location, roof material (if available), date and time since last rain were recorded for each sample.

All samples were transported to the Environmental Engineering Laboratory at the University of Maryland, College Park and acidified to a pH less than 2 by the addition of 1 drop of reagent grade HNO_3 (J. T. Baker) per 100 ml of sample volume. Samples were then occasionally agitated while stored at 4 ± 2°C.

Prior to acidification several samples were randomly selected for particulate analysis. Selected samples were divided in half. One sub-sample was filtered through a 0.2 μm filter (Gelman, 25 mm diameter cellulose filter). Filtrate was collected after wasting the first 5 ml to minimize any artifacts due to the filtration. Both subsamples were then acidified and lead concentrations determined. It is expected that any particulate lead is dissolved by the pH < 2 acidification; no evidence of residual particles was found after this treatment. Particulate lead concentration was quantified by subtracting the total lead value of the unfiltered portion from the lead concentration in the filtered portion.

Paint chip sample collection and preparation

Chips of paint from selected buildings were collected for total lead analysis by removing loose, pealing paint with a glass rod. Non-attached paint chips were also collected from window sills and other protrusions that tended to accumulate these materials. No attempt was made to remove paint that was securely or moderately securely attached to wall surfaces. Paint chips were placed in pre-washed plastic bottles and stored at 4 ± 2°C.

The paint chips were analyzed for total lead content in accordance with ASTM procedure D335-85a. Specifically, a known mass of paint chips was placed in a 30 ml crucible and ashed at 500°C for one hour. Ashed chips were ground into fine particles. A 10 ml mixture of 50% HNO_3/DI water [HNO_3 (1 + 1)] was added to the ground ash and heated on a hot plate until approximately 3 ml remained. An additional 10 ml of HNO_3 (1 + 1) was added and subsequently heated until the volume was reduced to 5 ml. The contents of the crucible were filtered through a Whatman medium-porosity filter paper into a 50 ml volumetric flask. The remaining contents of the crucible were washed into the filter by three successive rinses with 2.5 ml of 50% weight/volume ammonium acetate (Baker) solution. After crucible rinsing, the volumetric flask was brought to volume with DI water.

Lead analysis

Analyses for dissolved lead in all samples were performed utilizing a Perkin Elmer Model 5100PC atomic absorption spectrophotometer (AAS) with a Zeeman Furnace Module Model 5100ZL, a Perkin Elmer Model AS-71 autosampler and a hollow cathode lead lamp. Paint chip lead extract concentrations were determined via flame AAS. Lead standards were prepared from 1000 mg/l VWR atomic absorption standard. SRW matrix stocks were made at a concentration of 100 μg/l; the stock solutions required for paint chip lead analyses were 100 mg/l Pb. Calibration standards and quality control check solutions were made from dilution of the stock solutions. All transfers of atomic absorption standard and stock solutions made for SRW sampling were brought to volume by the addition of at least 10 drops of HNO_3 per 100 ml of SRW. Stock solutions, standards and the quality control checks were stored in 125 ml Nalgene bottles at 4 ± 2°C. Linear Pb concentration calibration curves were calculated by the AAS software. After the calibration was performed, it was then verified by a Quality Control Check with samples within the linear range; the acceptance criterion was ± 15% of the expected value. Calibration curves were also required to achieve a correlation coefficient of 0.997 or greater. Continuing calibration verification occurred after every 10 samples. A method detection limit study (MDL) for lead in SRW was completed in accordance with 40 CFR136, Appendix B, to evaluate analytical limitations via analysis of ten 2 μg/l samples. The results support a practical quantitation limit of 2 μg/l which was adopted for all SRW matrices. For sample lead concentrations below 2 μg/l, the concentrations > 2 μg/l in that data set were fitted using a log distribution. Values for the < 2 μg/l concentrations were predicted using the predictive distribution and statistical analyses were completed on the entire data set (Helsel, 1990).

Accuracy and precision were addressed with the last three samples from the duration study. Results indicated that by these washes, lead levels at the surfaces and accordingly, lead wash concentrations, are nearly constant. Of the 17 sample sets above the quantification limit, the average deviation was 20% on samples with means from 3.2 to 13,000 μg/l; the deviation ranged from 6 to 44%.

For a limited number of samples collected prior to October 1995 a SRW volume of either 200 or 300 ml was used. After this time, a 100 ml volume was employed. The lead concentrations for 200 and 300 ml samples were normalized to 100 ml employing a correction factor calculated from duration sampling results. These values ranged from 1.07 to 1.23 depending on the surface characteristics under investigation.

Table 2. Description of spray intensity used for wall sampling

	Weak	Medium	Strong
Diameter of spray on wall from 30 cm	30 cm	10 cm	0.5 cm
Flow rate (cm^3/s)	6	5	2
Intensity value (cm/s)	8.5×10^{-3}	6.4×10^{-2}	10

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RESULTS AND DISCUSSION

Random sampling

All SRW blanks had concentrations below the quantitation limit (< 2 μg/l), indicating no lead contamination during sampling and analyses. Random sampling data were correlated and examined by both structure wall type (block, brick and wood) and estimated age of surface paint (0–5 y, 5–10 y and > 10 y). Results of 169 samples are summarized in Table 3. Correlations based on structure type indicate that mean SRW lead concentrations are highest for brick structures (580 μg/l) followed by wood structures (170 μg/l) and finally block structures (38 μg/l). The median lead levels, however, followed the order: wood (49 μg/l) > brick (16 μg/l) > block (8.0 μg/l). Two very high values found in brick sampling produced the high mean and standard deviation. The obvious variation among building materials indicates that the structures are responsible for the measured lead and not atmospheric deposition. Previous preliminary work that showed low lead contents in SRW washing of plastic siding walls support this conclusion (Ni *et al.*, 1995).

The concentration distributions showed that a majority of samples contained low lead levels. Twenty two of the 169 samples contained lead < 2 μg/l. However, a few samples in all categories had very high concentrations. These higher lead values resulted in high means with correspondingly large standard deviations. Because of the dominating effect of the few high lead concentrations, the sampling results were analyzed through log–transformation. Log concentration distributions are presented for each material type in Fig. 1. Even with the log transformation, distributions for block and brick sampling were skewed toward lower concentrations. The wood distribution was skewed somewhat toward higher Pb concentrations. Accordingly, the geometric mean is greatest for wood (43 μg/l; Q10–Q90 = 2.6–380) as compared to brick (22 μg/l; 3.3–240) and block (9.2 μg/l; < 2–110). The close agreement between median values and geometric means suggest that log–transformed statistics provide better data representation than normal statistics.

Although the log transformations do not normalize the data, they do minimize the impact of outliers. This is especially evident with the brick data, where the arithmetic mean of 580 μg/l is strongly influenced by two very high sample points, producing a mean higher than that for wood, although the median for wood is higher. The geometric mean for brick is lower than for wood. Results from student's *t*-tests applied to the data sets show that the geometric mean of the block sampling is statistically lower (at the 95% level) than both the brick and wood values. The data variation resulted in inconclusive significance between the geometric means from brick and wood.

Surfaces with older paint had higher SRW lead concentrations than surfaces painted more recently. Surfaces greater than 10 y old have a geometric mean SRW lead concentration of 81 μg/l (median = 88), surface paint age between the ages of 5 and 10 y have a geometric mean of 18 μg/l (median = 14) and surface paints less than 5 y old have a geometric mean of 8.0 μg/l (median = 8.1) Table 3. Examination of the log–distributions for the three different paint ages indicates a shift in the distribution peak from low to middle values as the age category increases from 0–5 to > 10 y (Fig. 2). In fact, the data for > 10 y age is fairly well described by a log–normal distribution. Note also the increasing concentration scale as the age category increases. Using the log–transformed data, *t*-tests show that the differences between the means of 0–5 y and 5–10 y, as well as between 5–10 y and > 10 y are statistically significant. The older paints clearly produce more lead in the SRW wash. Both the physical deterioration of the older paints and the higher paint lead levels likely contribute to the higher wash lead values.

The data were further categorized by both structure type and age (Table 4). The number of samples within each category ranged from 11 to 29. For every structure type, the lead levels increased as the paint age increased, based on the geometric mean, median and mean values. Comparing structure types, for the 0–5 y age, wood > brick > block, based on log–transformed and untransformed analysis. For 5–10 y and > 10 y, the same trend is

Table 3. Results of lead concentrations from painted structures and building roofs

		Pb concentration (μg/l)						
	Number of samples	geometric mean	median	mean	Q10	Q90	minimum	maximum
Structure type								
Block	56	9.2	8.0	38	< 2	110	< 2	590
Brick	63	22	16	580	3.3	240	< 2	28000
Wood	50	43	49	170	2.6	380	< 2	1900
Paint age								
0–5 y	67	8.0	8.1	27	< 2	64	< 2	370
5–10 y	54	18	14	120	< 2	240	< 2	2600
> 10 y	48	81	88	810	6.9	590	< 2	28000
Roof runoff	34	6.0	5.2	38	< 2	67	< 2	590

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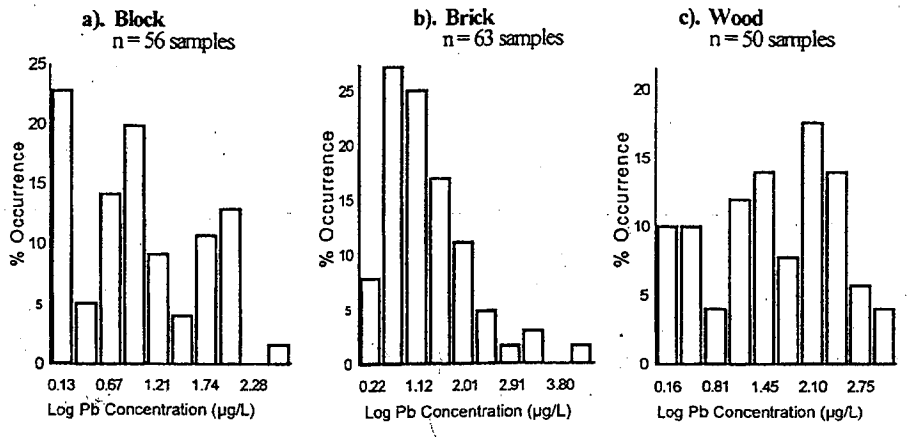

Fig. 1. Sampling results for SRW washing of random painted structures. (a) block, $n=56$ samples; (b) brick, $n=63$ samples; (c) wood, $n=50$ samples.

found in geometric means and median values. However, the brick arithmetic mean is greater than that for wood because of some high concentrations found in the brick sampling. The influence of these high concentrations is noted by the high standard deviations for brick 5–10 y and >10 y. The brick geometric ranges, through use of log–transformations, are closer to those of the two other surfaces.

The closer agreement between median values and geometric means indicate the skew of the data toward low concentrations. It also suggests that a significant amount of the total lead found during sampling is contributed by only a few structures. This is seen by grouping all 169 samples together for a mean concentration of 280 µg/l Pb. However, by eliminating the top 10% of the samples (the 17 greatest lead producers), the mean declines to 38 µg/l. Thus, 10% of the structures are responsible for 86% of the total lead. Targeting these structures for lead reduction can have a significant impact on lead release to the environment.

Particulate analysis

Particulate fractions in the SRW samples were also correlated and examined by both structure type and age of surface paint (Table 5). These data represent a subset of the random data discussed above. The means (geometric and arithmetic) follow wood > brick > block and (>10 y) > (5–10 y) > (0–5 y). All samples showed particulate lead as a major fraction of the total lead. Results consistently indicated that 69–84% of the lead was particulate, with a moderate standard deviation. The exception to this was surface paint greater than 10 y in age. Samples in this category were 93% particulate lead (7% standard deviation). These analyses clearly indicate that the lead in the SRW wash results from the release of small lead-containing particulates.

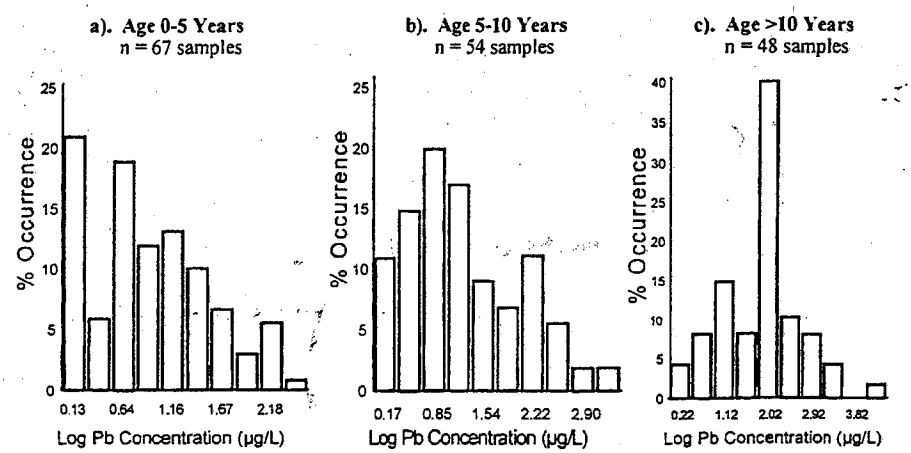

Fig. 2. Sampling results for SRW washing of random painted structures. (a) age 0–5 y, $n=67$ samples; (b) age 5–10 y, $n=54$ samples; (c) age >10 y, $n=48$ samples.

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Table 4. Results of lead concentrations based on structure type and age of surface paint

Structure type and estimated paint age	Number of samples	Pb concentration (μg/l)						
		geometric mean	median	mean	Q10	Q90	minimum	maximum
Block, 0–5 y	20	5.2	5.8	13	< 2	32	< 2	98
Block, 5–10 y	20	5.0	4.5	17	< 2	50	< 2	150
Block, > 10 y	16	40	63	96	7.4	150	< 2	590
Brick, 0–5 y	29	7.4	5.9	17	< 2	39	< 2	140
Brick, 5–10 y	13	21	14	220	6.5	57	3.3	2600
Brick, > 10 y	21	95	84	1600	6.6	1200	4.6	28000
Wood, 0–5 y	18	19	25	58	< 2	130	< 2	370
Wood, 5–10 y	21	47	58	150	4.4	300	< 2	980
Wood, > 10 y	11	130	160	370	11	590	< 2	1900

These are likely paint particles but may be environmental particles to which the lead has become affiliated. For surfaces > 10 y old, particulate and colloidal-size paint are easily removed from the dry paint matrix. The organic paint binders become destroyed in the weathering and aging of these paints; therefore, the remaining particulate lead is easily removed from the matrix. Field visual observations indicated that surfaces with paint older than 10 y chalked more often than more recently painted surfaces. This observation was made by qualitatively performing the 'finger stroke method' in which the end of the index finger is moved across a painted surface with light pressure (Lambourne, 1987). A visual determination of the amount of chalk removed was then made. Chalking results from release of the paint pigments due to weathering of the binders.

Intensity and duration analysis

In the intensity analysis, lead levels for each surface examined were normalized by dividing the lead concentrations at high and low intensities by that found at the medium intensity. Results for different structure types are shown in Fig. 3. All surface types show indications that higher intensities will produce greater levels of lead, but the high deviations in concentration ratios show significant variability in results. These results suggest that an increase in force applied to a surface paint will result in a greater SRW washing lead concentration. This in turn supports the hypothesis that paint particles from painted surfaces are readily removed from the structure. Categorizing the samples with respect to paint age, similar conclusions are apparent with older paints (Fig. 4). With surfaces that have paint 5–10 y and > 10 y of age (Fig. 4c), a marked increase between the normalized medium and strong intensity SRW washes is apparent. For newer paints (0–5 y), no significant effect from intensity was found.

To evaluate the effect of wash duration, lead concentrations for each 100 ml sample were divided by the concentration determined for the first 100 ml sample taken at that point; results are presented in Fig. 5 for surface types and Fig. 6 for paint age. Although standard deviations are large, Figs 5 and 6 show a clear decrease in SRW wash lead concentration with the volume of SRW applied for each surface type and age of surface paint examined. Also, SRW wash lead concentrations for each paint category reached an apparent steady level after the eighth sampling event (or 800 ml total SRW applied). The lead concentration stabilized at approximately 20% of the initial SRW washing concentration for surfaces painted less than 5 y ago and at approximately 40% of the initial concentration for all other surfaces. Both intensity and duration results indicate the lack of particulate paint release by the newer painted surfaces, which have been minimally weathered. These data clearly indicate that the first flush off these painted structures will contain higher lead concentrations than

Table 5. Lead particulate fraction in washes from painted structures

	Number of samples	Pb concentration (μg/l)		Particulate lead (%)	
		geometric mean	mean	mean	standard deviation
Structure type					
Block	8	11	27	84	12
Brick	10	12	110	69	27
Wood	9	110	270	83	12
Paint age					
0–5 y	11	7.8	15	79	11
5–10 y	10	25	140	69	27
> 10 y	6	240	360	93	7

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wash or rain that contacts these structures later in a storm event.

Paint chip results

Paint chips were collected from 18 building surfaces that had peeling paint and analyzed for total lead content. The relationship between paint lead content and the SRW wash lead concentration from the same surface is shown in Fig. 7. Although significant scatter is present, some correlation is apparent, showing a trend of increasing lead concentration in the SRW wash with increasing lead content in the chip (and with paint age). Additionally, an artifact related to the sampling technique must be considered. Only paint chips that were flaking or otherwise readily removable were collected. Inert materials such as wood or mortar may have been attached to some paint chip samples. This would have the effect of lowering the total lead content of the paint sample. This explanation is supported by noting that the texture and color on the back side of some paint chips appeared to differ from the front side of the chip.

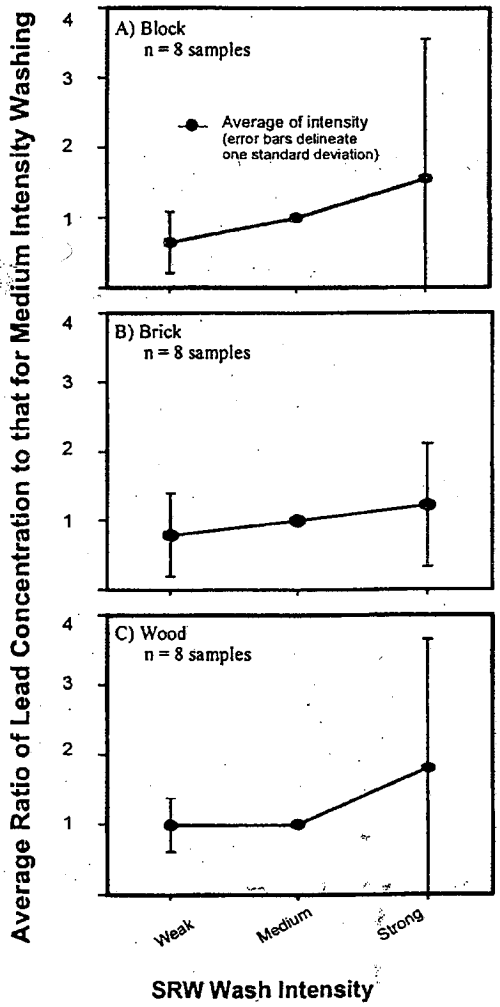

Fig. 3. Intensity sampling results for SRW washing of random painted structures. (a) block, $n=8$ samples; (b) brick, $n=8$ samples; (c) wood, $n=8$ samples.

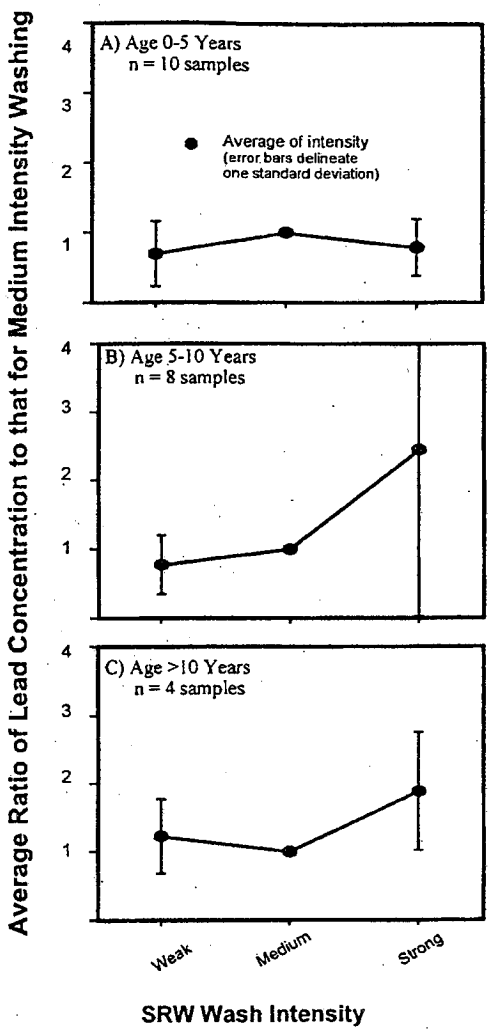

Fig. 4. Intensity sampling results for SRW washing of random painted structures. (a) age 0–5 y, $n=10$ samples; (b) age 5–10 y, $n=8$ samples; (c) age >10 y, $n=4$ samples.

Roof sampling

Because of the difficulty of accurately identifying roofing material, all roofing samples were grouped together. Results of roof sampling are presented at the bottom of Table 3. The mean lead concentration from roofs is 38 μg/l with a standard deviation of 110 μg/l, again indicating a high variability in lead levels. The median of 5.2 μg/l and geometric mean of 6.0 μg/l should be considered as more representative of typical roof concentrations. These values are low and comparable to SRW lead concentrations from block structures or structures with surface paint less than 5 y in age. These samples represent first-flush capture and therefore, ad-

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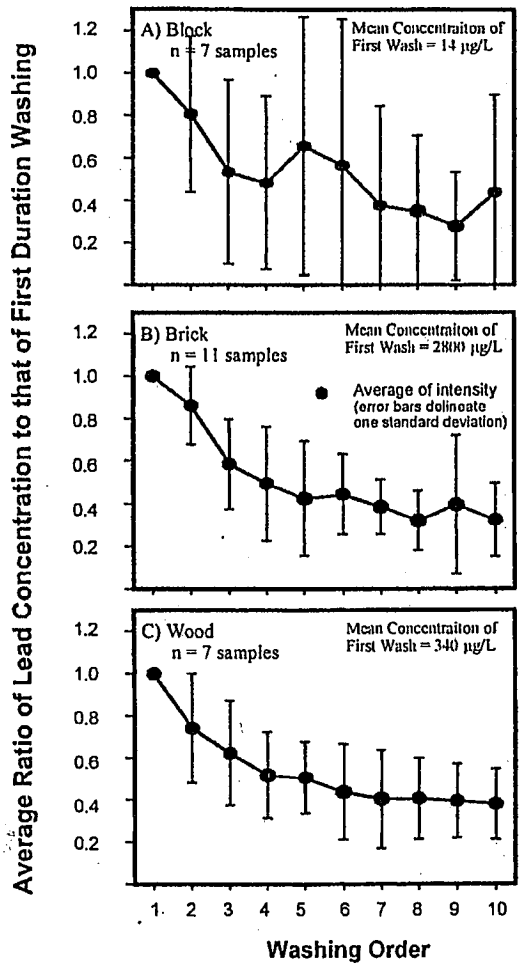

Fig. 5. Duration sampling results for SRW washing of random painted structures. (a) block, $n=7$ samples, mean concentration of first wash = 14 µg/l; (b) brick, $n=11$ samples, mean concentration of first wash = 2800 µg/l; (c) wood $n=7$ samples, mean concentration of first wash = 340 µg/l.

ditional roof runoff should have lower lead levels. Based on these results, it is suggested that roof rain lead is a comparatively minor contributor of lead to stormwater runoff.

CONCLUSIONS AND ENVIRONMENTAL RELEVANCE

Urban stormwater has been implicated as a major source of pollution in local waterways. This study has evaluated painted buildings as a source of lead in stormwater runoff. Synthetic rainwater washes of wood (geometric mean = 130 µg/l, median = 160 µg/l, $n=11$ samples) and brick (geometric mean = 95 µg/l, median = 84 µg/l, $n=21$ samples) structures with estimated exterior paint surfaces older than 10 y were found to have the greatest average lead concentrations. Maximum lead concentrations found for these surface types were 1900 µg/l and 28,000 µg/l. Differences in lead concentrations among surfaces were better represented by log–normal statistics since a few large values dominated analyses with normal statistics. Significantly lower lead concentrations were found in SRW washes from block structures with surface paints of all ages (geometric mean only 40 µg/l for > 10 y) and brick and wood structures with surface paints less than 10 y of age. A mean lead concentration of 38 µg/l for first-flush rain runoff from roofs suggests that roofs are not major lead contributors.

The SRW lead concentration was found to stabilize at approximately 40% of the initial concentration after the first 800 ml (over a 1600 cm^2 area) was sprayed on a surface. This was true for all surfaces with the exception of those painted less than 5 y ago, which stabilized at 20% of the initial con-

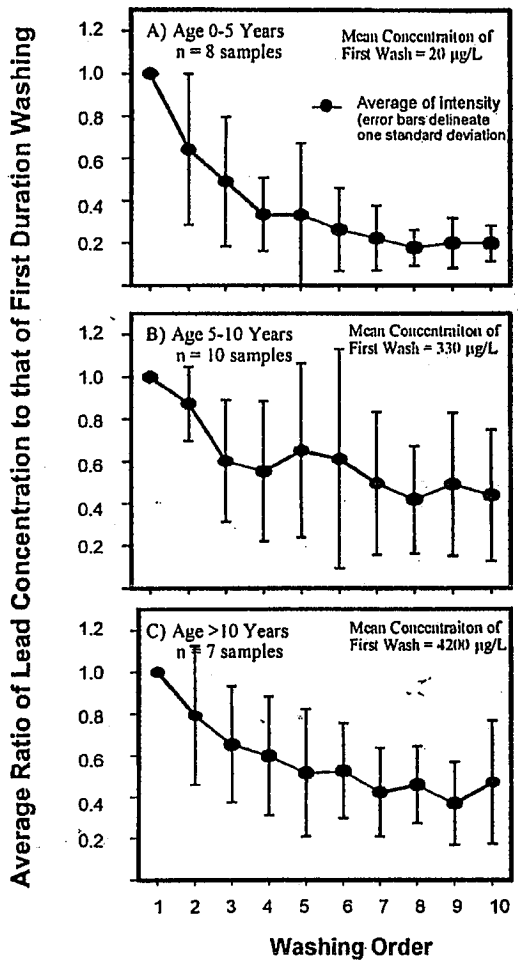

Fig. 6. Duration sampling results for SRW washing of random painted structures. (a) age 0–5 y, $n=8$ samples, mean concentration of first wash = 20 µg/l; (b) age 5–10 y, $n=10$ samples, mean concentration of first wash = 330 µg/l; (c) age > 10 y, $n=7$ samples, mean concentration of first wash = 4200 µg/l.

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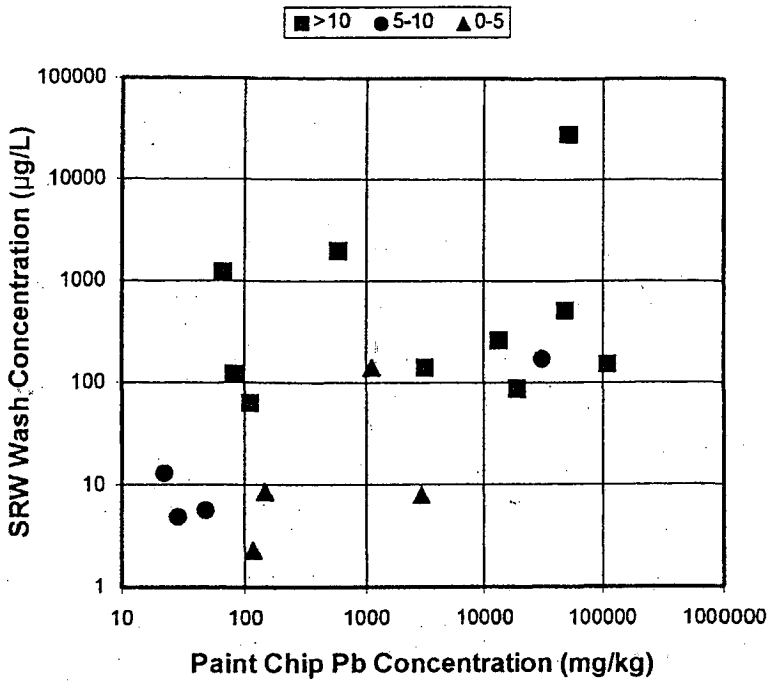

Fig. 7. Paint chip lead content compared to the corresponding SRW wash lead concentration.

centration. The observed decrease in SRW lead concentration with volume supports the first flush phenomenon where the first runoff from a storm contains the highest concentration of contaminants.

Paint chips from structures where the most recent coat of paint was apparently applied more than ten years ago were found to contain several times more lead than surfaces painted less than 5 y ago. A correlation between high paint lead content and high SRW wash lead concentration may exist but was not definitively proven due to sampling complications in which inert material may have been analyzed as a part of the paint chip matrix in some samples.

Approximately 80% of the total lead washed from painted surfaces was found to be in particulate form, with the exception of surfaces greater than 10 y in age, which had a 93% mean particulate lead concentration. Additionally, in nearly all samples, higher lead flux was observed with increased synthetic rain spray intensity, also suggesting the importance of particulate release from painted surfaces. These small chips and particles of lead paint may be transported away from a lead-painted structure by stormwater runoff. Consequently, stormwater treatment devices that target small particulates may be successful in the removal of this type of lead.

Throughout this study, measured lead concentrations were orders of magnitude greater than the U.S. drinking water action level of 15 µg/l and recommended chronic and acute lead levels in fresh waters (3.2 and 83 µg/l, respectively). Although the exact fate of this lead once it is washed from the structures varies depending on site conditions, a significant source of lead to the environment has been identified. Although the lead is primarily in the form of paint particles, the particles can be dissolved over time, releasing the lead. Some degree of lead affiliation with environmental solids (soils, sediments) is expected once exposure to these solids occurs.

Based on the results of this study, lead fluxes from brick or wood structures with old paint may be estimated. For flux estimations, all concentrations in this work can be converted to $\mu g/m^2$ wall area by multiplying by the water volume used (0.1 l) and dividing by the test surface area ($0.16\ m^2$). Identification of such structures affords preventive actions such as the removal of lead paint from surfaces or possibly the application of an additional coat of paint. Additionally, specific stormwater treatment devices may be targeted to these areas. The skewed distributions of the results indicate that addressing the few most significant lead problems can have a significant impact on lead fluxes into a watershed.

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Storm Water Metals—Issues and Historical Trends,

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Abstract

Lawrence Livermore National Laboratory (LLNL) is operated by the University of California under contract with the U.S. Department of Energy (DOE) under Waste Discharge Requirements (WDR) 95-174, allowing storm water discharges associated with industrial activities. Permit requirements include:

- Building drain tracking
- Non-storm water discharge tracking
- Dry and wet season observations
- Runoff sampling and analysis
- Development and application of a Storm Water Pollution Prevention Plan which includes detailed Best Management Practices (BMPs)

There are no chemical-specific limits for LLNL storm water effluent; the only limit applies to an annual fish toxicity test.

LLNL has over 10 years of storm water metals data. Recent data seem to indicate that concentrations of some metals are increasing in LLNL storm water effluent. If these trends can be attributed to LLNL, it may lead to increased and costly changes to infrastructure and BMPs. However, the trend may be due to changes in testing laboratories, and/or changes in procedures used at the laboratories (specifically, there may have been a shift from procedures which recover dissolved metals to procedures which recover total metal concentrations). It is also not clear how much of the trend is due to sediment loads, natural concentrations, or off-site contributions. During the 1997/1998 season, sampling at site influent and effluent locations included analysis for total suspended solids and analysis for metals in both filtered and unfiltered storm water. This study presents the preliminary conclusions of the 1997/1998 sampling. The comparison of filtered/unfiltered metals results, and comparison of these results with total suspended solids indicated that the source of increasing metals was naturally-occurring sediments being transported in storm water.

Introduction

LLNL serves as a national resource of scientific, technical, and engineering capabilities. The Laboratory's mission focuses on nuclear weapons and national security, and over the years has been broadened to include areas such as strategic defense, energy, the environment, biomedicine, technology transfer, the economy, and education. The Laboratory carries out this mission in compliance with local, state, and federal environmental regulatory requirements. It does so with the support of the

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Environmental Protection Department, which is responsible for environmental monitoring and analysis, hazardous waste management, environmental restoration, and assisting Laboratory organizations in ensuring compliance with environmental laws and regulations.

LLNL comprises two sites. The focus of this paper is the Livermore main site, which occupies an area of 3.28 square kilometers on the eastern edge of Livermore, California, approximately 80 kilometers southeast of San Francisco. Immediately to the south of the Livermore site is Sandia National Laboratories, operated by Lockheed-Martin under DOE contract. There are also some low-density residential areas and agricultural areas to the south of LLNL. Business parks are located to the southwest and north of the site, and a 200-hectare parcel of open space to the northeast has been rezoned to allow development of light industry. A small amount of low-density residential development lies to the east of the site, and agricultural land extends to the foothills that define the eastern margin of the Livermore Valley. Flow patterns at the site are such that storm water at sampling locations includes runoff components from these other sources, including agricultural land, industrial facilities, parking lots, and landscaped areas.

LLNL first monitored storm water runoff at the Livermore site in 1975. The original monitoring network, designed to detect pesticides, was expanded in 1990 to cover new locations and additional water quality parameters (including metals). Additional changes in 1993 complied with the National Pollutant Discharge Elimination System (NPDES) General Industrial Activities Storm Water Permit. It is important to show that LLNL is not contributing to storm water metals concentrations, in order to verify that provisions of the existing, BMP-based storm water permit are protective of storm water quality.

Methods

During the 1997/1998 wet season, source investigations were conducted to determine how much of the metals are present in the liquid (dissolved) and how much in sediments (suspended) being transported, for example, during high flow events. The study was also designed to evaluate how much of the loading in each fraction (dissolved and suspended) originates off site, and how much is contributed by on-site sources, and to relate concentrations of constituents in storm water from a particular storm and location to the concentration of total suspended solids from the same storm and location. To accomplish these goals, samples for applicable constituents were collected in duplicate. One sample was analyzed for total concentration (i.e., dissolved and suspended) of the constituents of interest. The second sample was passed through a 0.45 μ m filter in order to evaluate the dissolved component. Although particles smaller than 0.45 μ m (i.e., not dissolved) will of course pass through this filter, this removes the majority of the sediments, and is therefore adequate for evaluation of the dissolved fraction of the storm water. LLNL's contracts with the analytical laboratories are designed around collections or "suites" of analyses. Metals are included in two suites identified by "GENMIN" (general minerals) and "NPDESMETALS" (low reporting level drinking water metals under NPDES). Because there is some overlap in the metals specified in these two suites, some metals were subjected to duplicative analyses. In such cases, all analyses were utilized. Samples were also analyzed for concentration of total suspended solids (TSS).

Sample collection was by "grab sampling." In this method, technicians were dispatched to the field during rain events. When flow was observed, samples were collected by the technicians in one-liter bottles. Sample bottles, pre-labeled for the various analyses, were then shipped to off-site laboratories for analysis.

There are two main storm water flow pathways through the Livermore site (Figure 1). The majority of

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the site drains into Arroyo Las Positas. Arroyo Las Positas effluent is monitored at location WPDC, and influent to Arroyo Las Positas is monitored at locations ALPE, ALPO, and GRNE. Arroyo Seco crosses the southwest corner of the site. Influent and effluent monitoring locations for Arroyo Seco are ASS2 and ASW, respectively. During the 1997/1998 wet season, runoff samples from four storms were collected at these locations. For one sample set, the NPDESMETALS analyses reported as total metals were filtered. Because of this error by the analytical laboratory, this portion of the data was eliminated from the study.

Because there are no numerical criteria that limit concentrations of specific constituents in storm water effluent, various criteria were used to evaluate LLNL storm water quality. In the federal multisector permit, the Environmental Protection Agency (EPA) established benchmark values for 41 parameters but stressed that these concentrations were not intended to be interpreted as effluent limitations. Rather, they are levels that the EPA has used to determine if storm water discharged from any given facility merits further monitoring. Maximum Contaminant Levels (MCLs) for drinking water and Ambient Water Quality Criteria (AWQC) protective of fresh water organisms, developed by California and the federal government were also used as comparisons with LLNL storm water analytical results. However, these criteria are defined for other purposes, and are therefore not directly applicable to storm water effluent. Nevertheless, use of a broad range of criteria can help to evaluate LLNL's storm water management program and to allow LLNL to ensure high quality in its storm water effluent. Of greatest concern are constituents that exceeded comparison criteria at effluent points, but for which the influent concentrations were less than the corresponding effluent concentrations (indicating a possible on-site source). Each year, constituents identified by this screening process are subjected to detailed analysis, generally including evaluation of all historical data. It was this process that identified the apparent increasing trend in storm water metals. A review of data for the past five years identified four metals selected by this screening in multiple years, and with greater frequency of effluent values higher than influent values in recent years. The metals are chromium, copper, iron and zinc. These metals were therefore selected for detailed analysis in this study.

Data were evaluated in a variety of ways. First, dissolved concentrations were compared to total concentrations for each metal. Next, concentrations (both dissolved and total) were compared to total suspended solids concentrations. Finally, the dissolved and total concentrations were compared against the historical record. This last comparison was done on a location-specific basis, so that the apparent increases in influent and effluent concentrations for both pathways across the site could be evaluated for the relative contribution of total metals and dissolved metals.

Results

For every metal at every location, median total concentrations were greater than median dissolved concentrations (Table 1), generally by a factor of three or more. Dissolved concentrations of chromium and iron were almost all below their respective detection limits (0.001 and 0.05 mg/L, respectively). Median total iron concentrations ranged as high as 100 times the median dissolved concentrations. This provides the first clear indication that it is total metals that result in concentrations above the comparison criteria.

Plots of concentration and TSS (Figure 2) provide further evidence that suspended solids are at the root of the high concentrations. While there is a lot of variability in the data, all four metals show a clear relationship, with total concentrations increasing as TSS increases. As expected, dissolved concentrations do not increase with increasing TSS. For zinc, on the contrary, some of the highest dissolved concentrations occurred at low TSS levels.

Some of the observed variability may be due to between-sample variability. Separate sample bottles are

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submitted for each analysis (i.e. GENMIN filtered, GENMIN unfiltered, NPDESMETALS filtered, NPDESMETALS unfiltered, and TSS). The actual TSS level in the bottle submitted for GENMIN unfiltered analysis, for example, will not be identical to the TSS level in the bottle submitted for TSS analysis. Routine procedures exist at LLNL to collect duplicate samples at a frequency of approximately 1 out of every 10 samples. Duplicate samples are collected at the same location as the routine samples, immediately following collection of the routine sample. To evaluate the impact of between-sample variability, TSS in routine and duplicate samples from 1993 to present (25 data pairs) were compared. The average difference between duplicate and routine samples was 33%, and the difference ranged as high as 117%. Thus, between-sample variability may account for much of the variability observed, both in the relationship between total metal concentrations and TSS discussed above, and between dissolved and total metals concentrations (below).

Dissolved concentrations seem to be somewhat positively correlated to total concentrations for zinc, but again there is a lot of variability (Figure 3). No relationship is apparent for chromium, copper and iron (the two rows of points at dissolved copper concentrations of 0.01 and 0.001 mg/L are the result of differing reporting limits for the GENMIN and NPDESMETALS analyses, respectively). This provides strong evidence that the high concentrations observed in the historical record are due to metals bound up in the sediments, transported by turbulent storm flows, and not available for dissolution into the liquid phase.

The total and dissolved concentrations are compared to the historical record in Figure 4. In these historical trend figures, all available data for the influent and effluent locations of the two runoff pathways through the Livermore site have been aggregated. Also, data have been aggregated on a wet season basis—that is, October of one year through May of the next—rather than on a calendar year basis. Thus, data labeled 96/97 represent October 1996 through May 1997. For the 1997/1998 season, this was done separately for the total concentrations and dissolved concentrations. Because it is not certain *a priori* whether the historical data represent total concentrations, dissolved concentrations, or some combination, the lines connecting historical data points were not extended to the 1997/1998 data points. Also shown on each plot are the comparison criteria available for each constituent. To simplify interpretation of these complex plots, note that squares and diamonds were used to represent the Arroyo Seco pathway; and circles and triangles for the Arroyo Las Positas pathway. Also, solid shapes represent effluent, while open shapes represent influent.

The historical trends were compared to the historical trend in TSS concentrations (Figure 5). In the Arroyo Seco pathway, TSS at both influent and effluent locations increased up to the 1996/1997 season, and then decreased in the 1997/1998 season. In the Arroyo Las Positas pathway, TSS levels were relatively low during the most recent two years, and alternated between high and low values during the preceding 3 years. These trends were compared qualitatively to the trends for each of the metals, as summarized in Table 2. In general, metal concentrations corresponded to TSS concentrations, with only a few cases in which there was little or no correspondence. For example, the 1993/1994 high TSS in Arroyo Las Positas is generally not reflected in the metals data. This indicates that the historical record starting in 1994/1995 is primarily based on total concentrations, but that there may be some inconsistencies.

For the 1997/1998 data, chromium, copper and iron, median dissolved concentrations for both pathways at both influent and effluent locations were at or very near the reporting limits. Similarly, median dissolved zinc concentrations were generally much lower than median total zinc concentrations. Total concentrations are more consistent with the historical record, and generally correspond with the 1997/1998 TSS values, once again indicating that the historical trend is primarily due to total metals concentrations.

Discussion

An important lesson learned in this study is that it is essential that procedures at analytical laboratories be closely monitored in order to ensure that the correct data are being produced. Even during the course of this study, which required close, personal contact with laboratory personnel, not all analyses were done as specified. In the future, metals such as iron, for which there is a clear and consistent difference between dissolved and total concentrations, will be used to determine if the laboratory has used filtration on the appropriate analyses. Iron is a major component in aluminosilicate minerals that make up a major portion of sediment load.

The available data indicate that the apparent trend in increasing metals concentrations is due to a shift from analyses that recover the dissolved portion (i.e. filtered), to analyses that recover total metals. This is compounded by the observed increase in TSS in Arroyo Seco, due to the metals associated with the naturally-occurring sediments. There is a clear positive correlation between TSS and total metals concentrations, although there is notable variability. This variability could be reduced by homogenizing a large storm water sample volume and then separating it into the bottles submitted for the various analyses. Plans are underway to collect 1998/1999 samples in this manner. There is no relationship between dissolved concentrations and TSS. Only in the case of zinc was a relationship observed between dissolved concentrations and total concentrations. Where effluent metal concentrations were higher than influent concentrations, the data indicate that this is due to higher TSS levels.

While it is not completely clear how much of the historical record should be attributed to total metals analyses, it is clear that high metal concentrations are due to the suspended solids transported in the storm water. Because these high metal concentrations can be attributed to naturally-occurring sediments, costly changes to infrastructure and additional BMPs are not necessary. If reduction of storm water metal concentrations is needed, the appropriate response would be erosion control measures.

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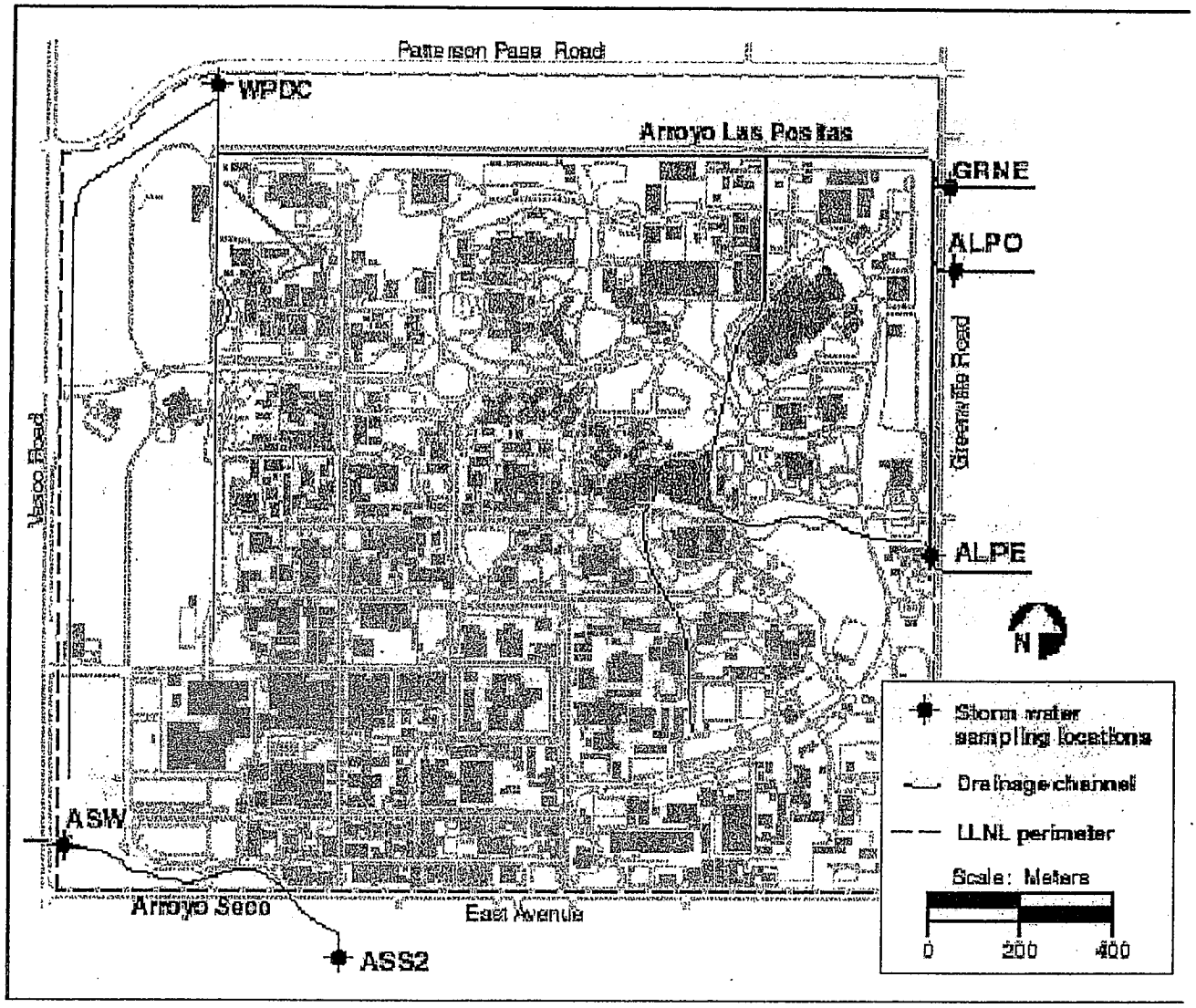

Figure 1. Livermore site storm water sampling locations.

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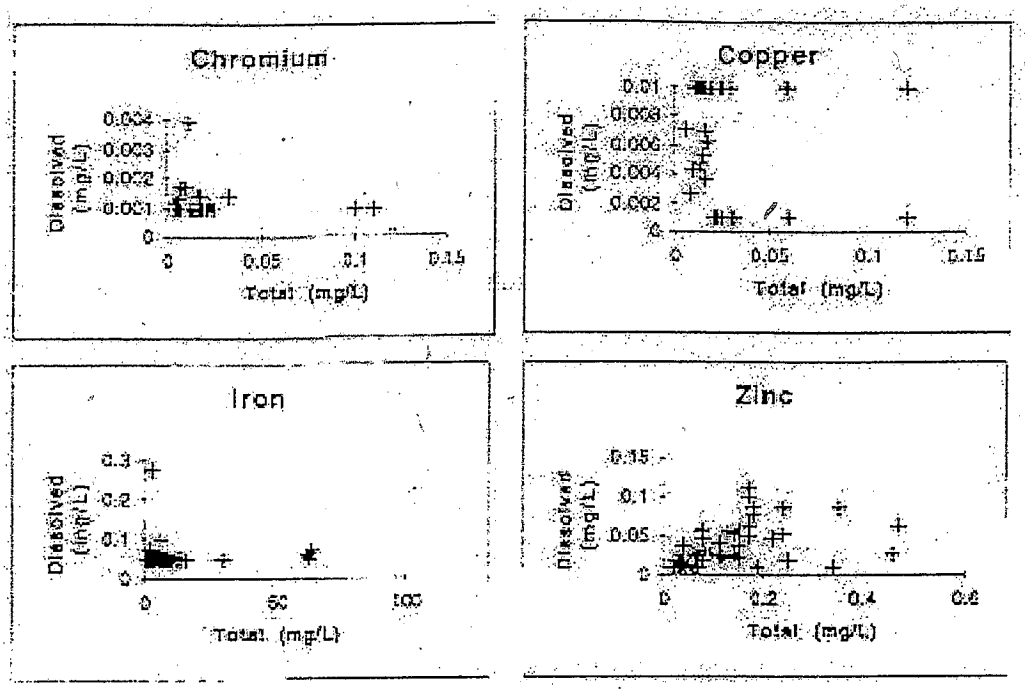

Figure 2. Relationship between metals concentrations and TSS.

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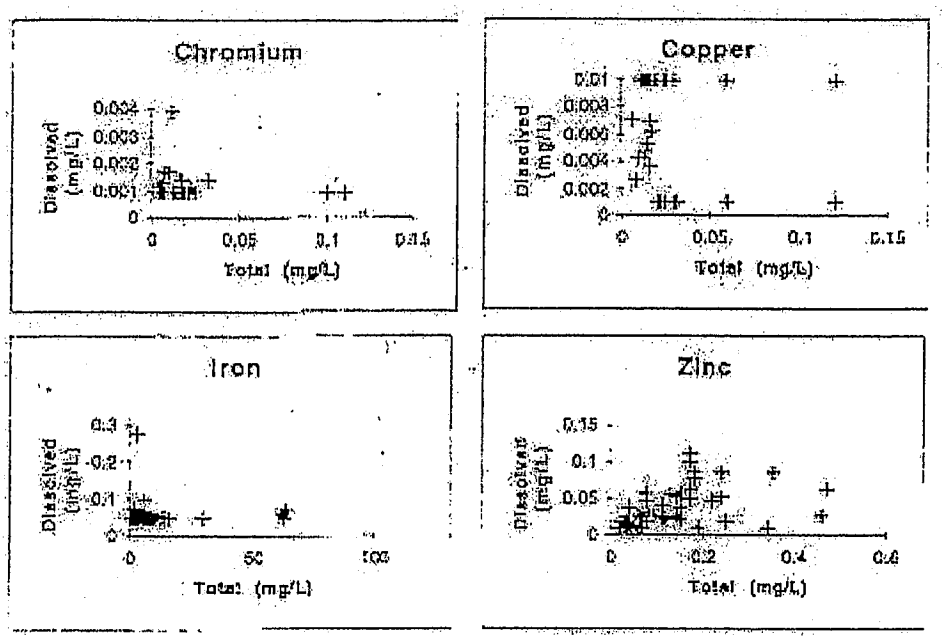

Figure 3. Relationship between dissolved and total metal concentrations.

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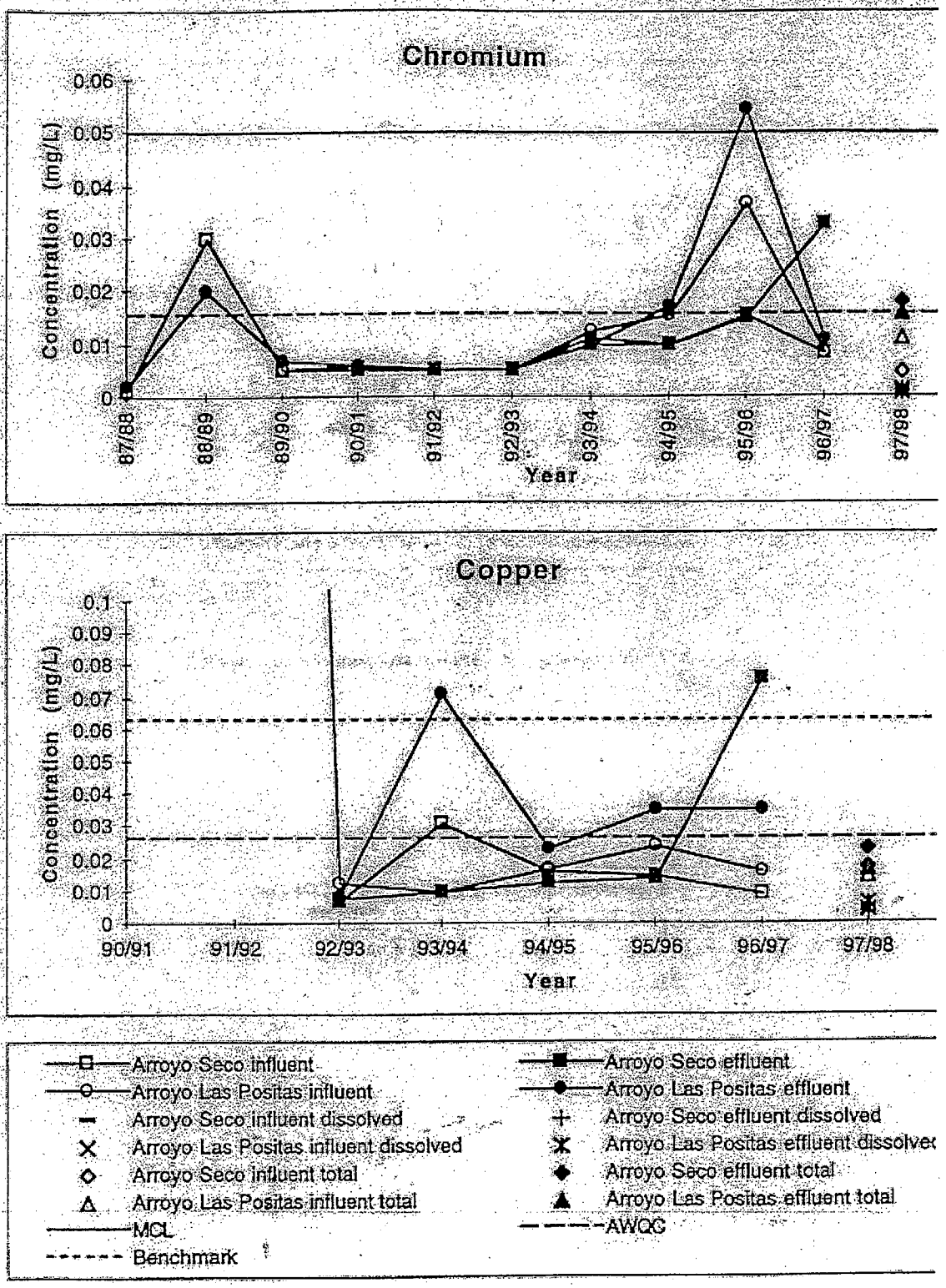

Figure 4. Annual median metal concentrations in LLNL storm water.

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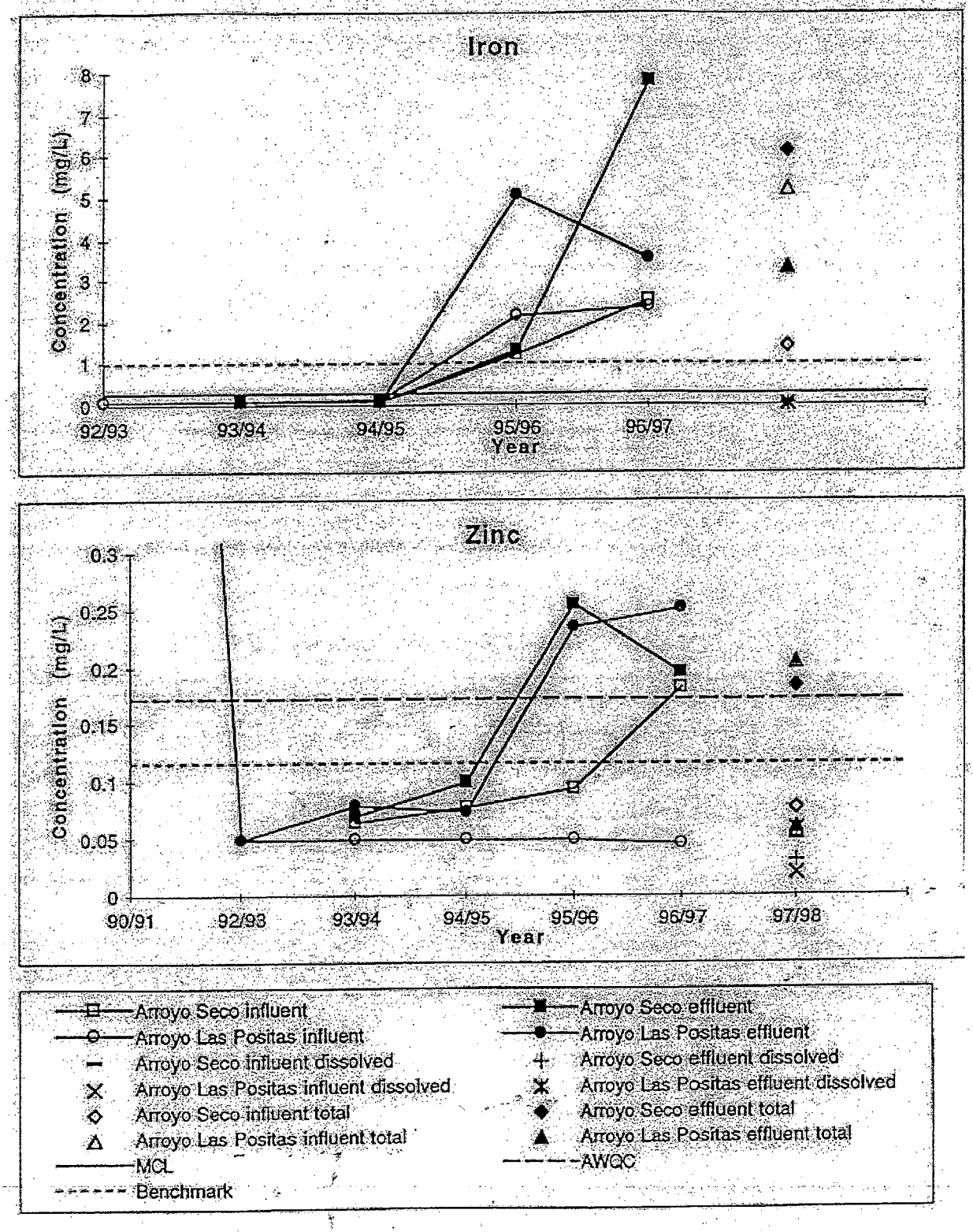

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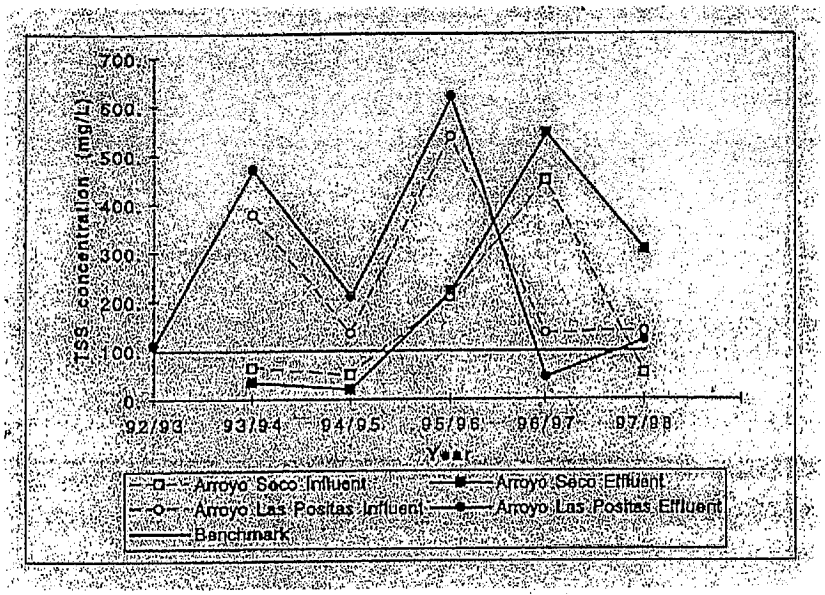

Figure 5. Annual median TSS concentrations in LLNL storm water.

Table 1. Median Influent and Effluent Concentrations, 1997/1998 Wet Season

		Arroyo Seco		Arroyo Las Positas	
		Influent	Effluent	Influent	Effluent
TSS		55	306	139	121
Chromium	Dissolved	0.001	0.001	0.001	0.0014
	Total	0.0047	0.018	0.011	0.016
Copper	Dissolved	0.0048	0.0038	0.0044	0.0062
	Total	0.0175	0.023	0.015	0.017
Iron	Dissolved	0.05	0.05	0.05	0.05
	Total	1.45	6.1	5.2	3.3
Zinc	Dissolved	0.0505	0.0325	0.02	0.059
	Total	0.0785	0.185	0.061	0.205

Table 2. Qualitative Comparison of Agreement Between Historical TSS and Metals Concentrations

	Arroyo Seco		Arroyo Las Positas	
	Influent	**Effluent**	**Influent**	**Effluent**
Chromium	medium	high	high	high
Copper	low	high	high	low
Iron	high	high	low	high
Zinc	high	medium	low	high

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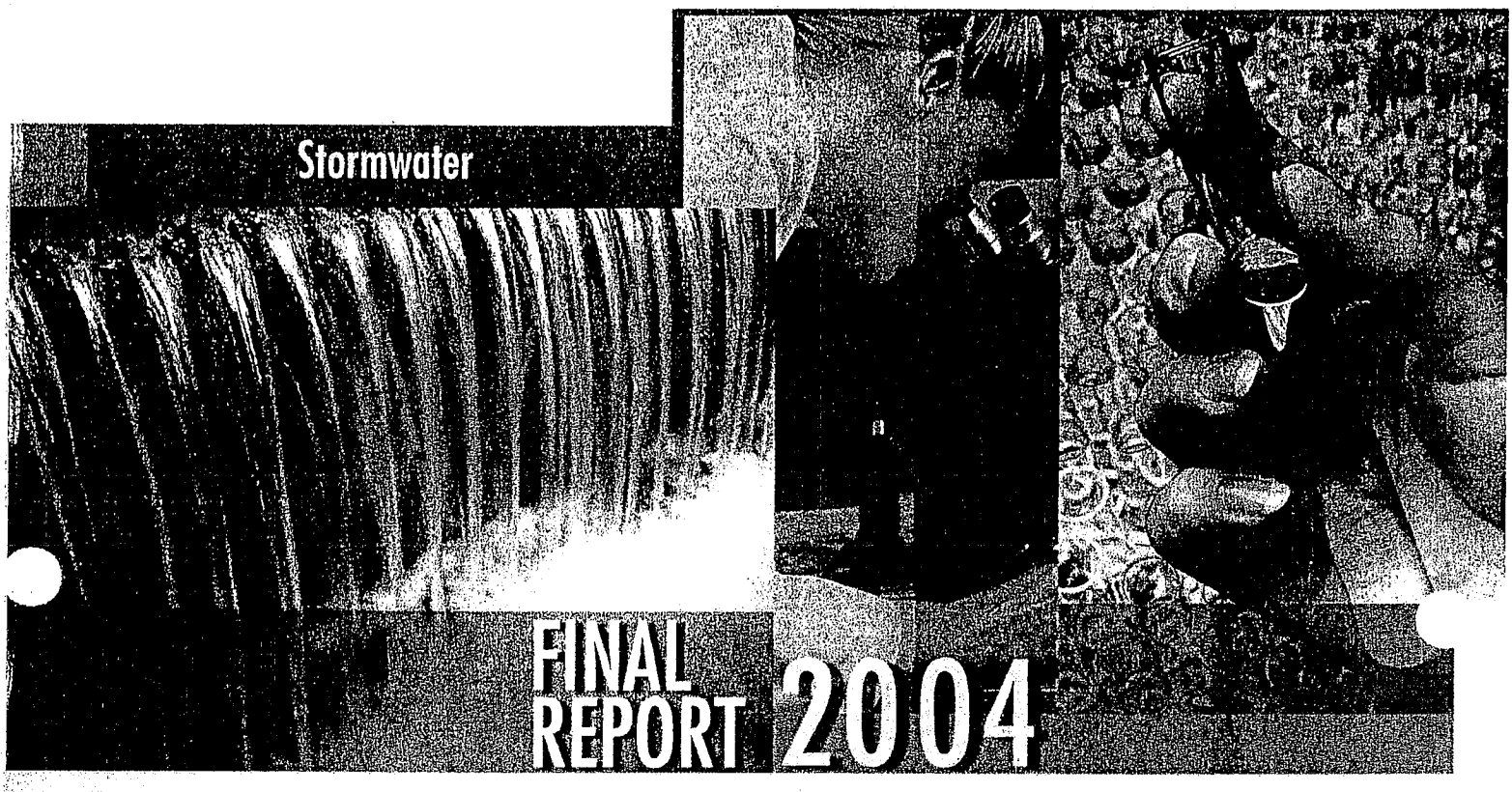

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RESEARCH DIGEST: METALS REMOVAL TECHNOLOGIES FOR URBAN STORMWATER

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ABSTRACT AND BENEFITS

Abstract:

This WERF-sponsored study to investigate innovative heavy metals removal from stormwater mainly focused on two control systems: media filters and swales.

Twelve media were chosen for initial evaluation. The three overall best performing media were then selected for in-depth study. The results of this investigation emphasize the importance of characterizing the stormwater before selecting a treatment media since the type and quantity of metals, pH, and other runoff characteristics can vary a great deal between sites. For example, determining the range of metal concentrations to be treated is crucial to selecting the best media, since the removal efficiencies of the media relative to each other changed with varying metal concentration. Media that were effective at high metals concentrations were outperformed by some media at the low metals concentrations typically found in stormwater. Upflow columns proved more effective than downflow columns in the control of detention time and a reduction in clogging of the media by solids and associated head loss in the column. Studies on the effect of anaerobiosis on metal retention by filter systems indicated that heavy metals were not mobilized from filter systems under anaerobic conditions. Tests also indicate that the heavy metals of concern remain strongly bound to the particulates during long exposures at the extreme pH conditions likely to occur in receiving water sediments.

In the swale study, the hydraulic characteristics of grass swales appear to be more important than grass species for removing heavy metals from stormwater during single storm events. Because of the potentials for both sediment deposition and scouring, swales can improve or deteriorate water quality during storm events with "negative removals", possibly associated with scour of previously deposited materials. Long term performance considering infiltration has shown significant heavy metal retention in swale systems. The phytoremediation study suggests that there is a relatively similar behavior among the different grass species; therefore, any grass added to the surface of a swale system would represent a positive influence on metal uptake. However centipede is possibly be the best overall choice for its resilience to drought, its nutritional frugality, and its slightly greater ability to accumulate key contaminant metals such as Cu, Zn and Pb.

Benefits:

- Provides results of a broad study of metals removal from stormwater
- Furthers the understanding of the effectiveness of conventional and novel media and filter flow configuration on the capture of metals from urban runoff.
- Identifies the most suitable media for different site conditions.
- Sets forth the relative benefits of upflow columns.
- Identifies that disposal issues are a significant consideration in media selection.
- Provides design information for typical low volume flows in stormwater drainage swales.
- Identifies the role of common grass varieties in the capture of metals in runoff.

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- Answers critical questions on stormwater particulate size—metal fraction associations in regard to treatability and the significance of filterable forms of metals.
- Provides guidelines for the development of working systems for the capture of metals from urban runoff.

Keywords: Heavy metals, stormwater, runoff, swales, phytoremediation, filters

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PROJECT SUMMARY

Stormwater runoff has been identified by the U.S. EPA as a leading cause of water quality impairment nationwide. Heavy metals in urban stormwater originate primarily from automobile-related activities and the exposure of building materials to rain.

Opportunities for the control of metal-bearing urban runoff can be grouped into three basic strategies: source avoidance or reduction; passive systems; and installed treatment technologies. While the concept of pollution avoidance and minimization at critical sources is the most preferred option for the control of metals in urban runoff, it is unlikely that any one method will provide either a realistic or effective solution to the problem. The stormwater control technologies evaluated in this study for the capture of heavy metals from urban runoff were media filtration systems and grass swales. This report provides further understanding of the role of these technologies in metals capture from urban runoff and provides guidelines for system design.

Filter Studies

Twelve media were initially evaluated through kinetic and equilibrium tests. The results of this investigation emphasize the importance of characterizing the stormwater before selecting a treatment media since the type and quantity of metals, pH, and other runoff characteristics can vary a great deal between sites. For example, determining the range of metal concentrations to be treated is crucial to selecting the best media, since the removal efficiencies of the media relative to each other changed with varying metal concentration. Media that were effective at high metals concentrations were outperformed by some media at the low metals concentrations typically found in stormwater. In addition, some media that offer potential as sorbents of metals may create water quality problems of their own. In equilibrium tests for all media, correlations were evident between the metals sorbed and the Ca, Mg, K, and Na ions desorbed. The ions desorbing and their quantity varied depending on the media and exchange metals present. The three overall best performing media: peat-sand mix, compost, and zeolite were then selected for in-depth study.

Upflow columns proved more effective than downflow columns in the control of detention time, reducing clogging of the media by solids and associated head loss in the column. At residence times of three to ten minutes, most of the suspended solids settled out in the sump area of the columns. Compost and zeolite columns showed little sign of increased headloss during these runs, even when influent suspended solids concentrations were around 400 mg/L.

In extensive comparisons of the three media, the peat-sand mix performed best overall in capturing dissolved metals (Figure 1). However peat-sand had the greatest headloss and the greatest change in headloss over the course of each run. All three media removed total suspended solids well over all runs, but only peat showed any removal of total dissolved solids. Compost increased the total dissolved solids concentrations. As expected, the behavior of the total suspended solids and particulate-bound metals paralleled each other. Copper and chromium typically had lower removal efficiencies than the other metals; one possible explanation is that these metals had a larger fraction of their particulate-bound metal concentrations associated with smaller particulates which passed more easily through the columns. Peat had the best removal efficiencies for particulate-bound metals. Removal efficiencies of compost and zeolite were approximately the same. The relative advantages and disadvantages of the three media are summarized in Table 1.

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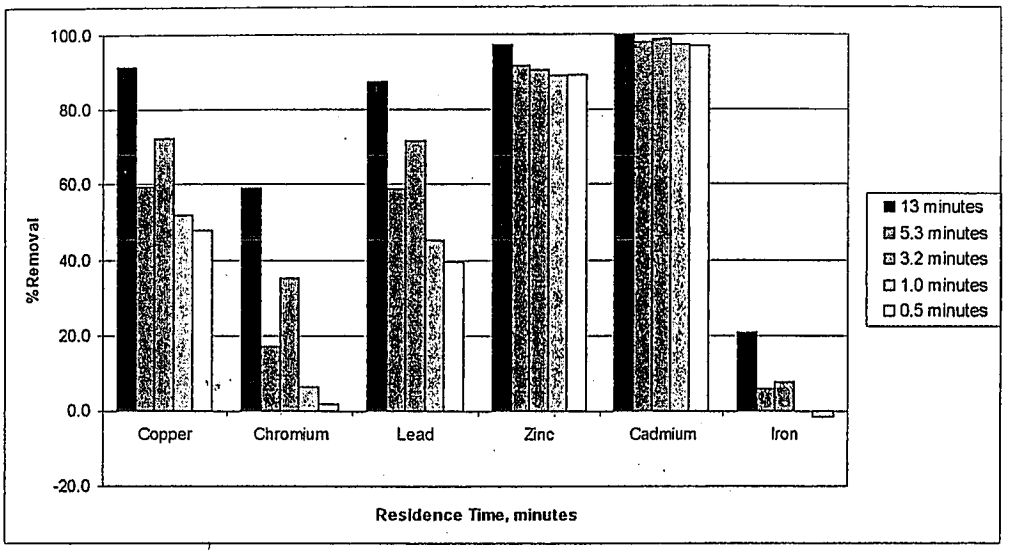

Figure 1. Percent Dissolved Metals Removal by the Peat-Sand Column.

Table 1. Relative Advantages and Drawbacks of Three Media.

Media	Main Advantages	Main drawbacks
Peat-Sand Mix	Best metal capture capability	Most detrimental impact on pH, the greatest headloss, and showed the most potential for clogging
Compost	Second best metal capture capability	Added color to the effluent. Less impact on the pH of the effluent, less headloss, and exhibited less potential for clogging
Zeolite	Lowest metal capture capability	Less impact on the pH of the effluent, less headloss, and exhibited less potential for clogging

Studies on the effect of anaerobiosis on metal retention by filter systems indicated that heavy metals were not mobilized from filter systems under anaerobic conditions (i.e. metal retention within the filters was not different from what was observed in oxygenated environments). However, it is plausible that under certain specific environmental conditions, co-precipitation of metals by iron- and sulfate- reducing bacteria may take place in stormwater treatment systems. Tests also indicate that the heavy metals of concern remain strongly bound to the particulates during long exposures at the extreme pH conditions likely to occur in receiving water sediments. They will also likely remain strongly bound to the particulates in stormwater control device sumps or detention pond sediments where particulate-bound metals are captured.

The minimum effluent metal concentration attainable in a filter will depend on many variables, including metal type, metal concentration, media type, contact time between the media and runoff, the degree of media saturation and runoff pH. Table 2 lists the lowest the minimum attainable effluent concentrations for the media with variable residence time filter runs. Similar ranges were observed during these field pilot-scale and related full-scale media filtration tests.

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Table 2. Minimum Dissolved Metal Concentrations Achieved in Variable Residence Time Filter Studies.

Media	Effluent Metal Concentration, mg/L					
	Copper	Chromium	Lead	Zinc	Cadmium	Iron
Peat-Sand	0.006	0.044	<0.007	0.005	<0.002	0.122
Compost	0.037	0.077	0.042	0.017	0.005	0.213
St. Cloud Zeolite	0.042	0.083	0.038	0.007	0.006	0.203

Pilot-scale studies confirmed the modeling equations for a few pollutants for some media and indicated that the modeling approach adopted has the potential to provide an estimate of the life of the filter, i.e., the time until media replacement is needed for applications where the influent concentration is not quite as low as it was in the two detention ponds used in this pilot scale study. The best application for these filters may then be to further treat the effluent from a detention pond in critical source areas, such as scrap metal recyclers, rather than as a polisher for effluent from a detention pond in a residential area.

The ability of spent media to hold on to captured metals and pass the RCRA TCLP test has significant implications to its economic viability. Samples of spent media from column studies underwent TCLP analysis for RCRA metals. Under the Land Disposal Restrictions program, a restricted waste may be land disposed only if a TCLP extract of the waste, or a TCLP extract of the treatment residue of the waste, does not exceed the regulatory levels for hazardous constituents listed for that waste. The regulatory levels are 1 mg/L for cadmium and 5 mg/L for chromium and lead. Chromium and lead did not present a problem for any of the media, however, the cadmium concentration in the leachate was above the acceptable limit for peat-sand, and was close to the limit for zeolite and compost. Compost performed best of the three media in retaining all three RCRA metals studied.

Swale Hydrologic and Phytoremediation Studies

Grass swales reduce heavy metal discharges through a combination of sedimentation, infiltration through the soil, and biological uptake. Grass swales can incorporate many positive features to reduce heavy metal discharges to surface and groundwaters. Sedimentation occurs due to increased channel lining roughness, infiltration is common, and amended soils can easily be incorporated in swale liners. Critical source area controls can be used incorporating special sorption/filtration media. Finally, sedimentation in wet detention ponds can be used to better remove and contain finer particulates, and post-treatment with wetlands can be used for increased biological control processes.

The outdoor phytoremediation study on the role of common grass varieties in the capture of metals from runoff indicated that both Centipede and Zoysia grass varieties, common in many lawns in the Southeastern United States, exhibit a capability to uptake metals from soil that receives stormwater. Experiments in indoor swales with spiked stormwater, however, suggested that Centipede had a greater maximum ability to accumulate Cu and Zn than Zoysia and Kentucky Bluegrass, commonly used in northern areas of the country. Pb was the metal retained with the best efficiency (57-65%), followed by Cu (~40% retention), Cd (21-28% retention), Zn (13-26%) and Cr (14-16% for Zoysia and Centipede, 37% for Bluegrass) (Table 3, see below). Overall, the results suggest that there is relatively similar behavior among the different grass species. In other words, any grass added to the surface of a swale system would represent a positive influence on metal uptake from runoff. However, if a recommendation should be made for systems designed to

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have a long life as filters for metal accumulation from stormwater, Centipede could possibly be the best overall choice for its resilience to drought, its nutritional frugality, and its ability to accumulate key contaminant metals, such as Cu, Zn, and Pb.

Table 3. Percentage of Soluble Metal in the Stormwater Retained by the Indoor Swales During the Indoor Spike Experiments.

Values were calculated from the concentrations of metals in the input stormwater and final runoff, after 24 hours contact time.

Metal retained (%)	Cu	Cr	Pb	Zn	Cd
Zoysia	39.8	16.3	64.8	13.3	21.1
Centipede	39.0	13.8	57.1	20.4	27.9
Bluegrass	40.3	36.8	66.7	26.1	25.2

The goal of the indoor swale experiments was to investigate the hydraulic characteristics, specifically Manning's n, for three grass species (Centipede, Kentucky Bluegrass, and Zoysia). Shallow depths of flow are essential to optimizing metal removal rates in vegetated swales. Indoor laboratory swale experiments produced retardance curves for the three grass species for flow depths that will optimize heavy metal removal (Figure 2). Retardance curves display the relationship between Manning's n and the product of velocity and hydraulic radius (VR) for different types or classes of vegetation. The hydraulic characteristics of grass swales appear to be more important than the grass species for removing heavy metals from stormwater during single storm events. Because of the potentials for both sediment deposition and scouring, swales can improve or deteriorate water quality during storm events. The outdoor swale tests showed highly variable results. Many of the concentration reductions were quite large, but some "negative removals" possibly associated with scour of previously deposited materials, were also noted. Because of the potentials for both sediment deposition and scouring, swales can improve or deteriorate water quality during storm events. However, mass metal removals would generally occur due to infiltration in the swale. Long-term performance considering infiltration has shown significant heavy metal retention in swale systems.

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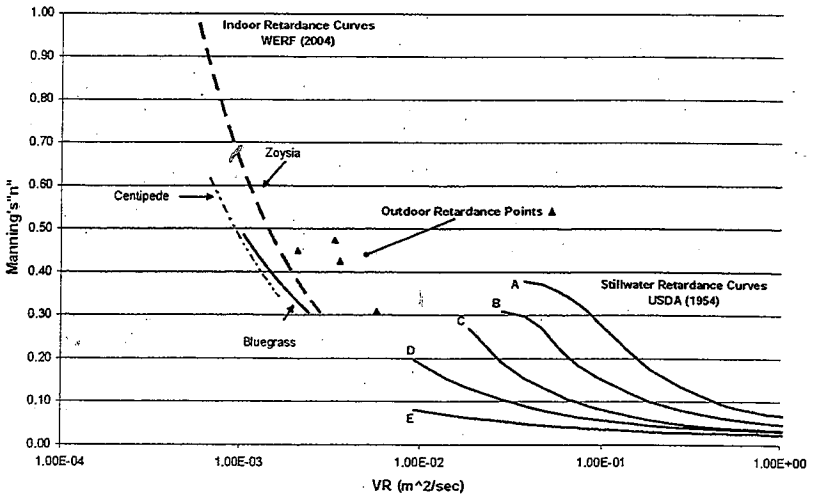

Figure 2. Indoor Grass "n" vs. VR Curves/Historical Retardance Curves.

Treatability Testing

Treatability tests were performed to assess the effectiveness of different treatment trains and processes by quantifying improvements in stormwater toxicity and metals capture. The treatability tests included intensive analyses of samples from twelve sampling locations in the Birmingham, AL, area that had elevated toxicant concentrations compared to the other urban source areas initially examined. The treatability tests conducted were: settling column, floatation, screening and filtering, photo-degradation, aeration, combined photo-degradation and aeration and an undisturbed control sample. More than 900 toxicity tests were performed using the Microtox™ procedure. Turbidity tests were also conducted on all samples. Results indicated a reduction in toxicity as the level of treatment increased. All samples, with one exception, showed dramatic reductions in toxicity with increasing settling times. Even though the data are separated into three source groups, as expected, there were greater apparent differences between the treatment methods than between the sample groupings.

Metals Associations

Metals associations data can be used to estimate the level of control that may be associated with different designs of particle trapping devices. Metal-particulate association tests using Celex-100 resin revealed that more than 90% of the filterable forms of calcium, magnesium, iron, chromium, and zinc were in ionic forms, with very little colloidal, or other bound forms (Table 4). Also, about 80% of the filterable potassium, lead and copper were also ionic, while only about 10% of the filterable cadmium was ionic, the only measured compound that was mostly colloidal.

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Table 4. Ionic and Colloidal Associations with Filtered (<0.45 μm) Pollutants.

Analyte	% Ionic	% Colloidal
Magnesium	100	0
Calcium	99.1	0.9
Zinc	98.7	1.3
Iron	97	3
Chromium	94.5	5.5
Potassium	86.7	13.3
Lead	78.4	21.6
Copper	77.4	22.6
Cadmium	10	90

Some pollutants can be significantly reduced by a reduction in particulates, such as suspended solids, total phosphorus and most heavy metals. Other pollutants, such as nitrates, are reduced much less, even after filtration down to 0.45 μm (Table 5).

Experiments were also conducted to examine the likelihood of the metals disassociating from the particulates under pH conditions ranging from about 4-11 with both weak and strong acids. These tests indicated that the heavy metals of concern remain strongly bound to the particulates during long exposures at the extreme pH conditions likely to occur in receiving water sediments. They will also likely remain strongly bound to the particulates in stormwater control device sumps or detention pond sediments where particulate-bound metals are captured.

Table 5. Percent Pollutant Reductions After Removal of Particulates Greater than Size Shown.

	20 μm	5 μm	1 μm	0.45 μm
Total-P	68	82	89	92
Suspended Solids	76	81	98	100
Chromium	69	81	82	84
Phosphate	71	78	81	88
Zinc	64	70	70	72
Iron	52	63	95	97
Lead	41	62	76	82
Turbidity	43	55	92	96
COD	48	52	52	47
Ammonia	35	46	54	58
Total Solids	40	43	52	53
Total-N	30	41	35	23
Copper	26	34	34	37
Cadmium	20	22	22	22
Nitrate	0	0	12	17

Design Guidelines

Much information has been collected during this WERF-sponsored research project that can be directly used for the design of stormwater controls for the reduction of heavy metals. The tests on the treatability of stormwater heavy metals examined the associations of metals with different stormwater fractions. These associations are also useful in predicting the performance of

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sedimentation controls in removing heavy metals. This information can be used to predict the heavy metal control associated with a wet detention pond that is designed to remove particles of a specific minimum size. Additionally, material on the selection of filtration media, the clogging rates under different conditions, and the metal retention capacity of the different media are all available in the final research report. A simple approach in the selection of filtration media and the sizing of stormwater filters is also outlined. Investigations of several important issues associated with the upflow filters are also presented. These filters hold promise in being much more cost-effective than the more-commonly-used traditional slow filters. Additional tests were also conducted that investigated the clogging behavior of the different media under upflow conditions. Both the hydraulic and the water quality objectives of a swale design were examined. Information on the selection of grass species and other channel parameters is also presented.

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Persistent Organic Pollutants (POPs)

On May 23, 2001, the United States signed the Convention on Persistent Organic Pollutants (POPs) at a diplomatic conference in Stockholm, Sweden. Under the Convention, countries commit to reduce and/or eliminate the production, use, and/or release of the 12 POPs of greatest concern to the global community and to establish a mechanism by which additional chemicals may be added to the Treaty in the future. The United States strongly supported efforts to complete this important agreement, which will have wide-ranging environmental and health benefits. This document provides information about the POPs agreement, and how the United States is participating.

What are Persistent Organic Pollutants?

POPs are a set of chemicals that are toxic, persist in the environment for long periods of time, and biomagnify as they move up through the food chain. POPs have been linked to adverse effects on human health and animals, such as cancer, damage to the nervous system, reproductive disorders, and disruption of the immune system. Because they circulate globally via the atmosphere, oceans, and other pathways, POPs released in one part of the world can travel to regions far from their source of origin.

What Pollutants are Targeted by the Treaty?

The agreement initially targets a group of POPs, informally called the "dirty dozen." (See table below.) The "dirty dozen" include:

- Certain insecticides, such as DDT and chlordane, which were once commonly used to control pests in agriculture and in building materials, as well as to protect public health, are now considered POPs.
- PCBs, which were used in hundreds of commercial applications, such as in electrical, heat transfer, and hydraulic equipment, and as plasticizers in paints, plastics, and rubber products.
- Certain chemical byproducts, such as dioxins and furans, which are produced unintentionally from most forms of combustion, including municipal and medical waste incinerators, open burning of trash, and industrial processes.

The "Dirty Dozen"	
[1]Pesticide	[2]Industrial Chemical [3]Byproduct
aldrin[1]	hexachlorobenzene[1,2,3]
chlordane[1]	mirex[1]
DDT[1]	toxaphene[1]

dieldrin[1]	polychlorinated biphenyls (PCBs)[2,3]
endrin[1]	polychlorinated dibenzo-p-dioxins (dioxins)[3]
heptachlor[1]	polychlorinated dibenzo-p-furans (furans)[3]

US Domestic Actions on POPs

The United States has taken strong domestic action to reduce emissions of POPs. None of the pesticide POPs are registered for sale and distribution in the United States today. In 1978, the US Congress prohibited the manufacture of new PCBs and severely restricted the use of remaining stocks.

Since 1987, EPA has been taking actions to effectively reduce environmental releases of dioxins and furans to land, air, and water from sources in the United States. An inventory of U.S. sources suggests that, in 1987, all known source activity contributed 13,998 grams of dioxins and furans to the environment, using a methodology developed by the World Health Organization called toxic equivalents, or WHO-TEQ. Regulatory actions have resulted in a 77% decline in total dioxin and furans releases between 1987 and 1995. When all current regulatory actions are fully implemented and enforced by the year 2004, the EPA predicts a further decrease of 92% in environmental releases from 1987 levels.

Additionally, EPA has sought to better understand the risks associated with dioxin emissions through its comprehensive dioxin reassessment, which the Agency anticipates releasing in 2001.

US International Actions on POPs

The United States has taken a leading role to reduce and/or eliminate certain POPs and their releases on a global basis. The United States has provided technical and financial assistance for POPs-related activities to a variety of countries and regions, including Mexico, Central and South America, Russia, Asia and Africa.

Useful POPs Web Sites

EPA

www.epa.gov/pesticides

www.epa.gov/pcb/

www.epa.gov/ncea/dioxin.htm

UN Environment Program

http://www.chem.unep.ch/pops/default.html EXIT disclaimer

US Department of State

www.state.gov/g/oes/env/fs/ EXIT disclaimer

- In 1997, Canada and the United States signed an agreement, the Canada-US Strategy for the Virtual Elimination of Persistent Toxic Substances in the Great Lakes Basin. The Strategy sets long-term goals to promote emissions reductions of toxic substances. For more information on this strategy, visit www.epa.gov/glnpo/.
- Under the auspices of the North American Commission on Environmental Cooperation, Mexico, Canada and the United States have developed a regional initiative on the sound management of chemicals, which was formally adopted in October 1995. Under this initiative, the Commission can develop Regional Action

Plans, which identify activities that reduce or eliminate risks from chemicals of concern. The Commission has already established such plans for PCBs, DDT, and chlordane and is developing action plans for dioxins, furans and HCB. For more information, visit www.cec.org. EXIT disclaimer

- In 1998, the United States participated in negotiations for a legally-binding regional protocol with other members of the United Nations Economic Commission for Europe (UN-ECE) on POPs under the Convention on Long-Range Transboundary Air Pollution (LRTAP). This agreement seeks to eliminate production and reduce emissions of POPs in the UN-ECE region. Elements from the LRTAP POPs protocol were used in negotiations for the global POPs Treaty. For more information, visit www.unece.org/env/lrtap. EXIT disclaimer

The Global Treaty on POPs

The Stockholm POPs Convention will require all Parties to stop production and new uses of intentionally produced POPs, with limited country-specific and general exceptions. All new manufacture of PCBs is banned, and Parties are to take steps to reduce use of existing PCBs. DDT use is restricted to vector control (e.g., to control malaria-bearing mosquitoes), and is slated for ultimate elimination as cost-effective alternatives become available. Parties will also be required to implement rigorous controls on sources of POP byproducts to reduce releases. The Treaty also includes requirements for safe handling and disposal of POPs in an environmentally sound manner.

The Treaty also includes provisions restricting trade of POPs for which uses or production continue to exist and bans all export of POPs, except for environmentally sound management once there are no longer any uses allowed. In addition, a strong financial and technical assistance provision in the agreement will provide support to developing countries and countries in economic transition to assist them in implementing the obligations under the Treaty. Finally, the Treaty includes a science-based procedure to allow for the addition of other chemicals to the agreement.

The Bush Administration strongly supports the POPs Treaty and will transmit it for advice and consent of the Senate for ratification. The Treaty must be ratified by at least 50 countries to enter into force.

The table below lists the U.S. regulatory status of intentionally produced substances included in the POPs agreement.

POP	U.S. Regulatory Status under FIFRA and TSCS*
aldrin	• no US registrations, most uses canceled in 1969, all uses by 1987 • no production, import or export • all tolerances on food crops revoked in 1986
chlordane	• no US registrations, most uses canceled in 1978, all uses by 1988 • no production (stopped in 1997), import or export
DDT	• no US registrations, most uses canceled in 1972, all by 1989 • no US production, import, or exports • all tolerances on food and feed crops revoked in 1986
dieldrin	• no US registrations, most uses canceled in 1969, all

	uses by 1987 • no production, import, or export • all tolerances on food crops revoked in 1986
endrin	• no US registrations, most uses canceled in 1979, all uses by 1984 • no production, import, or export
heptachlor	• most uses canceled by 1978, registrant voluntarily canceled use tocontrol fire ants in underground cable boxes in early 2000 • no production (stopped in 1997), import, or export • all tolerances on food crops revoked in 1989
hexachloro-benzene (HCB)	• no US registrations as pesticide, all uses canceled by 1985 • no production, import, or export of HCB as pesticide• production as a chemical intermediate as allowed under the convention (TSCA)
mirex	• no U.S. registrations, all uses canceled by 1977 • no production, import, or export
PCBs	• manufacture and new use prohibited in 1978 (TSCA)
toxaphene	• no U.S. registrations, most uses canceled in 1982, all uses by 1990 • no production, import, or export • all tolerances on food crops revoked in 1993

FIFRA:Federal Insecticide, Fungicide, and Rodenticide Act
TSCA:Toxic Substances Control Act
* relevant statute authority is FIFRA unless otherwise noted.

For More Information on Pesticides

Visit EPA's web site for information on our regulatory programs and international activities: www.epa.gov/pesticides or www.epa.gov/oia.

The Office of Pesticide Programs provides a variety of materials regarding the regulation of pesticides, which are available in paper copy. For a list of our available publications, or for other pesticide information, please call 703-305-5017.

Information (general and technical) on pesticides and their toxicity, in addition to health related information, is available from the The National Pesticide Information Center (NPIC) -- Telephone 1-800-858-7378, seven days a week excluding holidays, from 6:30 am to 4:30 pm Pacific Time - or fax (514) 737-0761 - or by email at npic@ace.orst.edu. EXIT disclaimer

For more information about the POPs Convention and other international activities, contact EPA's Office of International Activities at 202-564-6600.

Last updated on Wednesday, September 7th, 2005
URL: http://www.epa.gov/oppfead1/international/pops.htm

Environ. Sci. Technol. 2005, 39, 5567−5574

Trends in Hydrophobic Organic Contaminants in Urban and Reference Lake Sediments across the United States, 1970−2001

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A shift in national policy toward stronger environmental protection began in the United States in about 1970. Conversely, urban land use, population, energy consumption, and vehicle use have increased greatly since then. To assess the effects of these changes on water quality, the U.S. Geological Survey used sediment cores to reconstruct water-quality histories for 38 urban and reference lakes across the United States. Cores were age-dated, and concentration profiles of polycyclic aromatic hydrocarbons (PAHs) and chlorinated hydrocarbons were tested statistically. Significant trends in total DDT, *p,p′*-DDE, and total PCBs were all downward. Trends in chlordane were split evenly between upward and downward, and trends in PAHs were mostly upward. Significant trends did not occur in about one-half of cases tested. Concentrations of *p,p′*-DDE, *p,p′*-DDD, and PCBs were about one-half as likely to exceed the probable effect concentration (PEC), a sediment quality guideline, in sediments deposited in the 1990s as in 1965−1975, whereas PAHs were twice as likely to exceed the PEC in the more recently deposited sediments. Concentrations of all contaminants evaluated correlated strongly with urban land use. Upward trends in PAH concentrations, the strong association of PAH with urban settings, and rapid urbanization occurring in the United States suggest that PAHs could surpass chlorinated hydrocarbons in the threat they pose to aquatic biota in urban streams and lakes.

Introduction

Federal environmental policy in the United States changed markedly in about 1970 with the establishment of the U.S. Environmental Protection Agency (1969) and the passage of the Clean Air Act (1970), the Safe Drinking Water Act (1974), the Toxic Substances Control Act (1976), and other laws (*1*). Improving water quality is one objective of these actions. Conversely, increases in population, urban development, energy use, and vehicle use in the United States could lead to degradation of water quality. Identifying water-quality trends can provide measures of the success or failure of mitigation efforts and can provide a warning of unanticipated degradation. Understanding trends also can improve our understanding of cause and effect relations between human activities and water quality and can aid in developing efficient strategies for reducing adverse human effects on the environment.

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The U.S. Geological Survey is using paleolimnology, the reconstruction of water-quality histories from age-dated sediment cores, to evaluate water-quality trends across the United States (*2*). Organic compounds that are chemically persistent and strongly hydrophobic often are preserved in the sediments, thus creating a partial record of historical water quality. Downward trends in polychlorinated biphenyls (PCBs) and DDT since the 1960s, for example, have been documented in a variety of environmental settings (*3*, *4*). Trends in chlordane and polycyclic aromatic hydrocarbons (PAHs) have been presented by numerous investigators but are more variable (*5*, *6*). Many studies have addressed trends in these hydrophobic organic compounds (HOCs); however, most are local in scale or focus on only a few water bodies in one region (e.g., *3*−*5*, *7*−*9*).

This study determined trends in persistent HOCs since 1970 using sediment cores collected from 38 lakes across the United States. The study was conducted by the U.S. Geological Survey National Water-Quality Assessment (NAWQA) Program (*10*). The primary objectives were to identify trends in HOCs in urban and undeveloped reference settings across the U.S. and, to the extent possible, to determine the causes of those trends. To our knowledge, this study is the first attempt to apply a consistent paleolimnological approach to identifying trends in numerous HOCs across the United States.

Experimental Section

Study Design. Sediment cores were collected from 38 lakes in the United States between 1996 and 2001 (28 reservoirs and 10 natural lakes, hereafter referred to as lakes except where the distinction is relevant), age dated, analyzed chemically, and tested for trends (Figure 1; see Supporting Information for more information on lakes sampled). The NAWQA design provided a national framework for identifying potential study areas (*10*). The selection of urban areas in this study was based on the combination of NAWQA study units, metropolitan statistical areas (MSAs) (*11*), and ecoregions (*12*). Urban areas were selected to represent a diversity of ecoregions where a majority of United States cities and urban populations are located. Lakes in one or more cities in the five most populous (summing urban population only) level II ecoregions and eight of the 11 most populous ecoregions were sampled. In some cases, areas were chosen for study in less populous ecoregions to better represent the geographic diversity of the country (e.g., Las Vegas, NV (Lake Mead) in the Southern Basin and Range was included and Detroit, MI in the Erie/Ontario Lake Plain was not). Although it is not a probabilistic design, it does provide a geographically diverse coverage of major urban areas of the country.

Lakes were chosen for sampling on the basis of lake and watershed size, age of the lake (~40 years or more for reservoirs), and the amount and age of development in the watershed. The majority of lakes sampled have relatively small watersheds (74% of the watersheds are less than 100 km^2), although drainage area to lake surface area ratios (DA:SA) varied greatly, with generally larger ratios for urban lakes and smaller ratios for reference lakes. This bias was by design, with an objective in sampling the urban lakes being to represent historical trends in anthropogenic inputs to urban streams and an objective in the reference lakes being to represent historical trends in atmospheric deposition. Contaminant inputs to lakes with large DA:SA ratios and development in the watershed are typically dominated by fluvial inputs of contaminants from one or a few streams (*13*, *14*). Lakes with small DA:SA ratios often have contaminant

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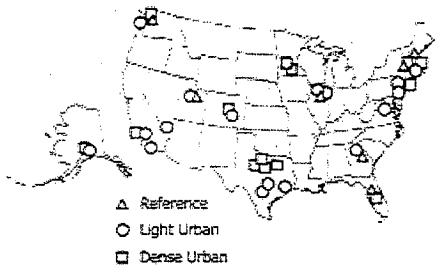

FIGURE 1. Locations of lakes sampled and land-use setting.

inputs that are dominantly from atmospheric fallout on the lake surface or watershed (*15, 16*).

The 38 lakes used in this analysis are a subset of 56 lakes sampled by the USGS from 1992 to 2001. These 38 cores (one from each lake) were selected because (a) they are from lakes representative of target land-use settings, (b) a common suite of organic compounds was analyzed using consistent methods, and (c) their age-control and relative lack of postdepositional sediment mixing were judged to be reliable for trend testing of the 35-year period of interest (*2*). Land use in the watersheds was categorized as "dense urban" (>52% urban land use; 14 lakes), "light urban" (5–42% urban; 17 lakes), or "reference" (<1.5% urban; 7 lakes), as determined from the 1992 USGS National Land Cover Data (NLCD) (*17*). In urban settings, residential and commercial land uses were favored, and large point sources and heavily contaminated industrial areas were avoided. Three of the seven reference lakes are water-supply reservoirs in protected watersheds, and three others and their watersheds are in county or state parks; the remaining reference lake (Big Round Top) has 1.5% developed land, consisting of one road and a few houses, and no evident agriculture or grazing.

Sampling. Cores were collected from the deepest part of the lake or in the middle or lower part of the reservoir, and sectioned into vertically discrete subsamples for analysis of major and trace elements, ^{137}Cs, ^{210}Pb (selected lakes only), organochlorine pesticides, PCBs, and PAHs (*2*). Gravity cores, piston cores, push cores (all 6.3 cm diameter polycarbonate tubes), and box cores (14-cm square polycarbonate liners) were collected. Cores were vertically extruded on site and sectioned into intervals ranging in thickness from 0.5 to 5 cm or more, depending on the assumed or known sedimentation rate at the site, sample mass requirements for chemical analyses, and site-specific objectives. Samples were transferred to baked glass jars and chilled pending shipment to the laboratory. Generally, sampling intervals were designed to represent from about 2 to 5 years of average sedimentation. The median number of samples per core was 12, and the median number of samples used for the trend-testing period, 1970 to top of core, was eight.

Chemical Analysis. Activities of ^{137}Cs were measured by counting freeze-dried sediments in fixed geometry with a high-resolution, inrinsic germanium detector gamma spectrometer, using a method similar to that reported by (*18*). Activities of ^{210}Pb were measured on freeze-dried sediments by high-precision gamma-ray spectrometry. Organochlorine pesticides, PCBs, PAHs, and alkyl-substituted PAHs (alkyl-PAHs) were extracted, isolated, and analyzed using the procedures of (*19*) and (*20*). Briefly, wet bottom sediment was extracted overnight with dichloromethane in a Soxhlet apparatus. The extract was reduced in volume and filtered. Two aliquots of the sample extract were quantitatively injected into a polystyrene-divinylbenzene gel permeation column and eluted with dichloromethane to remove sulfur and partially isolate the target analytes. The first aliquot was analyzed for PAHs and alkyl-PAHs by capillary-column gas chromatography with detection by full-scan mass spectrometry (MS) or by selected ion monitoring MS. Nineteen parent PAHs, 10 specific alkyl-PAHs, and the homologous series of alkyl-PAHs for 2- to 7-ringed PAH were determined. The second aliquot was split into two sample fractions by combined alumina/silica adsorption chromatography, followed by Florisil adsorption chromatography for further cleanup of the second fraction. Both fractions were analyzed by dual capillary-column gas chromatography with electron capture detection for the determination of the organochlorine pesticides and PCBs. The organochlorine pesticides were reported as individual compounds with the exception of chlordane, which was reported as technical chlordane (estimated from concentrations of *trans*-nonachlor, *cis*-chlordane, and *trans*-chlordane), and PCBs, which were reported as individual Aroclor (1016/1242, 1254, or 1260) equivalents. Quality assurance was provided by analyzing duplicate samples (environmental samples split at the laboratory), laboratory blanks, and spiked reagent samples, and monitoring recovery of surrogate compounds. Median relative percent difference for chlorinated hydrocarbons was 11.8% for 41 duplicate samples and for PAHs was 11.9% for 40 samples (*2*).

Age Dating. Sampling and analytical methods, detailed descriptions of age dating for each core, an assessment of the quality of age control, and a discussion of factors affecting dating are presented in ref *2*. The primary basis for age dating 26 of the cores was the ^{137}Cs profile, assigning the date of 1964 to the peak activity and, in a few cases, 1958 to a secondary peak (from testing in Nevada) and 1953 to the first occurrence. For six of the cores, dating was based on ^{210}Pb profiles using either the constant input concentration (CIC) model (four lakes) or the constant rate of supply (CRS) model (two lakes) (*2, 21*). The interface with pre-lacustrine sediment provided a date marker in most reservoirs and served as the primary basis for dating cores from six reservoirs, supplemented in three cases by the peak in total lead dated as 1975 (*22*).

Dates were assigned to individual samples, between date markers or using ^{210}Pb models, based on accumulation of dry mass per unit area in the core. For cores with no evidence to the contrary, a constant mass accumulation rate of sediment (MAR) was assumed between date markers. Thirty-two of the 38 cores had constant MARs over the time period of the trend testing. The strongest evidence supporting constant MARs during this period is the timing of the lead peak. The mean date of the peak for these lakes is 1975 (standard deviation of 5 yr), consistent with the reported peak in emissions and concentration peaks in cores from urban lakes in the United States (*22*). Age assignments in most of these cores were corroborated by peaks in ΣDDT (total DDT, the sum of *p,p′*-DDT, *p,p′*-DDD, and *p,p′*-DDE) in the early 1960s. Although confidence intervals cannot be assigned to the dates corresponding to individual sample intervals in the cores, the consistency of multiple corroborative date markers suggests that most dates are probably within a few years of the actual deposition dates.

Postdepositional mixing can affect contaminant profiles in cores, potentially obscuring or altering anthropogenic trends (*23*). Mixing was evaluated for all of the cores collected for the NAWQA study, and cores for which it was judged to have had a large influence on trends were excluded from the analysis presented here. Pronounced peaks and systematic variations in chemical profiles in most of the cores, in particular for ^{137}Cs, ^{210}Pb, total Pb, total DDT, and total PCBs (*2*), indicate that postdepositional mixing has not obscured contaminant trends on a decadal time scale.

Trend Analysis. Trends in concentrations of ΣPAH (total PAH), nine individual PAHs, chlordane, *p,p′*-DDD, *p,p′*-DDE, ΣDDT, and ΣPCB (total PCB, the sum of Aroclors 1016/1242, 1254, and 1260) were tested statistically. For this paper, ΣPAH is the sum of 13 compounds used for the consensus-based

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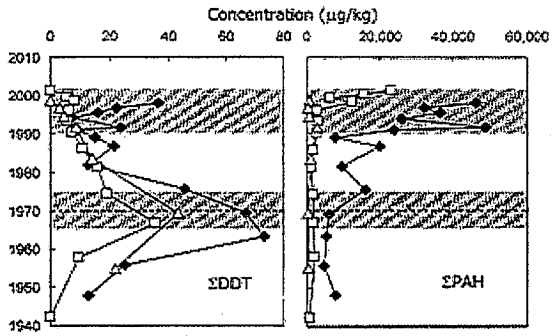

FIGURE 2. Trends in sediment cores from Lake Ballinger (◆), near Seattle, WA; Lake in the Hills (□), near Chicago, IL; and Sand Lake (△), near Orlando, FL. Dashed line (1970) is starting point of trend testing; shaded areas are periods used to compute decadal-mean concentrations.

sediment quality guidelines (*24*). The nine individual PAHs tested are those with a probable effect concentration (PEC) consensus-based guideline (*25*). Kendall's tau test was used to indicate whether there was a statistically significant relation (p-value < 0.1) between concentration and time from 1970 to the top of each core, representing 1996–2001. In a few cases, samples dated as late-1960s were included to increase sample count and improve statistical power. Trends also were evaluated by comparing mean concentrations of contaminants in sediment samples dated as deposited from 1965 to 1975 to those in samples deposited from 1990 to the top of the core. While not a statistical test, this comparison indicates the magnitude of change in concentration over a time period similar to that of the trend test. The starting period for these evaluations was chosen because it corresponds to the initiation of important environmental legislation or regulatory actions in the United States (*1*).

Nondetections were treated as zero values in summations (e.g., ΣPCB), in computing decadal mean concentrations, and in the Kendall's tau trend test, which gives them a lower rank in the test than detected values. If more than 60% of samples were nondetections, trend was not tested. Although 40% detections may seem to be a low rate to apply a trend test, significant trends occasionally were indicated if, for example, all of the detections occurred early in the time period with systematic decreases over time. Several other organochlorine pesticides were measured but rarely detected, including lindane, heptachlor, aldrin, endosulfan, methoxychlor, mirex, and toxaphene, and trends in these were not tested. Dieldrin and p,p'-DDT frequently were detected, but trends probably are not preserved in lake cores (*14*) so they were not tested.

Examples of contaminant profiles in selected cores and their relation to trend testing are shown in Figure 2 for ΣDDT and ΣPAH. Lake Ballinger is in a dense urban setting north of Seattle, WA. Lake in the Hills is in a light urban setting northwest of Chicago, IL, and has undergone rapid urbanization since about 1990. Sand Lake, an abandoned sand quarry, is a reference lake with a small watershed in a state park near Orlando, FL. Trends in concentrations of ΣDDT were significantly downward in two of these lakes, with p-values < 0.01; the trend in Lake Ballinger was not significant (p-value = 0.59). Trends in ΣPAH were upward in the two lakes in urban settings, with p-values < 0.01, whereas Sand Lake did not have a trend (p-value = 0.85). Although some details of the profiles are missed by the trend tests, the overall picture of trends in ΣDDT and ΣPAH in recent decades is reasonably represented. The magnitude of change since 1970 is also reasonably represented by the decadal-mean concentrations, indicated by shading on the graphs.

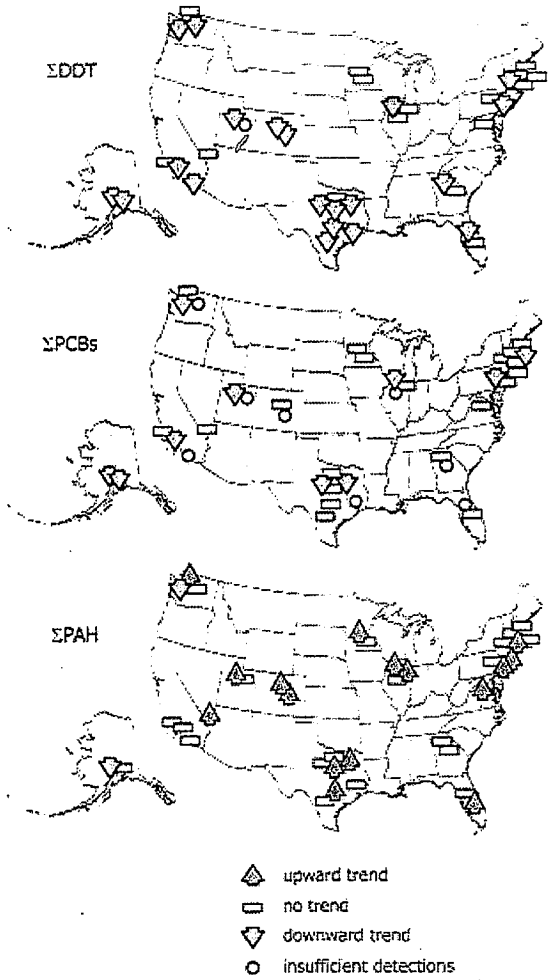

FIGURE 3. Trends in lake sediment cores from 1970 to 2001.

Results and Discussion

Trends. Two broad conclusions about trends are evident from these 38 lakes: DDT and PCB concentrations are decreasing, and PAH concentrations are increasing (Figures 3 and 4; Table 1) (see Supporting Information for trend results for all constituents by site). ΣDDT and p,p'-DDE decrease in about one-half of the lakes and increase in none; p,p'-DDD decreases in about one-half of those lakes with sufficient detections to test and increases in one lake. ΣPCB decreases in about one-quarter of the lakes and increases in none. DDT use in the United States peaked in the early 1960s and was canceled in 1972; PCB use peaked about 1970, was restricted in 1971, and was canceled in 1976 (*26*). These restrictions have resulted in widely reported decreases in the environment (*3, 4, 7*), although detections in soils, aquatic sediments, and aquatic biota remain very common (*27, 28*). About one-half of the lakes sampled showed no trend. This may be in part because of large variability in concentrations and small sample sizes at some lakes, which reduces the power of statistical tests to identify trends. For many reference lakes, a lack of a statistically significant decreasing trend in the DDTs may result from relatively small or no direct inputs during use and continuing diffuse inputs from atmospheric transport. For PCBs, all of the reference lakes either had no trend (29%) or insufficient detections to test (71%).

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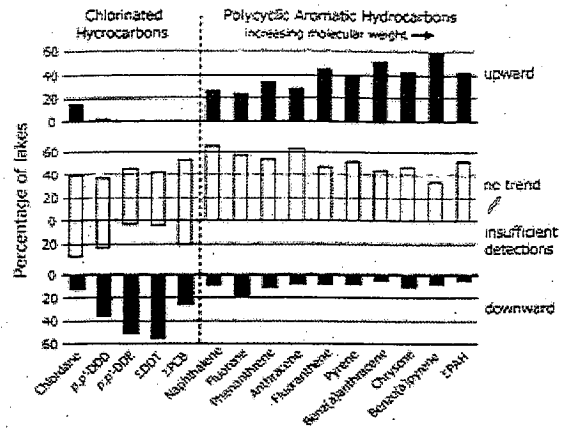

FIGURE 4. Percentage of 38 lakes with indicated trend for 1970–2001.

For chlordane, in contrast, there are roughly equal numbers of increasing and decreasing trends, and the most common result is no trend (Figure 4; Table 1). Chlordane was routinely detected in urban lakes, but the reference lakes had either no trend (29%) or insufficient detections to test (71%). As with ΣDDT and ΣPCB, the results for chlordane generally are consistent with historical use and regulation. Chlordane use in agriculture was primarily on corn, and agricultural applications were canceled in 1978, but use in urban areas, primarily for subterranean termite control, continued until 1988 (*29*). Substantial urban use by homeowners, permitted after cancellation of most other uses in 1988, was reported in 1990 (*30*). Thus, the lack of significant decreasing trends from 1970 to present is not surprising considering the test is for monotonic trend. Another factor that could result in incorrect indication of lack of trend or increasing trend is the degradation of chlordane in older aquatic sediment, which has been suggested for a few settings (*14*).

While concentrations of chlorinated hydrocarbons are relatively stable or decreasing, concentrations of PAHs are increasing. Increasing trends in ΣPAHs occur in 42% of the 38 lakes sampled, and decreasing trends occur in only 5%. Increasing trends in PAHs are almost exclusively in lakes with urbanized watersheds (Table 1). Although a few reference lakes had trends in an individual PAH, no reference lake had a trend in ΣPAH. Other researchers have reported decreasing trends in PAHs in remote and urban lakes in recent decades (e.g., *31*–*33*) and attributed the decreases to reduced use of coal for home heating, industrial emissions controls, and increased efficiency of power plants (*31*, *34*, *35*). Van Metre et al. (*6*), however, investigated PAH trends in 10 urban lakes, all of which are included in this study, and concluded most were increasing coincident with urbanization and increases in vehicle traffic in the watersheds. Here, we see increasing PAH trends in urban settings across the country.

Changes in PAH assemblages indicate combustion sources are responsible for increasing trends in the urban lakes. Increasing trends are more common as molecular weight increases (Figure 4); 26% of lakes have increasing trends for naphthalene (2 rings), 34% for phenanthrene (3 rings), 45% for fluoranthene (4 rings), and 58% for benzo[*a*]pyrene (5 rings). Combustion of hydrocarbons produces mostly higher molecular weight (4- to 7-ringed) parent PAH, whereas uncombusted fuels and organic matter contain more lower molecular weight PAH and their alkylated homologues. Combustion sources of PAHs are further indicated by changes in the ratio of 2- and 3-ringed PAH plus homologues to 4- and 5-ringed parent PAH, a value that decreases as combustion sources of PAH become more dominant (*6*). The median

TABLE 1. Summary of Trend Results and Decadal-Mean Concentrations for Selected Compounds [nd, Not Detected; PEC, Probable Effect Concentration (*25*)]

		percentage of lakes with trend of indicated type				median of decadal mean concentrations (μg/kg)		
parameter	land-use setting	increasing	decreasing	no trend	insuff det	1965–1975	1990–top of core	median percent change among lakes
ΣPAH	all lakes	42	5	53		1100	3400	41
PEC = 22 800	dense urban	50	7	43		9000	8900	74
	light urban	53	6	41		620	1300	76
	reference	0	0	100		200	320	0
phenanthrene	all lakes	34	11	55		140	240	27
PEC = 1170	dense urban	36	14	50		760	750	48
	light urban	47	6	47		56	150	49
	reference	0	14	86		26	40	21
fluoranthene	all lakes	45	8	47		270	790	61
PEC = 2230	dense urban	43	0	57		1500	2200	38
	light urban	59	6	35		120	240	93
	reference	14	29	57		35	83	−7
benzo[*a*]pyrene	all lakes	58	8	34		81	350	78
PEC = 1450	dense urban	57	0	43		580	1500	84
	light urban	76	6	18		50	120	105
	reference	14	29	57		7	20	5
chlordane	all lakes	16	13	39	32	12	26	0
PEC = 17.6	dense urban	36	14	50		52	92	−20
	light urban	6	18	35	41	8	4	nd
	reference	0	0	29	71	nd	nd	nd
ΣDDT	all lakes	0	55	42	3	45	17	−69
PEC = 572	dense urban	0	43	57		107	29	−68
	light urban	0	71	29		27	9	−73
	reference	0	43	43	14	7	4	−53
ΣPCBs	all lakes	0	26	53	21	65	43	−47
PEC = 676	dense urban	0	29	71		275	108	−59
	light urban	0	35	47	18	51	15	−61
	reference	0	0	29	71	nd	nd	nd

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of this ratio in the 38 lakes decreased from 1.05 in 1970 to 0.58 in the 1990s; among the lakes with an increasing trend in ΣPAH, the decrease was from 0.90 in 1970 to 0.39 in the 1990s.

Concentrations and Relations to Urban Land Use. In addition to the direction of trends, the magnitude of change in concentrations over time and the concentration in recent sediment in these lakes are important indicators of environmental condition. Median values of decadal-mean concentrations for 1965–75 and 1990 to top-of-core (Table 1) and percent change in concentrations for individual lakes show pronounced increases or decreases consistent with trends. The mean ΣDDT concentration in the 1990s was lower than the mean 1970 concentration in 34 of the 38 lakes (89%), and the median percent change was a decrease of 69%. For ΣPCB, 28 lakes (74%) had a decrease in mean concentration, and the median change was a decrease of 47%. Decadal-mean concentrations of chlordane are consistent with the general lack of trends, with 14 lakes increasing, 16 lakes decreasing, and a median change of 0%. In contrast, 28 of the 38 lakes had increases in decadal-mean concentrations of ΣPAH, and the median change was a 41% increase.

Urban land use exerts a strong influence on HOC concentrations, as indicated by differences in the decadal-mean concentrations by land-use setting (Table 1). Spearman's rank correlations between percent urban land use and concentration were significant for all compounds listed in Table 1 (all p-values < 0.003). Categorization of sites in groups by urban land use percentages for this study is based on the NLCD92 land use data for 1992 (*17*). To explore relations between land-use change and contamination in the 1970s and the 1990s, a land-use data set is needed for the 1970s. An earlier national land use data set is available for the 1970s (GIRAS (*36*)), but because of different classification schemes, the 1970s GIRAS and the NLCD92 data set are not sufficiently consistent for representation of land use change at the small urban watershed scale. Therefore, an alternative method for evaluating urban land-use change over the time period trend tested in the cores was used: the 1970s GIRAS data were compared to the 1970s GIRAS data updated with 2000 U.S. Census population data compiled at the block-group level to estimate new residential area (*37*). The GIRAS and the updated GIRAS were used in relation to mean decadal concentrations and mean decadal mass accumulation rates of contaminants (MAR_C: the product of sediment MAR and contaminant concentration) to evaluate relations to urbanization in more detail.

Decadal mean contaminant concentrations and MAR_C in the cores show strong relations to urban land use (Figure 5). Lines in Figure 5 are regression equations relating percentage of urban land use to the logarithm of concentration or of MAR_C (Table 2). In every case, the slope is significant at greater than 99.9% confidence (p-value < 0.001). The strengths of the relations were roughly similar using concentrations and MAR_C, although some differences are evident graphically (Figure 5). For all four contaminants, there is less scatter among the reference sites (urban land use at or near 0%) using MAR_C. Input of contaminants to the reference lakes is dominated by atmospheric deposition; thus concentrations will usually vary inversely with sediment MAR (more sedimentation causes more dilution). In these settings, a more representative measure of contaminant input is achieved using the MAR_C and less scatter about the regression lines results. In lakes with urban development in the watershed, in contrast, there is wider scatter about the regression lines using MAR_C than those using concentration (Figure 5). In urban settings, MAR_C scales to sediment MAR because most of the contaminant loading is via fluvial particulate loading from the watershed (*13*, *14*). Higher sedimentation rates can result in higher MAR_C, even for similar anthropogenic source strength in the watershed (in effect, greater sediment focusing). In this case, concentrations might be more representative of historical changes in contaminant releases to the watershed than are MAR_C's.

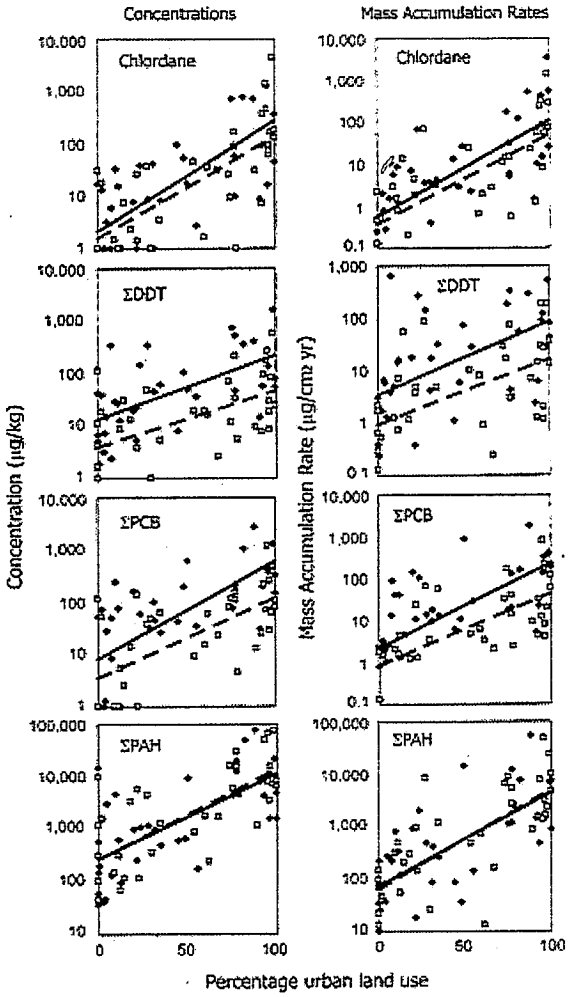

FIGURE 5. Mean concentration in lake cores in 1970 (1965–1975) (◆) and the 1990s (1990 to the top of the core) (□) as compared to percentage urban land use in the watershed. Lines on each graph are regressions fit to logarithms of concentrations or contaminant mass accumulation rates. Black line is fit to 1970 data; dashed line is fit to 1990s data.

On the basis of regression line slope, chlordane has the strongest relation to urban land use, followed by ΣPCB and ΣPAH. All three of these have (or had) many urban sources and limited rural sources, whereas ΣDDT, which here has a weaker relation to urban land use, was used heavily in agricultural areas and occasionally in forested and other more remote areas. The relative strength of the relation is also evident in the number of log cycles the lines cross, with about 2 cycles (factor of 100) for chlordane, about 1.5 for ΣPCB and ΣPAH, and about 1 cycle (factor of 10) for ΣDDT.

Chlordane, with about equal numbers of increasing and decreasing trends, has a small decrease in the regression lines between time periods (Figure 5). ΣDDT and ΣPCB decrease markedly, about one-half a log cycle. For ΣDDT, the decrease is uniform across the range in land use, but for ΣPCB narrows with less urban land use, with mostly nondetections in the reference settings in both time periods

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TABLE 2. Regression Equations and Statistics Relating Logarithm of Concentrations and Logarithm of Contaminant Mass Accumulation Rates to Percent Urban Land Use [Land Use for the 1970s Is Based on the GIRAS Data (*36*), and Land Use for the 1990s Is GIRAS Updated Using the U.S. Census Data (*37*)]

parameter	equation	n	*p*-value slope	*p*-value intercept	*F*-statistic	r^2	standard error of the estimate
			1970s				
log(ΣPAH)	0.0161(lu) + 2.43	38	<0.001	<0.001	30.5	0.46	0.66
log(chlordane)	0.0211(lu) + 0.325	38	<0.001	0.068	44.4	0.55	0.72
log(ΣDDT)	0.0123(lu) + 1.12	38	<0.001	<0.001	19.7	0.35	0.63
log(ΣPCB)	0.0188(lu) + 0.898	38	<0.001	<0.001	36	0.5	0.71
log(ΣPAH MAR)	0.0179(lu) + 1.86	38	<0.001	<0.001	37.5	0.51	0.66
log(chlordane MAR)	0.0228(lu) − 0.249	38	<0.001	0.19	40.7	0.53	0.81
log(ΣDDT MAR)	0.0141(lu) + 0.547	38	<0.001	0.008	15.6	0.3	0.81
log(ΣPCB MAR)	0.0206(lu) + 0.325	38	<0.001	0.12	30.7	0.46	0.84
			1990s				
log(ΣPAH)	0.0170(lu) + 2.43	38	<0.001	<0.001	40.9	0.53	0.63
log(chlordane)	0.0193(lu) + 0.197	38	<0.001	0.3	44.6	0.55	0.69
log(ΣDDT)	0.0107(lu) + 0.591	38	<0.001	0.002	15.4	0.3	0.65
log(ΣPCB)	0.0154(lu) + 0.543	38	<0.001	0.004	31.3	0.47	0.65
log(ΣPAH MAR)	0.0190(lu) + 1.81	38	<0.001	<0.001	45.1	0.56	0.67
log(chlordane MAR)	0.0213(lu) − 0.425	38	<0.001	0.054	41.5	0.54	0.78
log(ΣDDT MAR)	0.0126(lu) − 0.031	38	<0.001	0.88	15.2	0.3	0.77
log(ΣPCB MAR)	0.0174(lu) − 0.080	38	<0.001	0.68	32.9	0.48	0.72

for ΣPCB (nondetections were entered in the plots and regressions at the method reporting level). Despite the strong relations to urban land use for these "legacy" pollutants, increases in urban land use in individual watersheds since the 1970s did not translate into increasing trends. The median percent change in urban land use for the light urban watersheds from the 1970s to 2000, based on the land-use data sets used here, is a 115% increase. Among the dense urban watersheds, the median is no change (1% increase), although some of these watersheds experienced growth. The lack of increasing trends, especially for ΣDDT and ΣPCB, which were banned in the 1970s, indicates that recently urbanized areas are not contributing significantly to contamination of legacy pollutants.

ΣPAH shows a relation similar to urban land use in both the 1970s and the 1990s; thus the strong relations to urban land use and frequent increasing trends suggest that increasing urbanization, rather than an increase in the relative strength of urban sources, is responsible for the increase in PAHs. Light urban lakes had the most urban growth (proportionally) and the most frequent increasing trends in PAH, with 76% having an increasing trend in benzo[*a*]pyrene, although benzo[*a*]pyrene also increased in over 50% of dense urban lakes (Table 1). Palmer Lake in Minneapolis, MN, illustrates the magnitude of PAH increase with urbanization: urban land used increased from 28% in the 1970s to 74% in 2000, and decadal mean ΣPAH concentrations increased from 1190 to 16 100 μg/kg from 1970 to the 1990s. In a general sense, increased urbanization can explain increasing concentrations in PAHs, but their specific sources in the urban landscape are not as clear. Van Metre et al. (*6*) showed that PAH increases exceeded the rate of growth in urban land use for 10 lakes (all included here) and suggested that rapid increases in vehicle traffic in urban areas could be a contributing factor. Another possible factor recently reported is the use of parking lot sealants, many of which contain high concentrations of coal tar (20−35 wt %) and could be the dominant source of PAHs in some urban watersheds (*38*).

Rate of Change of DDT and PCBs. Van Metre et al. (*4*) found that concentrations of ΣDDT and ΣPCB followed an exponential decline since about 1970 in cores from 11 U.S. reservoirs, suggesting a first-order process. Three of the lakes used in that study are used in this study. First-order regression models fit to the concentration profiles yielded median half-lives of 12 and 9.6 yr for ΣDDT and ΣPCB, respectively. Decadal-mean concentrations for lakes presented here with detections in both time periods (36 lakes for ΣDDT and 30 for ΣPCB) were used to estimate half-lives, assuming a first-order process (exponential decrease). The median half-life for ΣDDT was 14.9 yr, and the median for ΣPCB was 19.7 y (interquartile ranges of 11.5−25 yr for ΣDDT and 14.4−47 yr for ΣPCB). The slightly longer half-lives (slower rate of decrease) than those found by (*4*) could result partly from using the mean value from 1965 to 1975 as the starting point instead of the peak concentration, and from inclusion here of reference lakes.

These half-lives can provide an estimate of expected changes in loading of persistent HOCs to aquatic systems following cessation of use. The lakes with detections of HOCs are mostly urban lakes, and most have relatively large DA:SA ratios. As a result, in these lakes the contaminant levels in surficial sediments are controlled primarily by recent loading from the watershed. Rates of change in concentrations of legacy pollutants in such systems are an indication of chemical processes in soils and erosion and transport of soil from the watershed, with historically contaminated soils gradually less available to erosion and transport to streams (*4*, *14*). This is in contrast to large systems such as the Great Lakes, large estuaries, and the oceans, where contaminant occurrence in surficial bottom sediments can be influenced greatly by atmospheric processes and internal cycling (*39*−*41*).

Implications. PCBs, DDT, dieldrin, and chlordane are responsible for many of the fish-consumption advisories in the United States (*42*). Are the 15−20-year half-lives for DDT and PCBs in sediments an indication of trends in fish? The National Contaminant Biomonitoring Program sampled fish at approximately 100 sites across the country, mostly in rivers, on an annual or bi-annual basis during 1969−86 (*7*, *43*). Regression equations fit to the natural logarithm of annual median fish concentrations yield half-lives of 7.0 (5.9−8.6, based on the standard error of the slope) and 5.5 (4.5−7.1) yr for ΣDDT and PCB Aroclor 1254 (the only PCB measure that spans the entire sampling period), respectively. These are approximately one-half to one-quarter the median half-lives in the sediment cores, indicating that concentrations, on average, decreased more than twice as fast in fish as in

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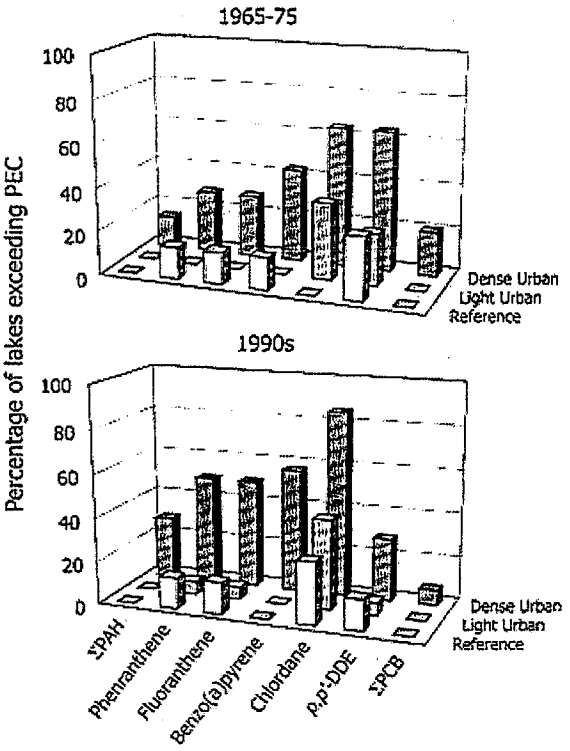

FIGURE 6. Percentage of lakes with a decadal-mean concentration exceeding the probable effect concentration (25).

cores. Although sediments are recognized as the primary reservoir of HOCs available to fish, the relations between fish and sediment are complex and not completely understood (*44*). Are concentrations decreasing more slowly in sediments than they are in fish? If so, could it be an indication of the effects of aging and sequestration on the bioavailability of HOCs in sediment (*45*)? Or does fish metabolism lead to more rapid reductions in fish than in sediment? These and other questions remain as to whether rates of contaminant decrease modeled in sediment cores can be extrapolated to other media and what factors control trends in each medium.

In addition to concerns for bioaccumulation, the HOCs presented here can be toxic to benthic biota, prompting the development of sediment quality guidelines (*25*). To assess the significance of trends in cores in relation to potential toxicity to aquatic biological communities, decadal-mean concentrations were compared to PECs, the concentration above which adverse effects on benthic biota are likely (*25*). Of the compounds examined, chlordane most frequently exceeds the PEC in the 1990s, followed by several individual PAHs and *p,p'*-DDE (Figure 6). The frequency with which both *p,p'*-DDE and ΣPCB exceed the PEC declined by more than one-half from 1970 to the 1990s, consistent with decreasing trends observed in both. Conversely, the frequency with which PAHs exceed the PEC approximately doubled during the same time period. Individual PAHs frequently exceed the PEC in the dense urban lakes but not in the other lakes.

The implications of the comparisons to PEC values and the concern for bioavailability extend to the streams flowing into these lakes and reservoirs. Van Metre and Mahler (*14*) showed that concentrations of HOCs in suspended sediment in urban streams are similar to or greater than concentrations in downstream reservoir sediments, often by a factor of 2 or more. This implies that reservoir sediment cores could underestimate the potential risk posed by HOCs to biota in urban streams. The increasing trends in PAH concentrations, the strong association of PAHs with urban settings, and the rapid urbanization occurring in the United States suggest that PAHs could surpass chlorinated hydrocarbons in the threat posed to aquatic biota in urban streams and lakes. Also, while improvements brought about by regulation of chlorinated hydrocarbons are occurring, the continuing high levels of chlordane and the slow rate of decreasing trends for DDT and PCBs indicate that chlorinated hydrocarbons will remain a concern for many years to come.

Acknowledgments

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Supporting Information Available

One figure and three tables. This material is available free of charge via the Internet at http://pubs.acs.org.

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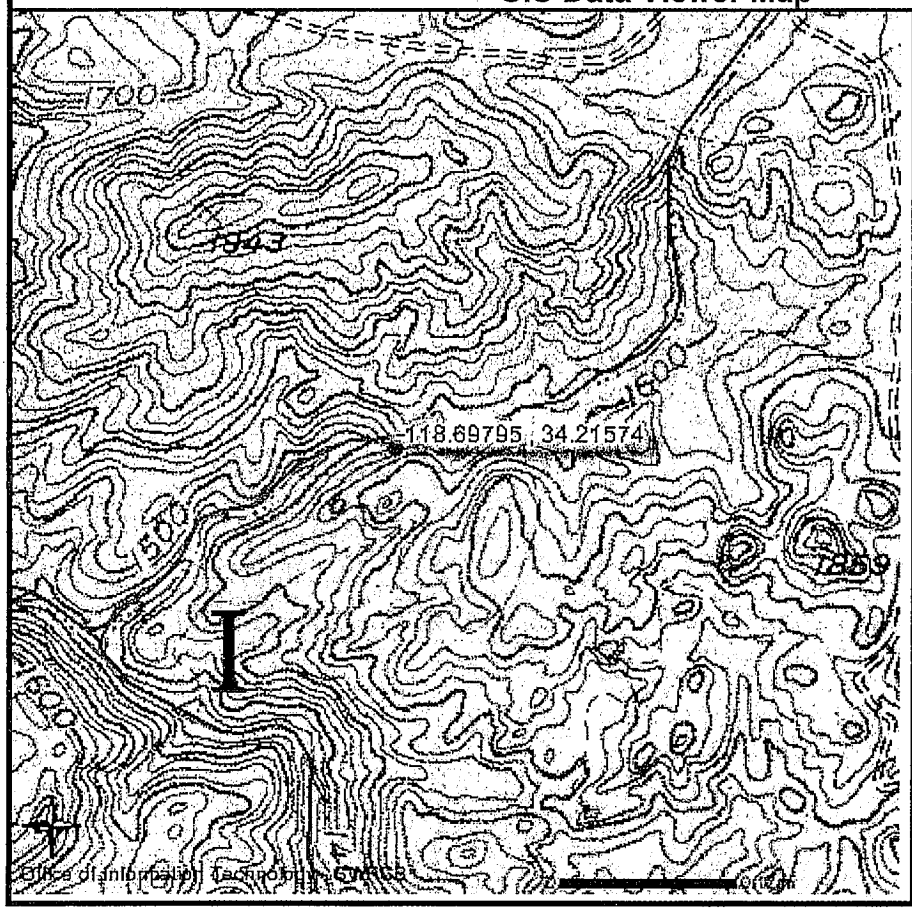
GIS Data Viewer Map



LEGEND

Highways

- Interstate
- US Highway
- State Highway

Rivers (100K)

Lakes (100K)

USGS
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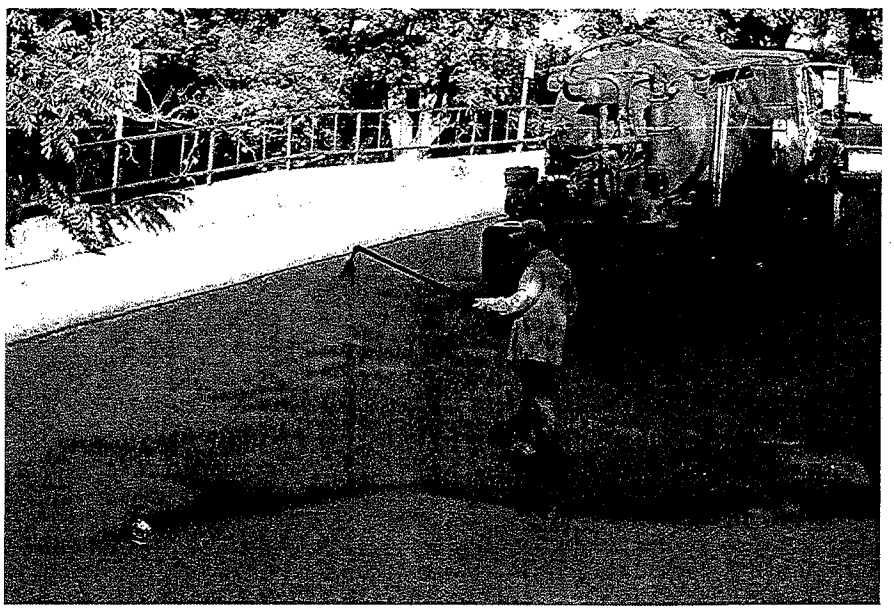
Prepared in cooperation with the City of Austin, Texas

Parking Lot Sealcoat: A Major Source of Polycyclic Aromatic Hydrocarbons (PAHs) in Urban and Suburban Environments

By Peter C. Van Metre[1], Barbara J. Mahler[1], Mateo Scoggins[2], and Pixie A. Hamilton[1]

Collaborative studies by the City of Austin and the U. S. Geological Survey (USGS) have identified coal-tar based sealcoat—the black, shiny emulsion painted or sprayed on asphalt pavement such as parking lots—as a major and previously unrecognized source of polycyclic aromatic hydrocarbon (PAH) contamination. Several PAHs are suspected human carcinogens and are toxic to aquatic life. Studies in Austin, Texas, showed that particles in runoff from coal-tar based sealcoated parking lots had concentrations of PAHs that were about 65 times higher than concentrations in particles washed off parking lots that had not been sealcoated. Biological studies, conducted by the City of Austin in the field and in the laboratory, indicated that PAH levels in sediment contaminated with abraded sealcoat were toxic to aquatic life and were degrading aquatic communities, as indicated by loss of species and decreased numbers of organisms. Identification of this source of PAHs may help to improve future strategies for controlling these compounds in urban water bodies across the Nation where parking lot sealcoat is used.



Particles in runoff from coal-tar based sealcoated parking lots had concentrations of PAHs that are about 65 times higher than concentrations in particles washed off parking lots that had not been sealcoated.

What are PAHs, coal tar, and sealcoat?

Polycyclic aromatic hydrocarbons (or PAHs) are a group of organic contaminants that form from the incomplete combustion of hydrocarbons, such as coal and gasoline. PAHs are an environmental concern because they are toxic to aquatic life and because several are suspected human carcinogens.

Coal tar is a byproduct of the coking of coal, and can contain 50 percent or more PAHs by weight.

Sealcoat is a black liquid that is sprayed or painted on asphalt pavement in an effort to protect and beautify the asphalt. Most sealcoat products are coal-tar or asphalt based. Many coal-tar sealcoat products contain as much as 30 percent coal tar by weight. Product analyses by the City of Austin indicated that coal-tar sealcoat products have median concentrations of total PAHs about 70 times higher than concentrations in asphalt-based sealcoat products.

Sealcoat is used commercially and by homeowners across the Nation. It is applied to residential driveways and to parking lots associated with commercial businesses (including strip malls and shopping centers), apartment and condominium complexes, churches, schools, and business parks. The City of Austin, Texas, estimates that about 600,000 gallons of sealcoat are applied every year in the greater Austin area. National use numbers are not available, but commercial availability suggests that asphalt-based sealcoat is commonly used on the West Coast and coal-tar based sealcoat is commonly used in the Midwest, the South, and on the East Coast.

U.S. Department of the Interior
U.S. Geological Survey

Fact Sheet 2005–3147
January, 2006

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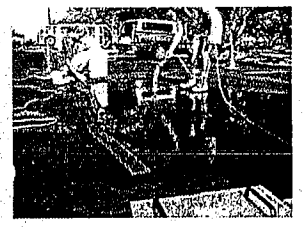
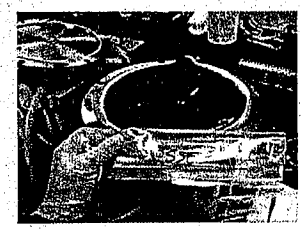
How did USGS study parking lot runoff?

USGS researchers sampled runoff at 13 parking lots in Austin. They also took scraping samples of parking lot surfaces to compare source materials to particles in the runoff. Scraping samples and the water and particles in the runoff samples were analyzed for a suite of PAHs, major elements, and trace elements. The researchers sprayed water on four different types of parking lot surfaces: lots sealed with coal-tar based sealcoat (top photo), lots sealed with asphalt-based sealcoat, unsealed asphalt lots, and unsealed concrete lots. The runoff was collected behind spill berms, pumped into containers (middle photo) and filtered through Teflon filters to collect the particulates for analysis (bottom photo). The particulates, the filtered water, and samples of sealcoat scraped from the parking lot surfaces were analyzed for PAHs at the USGS National Water Quality Laboratory in Denver, Colorado. Concentrations and yields (the amount of PAHs coming off a parking lot per unit area) were used to determine levels of contamination in runoff from each type of parking lot and the importance of sealed lots as a source of PAHs to urban streams.





How does sealcoat get from parking lots into the environment?

Vehicle tires abrade parking lot sealcoat into small particles. These small particles are washed off parking lots by precipitation and into storm sewers and streams. Sealcoat "wear and tear" is visible in high traffic areas within a few months after application. Sealcoat manufacturers recommend reapplication every 2 to 3 years.

What are potential environmental and human-health concerns?

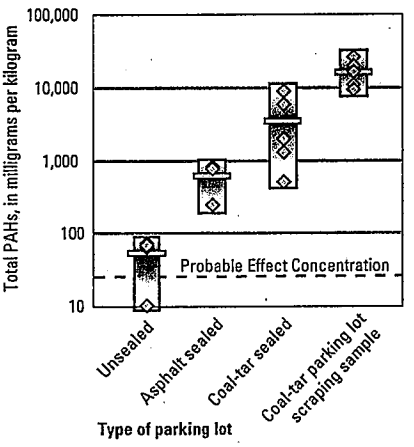
PAHs are toxic to mammals (including humans), birds, fish, amphibians, invertebrates, and plants. Aquatic invertebrates, the insects and other small animals that live in streams and lakes, are particularly susceptible to PAH contamination, especially the bottom dwellers (benthic invertebrates) that live in the mud where PAHs tend to accumulate. They are an important part of the food chain and are often monitored as indicators of stream quality (analogous to the "canary in the coal mine" concept). Possible effects of PAHs on aquatic invertebrates include inhibited reproduction, delayed emergence, sediment avoidance, and mortality, and possible adverse effects on fish include fin erosion, liver abnormalities, cataracts, and immune system impairments. PAHs tend to attach to sediment; the Probable Effect Concentration (PEC)—a widely used sediment-quality guideline that is the concentration of a contaminant in bed sediment expected to adversely affect benthic (or bottom-dwelling) biota—is 22.8 mg/kg (milligrams per kilogram) for total PAHs.

Studies by USGS and City of Austin did not evaluate human-health risk from exposure to sealcoat. Human-health risk from environmental contaminants is often evaluated in terms of exposure pathways. For example, people could potentially be exposed to PAHs in sealcoat through skin contact with abraded particles from parking lots, inhalation of wind-blown particles, and inhalation of fumes that volatilize from sealed parking lots. PAHs in streams and lakes rarely pose a human-health risk via drinking water because of their tendency to attach to sediment rather than dissolve in water. In addition, because PAHs do not readily bioaccumulate within the food chain, possible human-health risks associated with consumption of fish are low.

What are the concentrations of PAHs in runoff from sealed and unsealed parking lots?

Concentrations of PAHs in particles (including abraded sealcoat along with urban dust and other sediment) washed off from each of the different surface types—including the unsealed parking lots—were greater than the PEC of 22.8 mg/kg. The average concentration in particles washed off parking lots that were not sealcoated was 54 mg/kg. This is not surprising because runoff from parking lots is likely to contain PAHs from many sources, including leaking motor oil, tire particles, vehicle exhaust, and atmospheric deposition.

Concentrations of PAHs were much higher in particles in runoff from parking lots sealed with coal-tar based sealcoat than from all other types of parking lot surfaces. Specifically, the average concentration of PAHs from coal-tar sealed lots was 3,500 mg/kg, about 65 times higher than the average concentration in particles washed off unsealed parking lots. The average concentration in par-



Concentrations of total PAHs in particles in runoff from sealed parking lots greatly exceeded concentrations from unsealed parking lots. The bar on each graph is the mean concentration. The y-axis is logarithmic.

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ticles washed off parking lots sealed with asphalt-based sealcoat was 620 mg/kg, about 10 times higher than the average concentration from unsealed parking lots and 6 times less than the average concentration from coal-tar sealed lots.

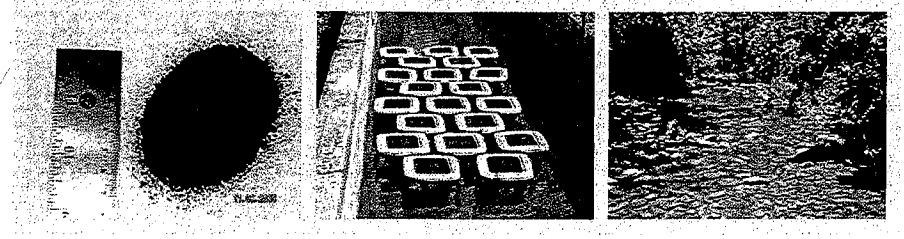
The large differences between concentrations associated with sealed and unsealed parking lots indicate that abraded sealcoat is a major and previously unrecognized contributor to PAH contamination.

How do PAHs from sealcoat affect the quality and biology of streams?

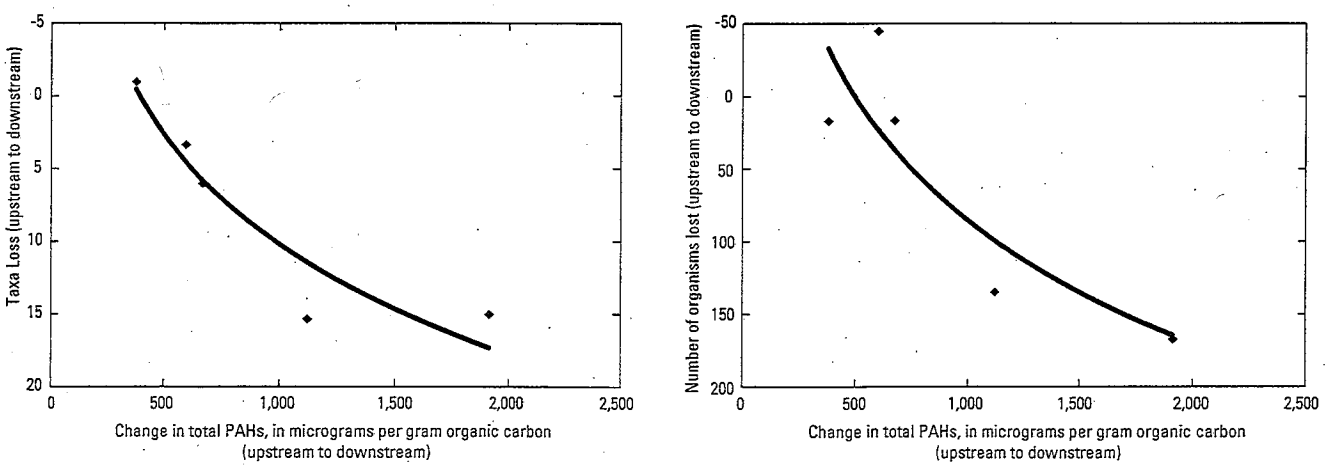
Studies by USGS scientists demonstrated possible connections between PAHs in particles washed off sealed parking lots and PAHs in suspended sediment in four streams in Austin and Fort Worth, Texas. The total mass of PAHs (or "load") expected to wash off sealed parking lots was compared to the load of PAHs measured in suspended sediment in the four streams after rainstorms. The load of PAHs estimated to come from the sealed parking lots was comparable to the measured load in the streams, indicating that runoff from sealed parking lots could account for the majority of PAHs in these streams. Findings also showed that PAHs in suspended sediment in the streams were chemically similar to those in particles washed off parking lots sealed with coal-tar based sealcoat. What would be the effect on PAH loading to the streams if parking lots were not sealed? Estimates from the USGS study indicate that total loads of PAHs coming from parking lots in the studied watersheds would be reduced to about one-tenth of their current levels if all of the parking lots were unsealed.

How did City of Austin scientists conduct biological studies?

City of Austin biologists conducted laboratory and field studies to evaluate the effects of sealcoated parking lots on aquatic communities in area streams. These studies included toxicity testing in controlled laboratory experiments that exposed organisms to sediment spiked with coal-tar and asphalt-based sealcoat (left photo); controlled experiments that used aquariums with diverse natural biological communities to which sealcoat was added (middle photo); and field assessments of aquatic communities in streams upstream and downstream from inflows of runoff from sealcoated parking lots (right photo).



Studies by City of Austin biologists showed that PAHs in sediment contaminated with abraded sealcoat could be adversely affecting aquatic communities. Specifically, toxicity testing of organisms in the laboratory showed large increases in mortality as sealcoat amounts and PAH concentrations were increased, and that sediment contaminated with coal-tar sealcoat was toxic to aquatic life at PAH concentrations observed in Austin waterways. Controlled experiments that used aquariums with diverse natural biological communities showed significant biological degradation in response to the addition of sealcoat particles. Finally, field assessments in selected Austin streams showed loss of species and decreases in the number of aquatic organisms downstream from inflows of runoff from coal-tar sealcoated parking lots. These effects coincided with increases in concentrations of PAHs in stream sediment below sealcoated parking lots. Overall, City of Austin scientists have reported PAH contamination at levels predicted to be toxic to benthic invertebrates in about 13 percent of sampled Austin creeks.



Field assessments in five selected Austin streams showed loss of species (taxa) and decreases in the number of aquatic organisms downstream of coal-tar sealcoated parking lots that can be, in large part, explained by increases in total PAHs.

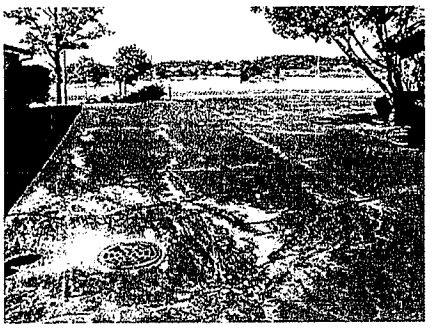
How do these findings apply to urban lakes and reservoirs?

The concentrations of PAHs in lakes and reservoirs across the Nation are increasing, as indicated by USGS studies of 38 reservoirs and lakes conducted in 18 metropolitan areas across the country (Van Metre and Mahler, 2005). Sediment cores (vertical tubes of mud) were collected from reservoir and lake bottoms (see photo below); analysis of these cores provides a reconstruction of historical water quality over time, much like using tree rings to reconstruct historical climate. Runoff carries soil, debris, and attached contaminants to lakes and reservoirs, which settle to the bottom; as the sediment builds up, changes in water quality are recorded in the successive sediment layers.

USGS findings show that concentrations of total PAHs in the majority of lakes and reservoirs in urban and suburban areas across the Nation increased significantly from 1970 to 2001. The increases were greatest in lakes with rapidly urbanizing watersheds (urban sprawl); for example, over the last 10 years, the concentrations of PAHs in Lake in the Hills (suburban Chicago, Illinois) increased ten-fold as the watershed was rapidly developed. Further study is needed to assess direct links between the use of sealcoat and PAH trends in these urban lakes and reservoirs across the Nation.

What are the implications of these studies?

The study of parking lot surfaces by the USGS and the City of Austin show that abraded sealcoat could be a major source of PAHs to urban and suburban water bodies in watersheds across the Nation where sealcoat is used. Such findings have implications that extend beyond Texas as sealcoat is used nationwide; further studies would help to evaluate the potential impacts of sealcoat on the aquatic environment in other parts of the country. Identification of this source may influence future strategies for controlling PAHs in urban environments. In the past, sources of PAHs in urban watersheds were thought to be dominated by numerous nonpoint sources, such as leaking motor oil, tire wear, vehicular exhaust, and atmospheric deposition. Such sources are difficult to quantify or control because of their diffuse nature. In contrast, sealcoated parking lots are specific areas that contribute directly to urban stormwater runoff (see photo below), and the use of sealcoat is voluntary and controllable. To address PAH contamination in streams, the City of Austin Council banned the use of coal-tar based sealcoat, effective January 2006 (Nancy McClintock, written communication, City of Austin, November 2005).



Possible alternatives to coal-tar based sealcoating of parking lots and driveways include the use of concrete and unsealed asphalt pavement, and the use of asphalt-based sealcoat that contains lower levels of PAHs.

Currently, the use of coal-tar based sealcoat is not federally regulated. In 1992, the U.S. Environmental Protection Agency excluded coke product residues, including coal tar, from classification as hazardous wastes if they are recycled. Under the Resource Conservation and Recovery Act, coal-tar based pavement sealants are products that contain recycled coal tar and, therefore, are not regulated.

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Links to related publications, data and maps

City of Austin Coal Tar Sealant Information–
http://www.ci.austin.tx.us/watershed/bs_coaltar.htm

USGS frequently asked questions–
http://water.usgs.gov/nawqa/asphalt_sealers.html

Basic information on the toxicity of PAHs to biological organisms, U.S. Environmental Protection Agency (USEPA)–
http://www.epa.gov/R5Super/ecology/html/toxprofiles.htm#pahs

General information on PAH exposure, Agency for Toxic Substances and Disease Registry (ATSDR)–
http://www.atsdr.cdc.gov/toxprofiles/phs69.html

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[1] U.S. Geological Survey
[2] City of Austin

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Environ. Sci. Technol. 2005, 39, 5560–5566

Parking Lot Sealcoat: An Unrecognized Source of Urban Polycyclic Aromatic Hydrocarbons

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Polycyclic aromatic hydrocarbons (PAHs) are a ubiquitous contaminant in urban environments. Although numerous sources of PAHs to urban runoff have been identified, their relative importance remains uncertain. We show that a previously unidentified source of urban PAHs, parking lot sealcoat, may dominate loading of PAHs to urban water bodies in the United States. Particles in runoff from parking lots with coal-tar emulsion sealcoat had mean concentrations of PAHs of 3500 mg/kg, 65 times higher than the mean concentration from unsealed asphalt and cement lots. Diagnostic ratios of individual PAHs indicating sources are similar for particles from coal-tar emulsion sealed lots and suspended sediment from four urban streams. Contaminant yields projected to the watershed scale for the four associated watersheds indicate that runoff from sealed parking lots could account for the majority of stream PAH loads.

Introduction

Concentrations of polycyclic aromatic hydrocarbons (PAHs)—a group of widely recognized aquatic contaminants (*1*) comprising numerous carcinogens (*2*)—have been increasing in recent decades in many urban lakes, particularly in areas undergoing rapid urban growth (*3*). PAHs adversely affect mammals (including humans), birds, fish, amphibians, invertebrates, and plants; in the aquatic environment, the effects of PAHs on invertebrates include inhibited reproduction, delayed emergence, sediment avoidance, and mortality, and the effects on fish include fin erosion, liver abnormalities, cataracts, and immune system impairments (*4*). Numerous sources of PAHs to urban runoff have been identified, including automobile exhaust, lubricating oils, gasoline, tire particles, erosion of street material, and atmospheric deposition (*5*–*8*), but uncertainty remains as to their relative importance. Investigations of urban sources of PAHs have thus far overlooked a potentially major source: parking lot sealants, also called "sealcoat". Our objective in this study was to evaluate the contribution of PAHs from sealed parking lots to urban streams.

In the United States and Canada, sealcoat is applied to many parking lots and driveways in an effort to protect the underlying asphalt pavement and enhance appearance. The two primary sealcoat materials on the market are refined coal-tar-pitch-based emulsion and asphalt-based emulsion. Although similar in appearance (glossy black), coal tar and asphalt have different molecular structures stemming from their origins: coal tar is a byproduct of the production of coke from coal, whereas asphalt is derived from the refining of crude petroleum. Coal tar, a known human carcinogen, is 50% or more PAHs by weight (*2*); the predominant constituents of asphalt are bitumens, complex mixtures of hydrocarbons that include asphaltenes, saturates, aromatics, and resins (*9*). Coal-tar-emulsion- and asphalt-emulsion-based sealcoats typically contain 20–35% of the emulsion.

Parking lot sealants are used extensively in the United States and Canada. Although national use figures are not available, the *Blue Book of Building and Construction* (*10*), a directory for the construction industry, lists over 3300 pavement sealant companies in 28 U.S. states. One company advertises the application of 1.7 billion liters to date worldwide (*11*), and another reports having sealed over 33 million square meters (*12*). The City of Austin, population 650000 (2000 census), estimates that about 2.5 million liters of sealcoat is used annually in this city (*13*).

Sealcoat abrades from the parking lot surface relatively rapidly, and reapplication is recommended every two to three years (*14*). In 2003, the City of Austin identified abraded parking lot sealcoat as a possible source of high concentrations of PAHs in streambed sediment (*15*). Here we present evidence suggesting that parking lot sealcoat could indeed be the dominant source of PAHs to watersheds with residential and commercial development.

Experimental Section

Sample Collection. We compared concentrations and yields of particulate PAHs in simulated runoff from parking lots sealed with coal-tar-based sealcoat, from lots sealed with asphalt-based sealcoat, and from unsealed asphalt and cement lots. Thirteen urban parking lots, representing a range of sealant types that are currently in use in Austin, TX, were sampled (Table 1). In addition, four test plots, each about 120 m^2, were sampled. Three of the test plots were sealed just prior to testing, and one was left unsealed (asphalt surface). The test plots are at the Robert Mueller Municipal Airport, Austin, TX, which has been closed since 1999. A full description of the sampling is given in ref *16*. In brief, 50 m^2 areas of each parking lot and the test plots were sprinkled with 2 mm of distilled water (100 L over a 50 m^2 area) to simulate a light rain, and concentrations of PAHs were analyzed in particles filtered from the runoff. The study focused on the particulate fraction, as PAHs in urban runoff, particularly those of higher molecular weight, are mostly associated with particulates (*7*, *17*); for selected samples (test plots and seven parking lots), the dissolved phase also was analyzed. The testing followed a minimum of 5 days with no rainfall. The parking lots were sampled once, and the test plots were sampled three times over a 6 week period. Water was sprayed from a plastic hand-held sprayer at a rate of about 7 L/min from a height of about 0.75 to 1 m. Spill berms were used at the down-slope end of the delineated area to gather water, which was then pumped into high-density polyethylene (HDPE) containers (Figure S1, Supporting Information). Recovery of water and observations about losses of water to wetting and leakage under the berms were noted. The water was returned to the laboratory, poured into a 50 L churn to keep the sample well mixed, and filtered through 0.45 μm pore size PTFE filters. The filters were

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TABLE 1. Sampling Site Characteristics

site name	surface type	date of sealant application	sampling date	study component
$CT_{TP}1$	coal-tar emulsion sealant	Aug 5–6, 2003	8/21/2003	test plot
$CT_{TP}2$	coal-tar emulsion sealant	Aug 5–6, 2003	8/21/2003	test plot
AS_{TP}	asphalt emulsion sealant	Aug 5–6, 2003	8/21/2003	test plot
$UNSAS_{TP}$	unsealed asphalt pavement	Aug 5–6, 2003	8/21/2003	test plot
$CT_{TP}1$	coal-tar emulsion sealant		9/9/2003	test plot
$CT_{TP}2$	coal-tar emulsion sealant		9/9/2003	test plot
AS_{TP}	asphalt emulsion sealant		9/9/2003	test plot
$UNSAS_{TP}$	unsealed asphalt pavement		9/9/2003	test plot
$CT_{TP}1$	coal-tar emulsion sealant		9/26/2003	test plot
$CT_{TP}2$	coal-tar emulsion sealant		9/26/2003	test plot
AS_{TP}	asphalt emulsion sealant		9/26/2003	test plot
$UNSAS_{TP}$	unsealed asphalt pavement		9/26/2003	test plot
$AS_{PL}1$	asphalt emulsion sealant	June 2003	9/7/2003	parking lot
$AS_{PL}2$	asphalt emulsion sealant	June 2003	9/7/2003	parking lot
$AS_{PL}3$	asphalt emulsion sealant	July 2003	9/28/2003	parking lot
$CT_{PL}1$	coal-tar emulsion sealant	March 2003	9/7/2003	parking lot
$CT_{PL}2$	coal-tar emulsion sealant	July 2003	9/28/2003	parking lot
$CT_{PL}3$	coal-tar emulsion sealant	July 2003	9/28/2003	parking lot
$CT_{PL}4$	coal-tar emulsion sealant	July 2003	9/30/2003	parking lot
$CT_{PL}5$	coal-tar emulsion sealant	July 1999	9/30/2003	parking lot
$CT_{PL}6$	coal-tar emulsion sealant	Nov 2000	9/30/2003	parking lot
$UNSAS_{PL}1$	unsealed asphalt pavement		9/8/2003	parking lot
$UNSAS_{PL}2$	unsealed asphalt pavement		9/30/2003	parking lot
$UNSCON_{PL}1$	unsealed concrete pavement		9/8/2003	parking lot
$UNSCON_{PL}2$	unsealed concrete pavement		9/8/2003	parking lot

massaged inside locking bags to remove retained particles, as described in ref *18*, and the recovered particulates were submitted as chilled slurries in clean glass vials to the U.S. Geological Survey National Water Quality Laboratory (NWQL) for analysis. In some cases the filtrate also was shipped, in chilled and clean amber glass bottles, to the NWQL for analysis of dissolved PAH. One or more samples of unfiltered water were collected from the churn for measurement of suspended sediment concentration (SSC), used to determine the mass of sediment recovered during each test. Although the 2 mm of simulated rain was not enough to wash off all of the mobile sediment, the recovered water was visibly clearer toward the end of each application. In samples from the five sites in which SSC was measured in the first 50 L and final 50 L of water, SSC decreased by a mean of 65% (range of 39–84%). We therefore assumed that the tests recovered most of the sediment that would be mobilized from the parking lot surfaces by a rain event, regardless of magnitude. Large, intense storms, however, likely would generate a higher yield of sediment.

The test plot and parking lot scrapings were obtained by scraping a small area (less than 0.25 m^2) with a metal paint scraper. The particulates removed were brushed onto a piece of new cardstock and then into a cleaned glass jar. The paint scraper was cleaned between sites, and a new brush was used at each site. Scrapings were examined by light and electron microscopy (Figure S2, Supporting Information), and submitted to the NWQL for PAH analysis.

Computation of Yields. Losses of water to wetting and losses of water and sediment leaking under the berms were estimated. Recovery of water ranged from 19 to 85 L with a median of 58 L. The lowest recoveries were from flat, unsealed asphalt lots, and the highest recoveries were from sealed lots and cement lots with gentle slopes. On the basis of recoveries and field observations, it was concluded that about 18 L of water was retained on the surface of sealed lots and cement lots and that the remainder of the water loss was a result of leakage past the berms. It was assumed that no yield of particles was associated with the water volume lost to surface wetting and that water leaking past the berms had the same SSC and contaminant levels as recovered water. For unsealed asphalt lots, the loss to wetting was estimated as 36 L for a maximum potential recovery of 64 L. Thus, to estimate the total yield of sediment from each lot, SSC was multiplied by the assumed maximum recovery (82 L for sealed and cement lots and 64 L for unsealed asphalt lots) to account for recovered water and leakage past the berms. Yields of PAH were estimated by multiplying the total yield of sediment times particle concentrations.

Chemical Analysis. Samples were prepared by extracting about 0.5 g dry weight of sample using pressurized solvent extraction at 120 and 200 °C with a mixture of water and isopropyl alcohol. The samples were extracted at each temperature at a pressure of 13800 kPa. Surrogate compounds were added to the sample prior to extraction to verify method recoveries. The extract was cleaned up using polystyrene divinylbenzene and Florisil solid-phase extraction cartridges. The extract was concentrated, solvent exchanged to ethyl acetate, and diluted to 10 mL. An internal standard mixture was added to an aliquot of the extract, and the extract was analyzed by full-scan gas chromatography/mass spectrometry (GC/MS). Difficult sample matrices were diluted before the full-scan analysis, and diluted surrogates were estimated in the samples.

Compound identifications were based on comparison of peak retention times and mass spectra to those of authentic standard compounds for the target compounds. Response factors were calculated for each compound from a set of calibration standards. Quantitation was carried out following the methods of Olson et al. (*19*). For PAHs in the particulate phase, the estimated method reporting limit (MRL) is 5 $\mu g/kg$ for a 25 g sample. As less than 25 g was extracted, the MRL was raised accordingly, on a sample-by-sample basis. In some cases, MRLs were raised because of background interferences.

Dissolved-phase samples were analyzed following the method described by Fishman and Friedman (*20*), with the

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difference that continuous liquid–liquid extraction was substituted for use of the separatory funnel. In brief, 1 L samples fortified with surrogate compounds were extracted by continuous liquid–liquid extraction for 6 h under acidic and then basic conditions. Internal standards were added and sample extracts concentrated to 1 mL. Samples were analyzed by GC/MS in electron impact mode. Sample identifications were made by matching retention times and mass spectra with those of standard compounds. Quantitation involved use of internal standards and calibration curves generated by standard compounds of known amounts.

Quality control (QC) consisted of environmental and internal laboratory samples. Two duplicate environmental samples for particulate analysis of PAH were collected. For one of the sets of duplicates, ΣPAH differed by 8%; for the second (which had ΣPAH > 4000 mg/kg), ΣPAH differed by 54%. In the equipment blank analyzed for dissolved PAH, three parent PAHs were detected at concentrations about half that of the environmental sample with the lowest concentrations, and less than 1% that of the environmental sample with the highest concentrations.

Laboratory QC samples for particulate PAH analyses consisted of analysis of spiked samples, blanks, and samples of certified reference material (CRM). The median recovery for the six spiked samples was 76%. For the six laboratory blanks, an analyte was detected in 85 of 336 possible cases. The detected concentrations ranged from 0.1% to 3.5% of that in the environmental sample with the lowest concentration for that analyte. For the two analyses of CRM, the recoveries were within the NWQL-established acceptable range for 83% of the cases.

Three commercially available asphalt-based emulsion sealcoat products and six coal-tar-based emulsion sealcoat products were analyzed at DHL Analytical, Round Rock, TX, using EPA method SW 8270 (*21*). In each case, the product sample was taken directly from the container. Concentrations of 16 parent PAHs were determined. The sealants analyzed were not necessarily the same as those applied to the test plots or on the parking lots in use, although there was some overlap (product AS_BA was used on test plot AS_{TP}; product CT_PE was used on test plot $CT_{TP}2$) (Table 2).

Results

Concentrations and yields of total particulate PAH and total dissolved PAH in the runoff and total PAH in the scrapings were computed and compared between parking lot surface types (Table 2). The total particulate PAH (ΣPAH) concentration was computed for each sample as the sum of naphthalene, 2-methylnaphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benz[*a*]anthracene, chrysene, benzo[*a*]pyrene, and dibenz[*ah*]anthracene, which are the same as those used for the consensus-based sediment quality guidelines of MacDonald et al. (*22*). For unsealed parking lots (asphalt pavement and concrete combined), the mean ΣPAH was 54 mg/kg (range of 7.2–75 mg/kg), more than twice the probable effect concentration sediment quality guideline of 22.8 mg/kg (*22*) (Table 2), and in the range of those found by others in urban and roadway runoff (e.g. refs *23*–*25*). However, the mean ΣPAH concentration from the asphalt-sealed parking lots was more than 10 times higher (mean of 620 mg/kg, range of 250–830 mg/kg) than that from unsealed parking lots, and the mean ΣPAH concentration from the coal-tar-sealed parking lots was 65 times higher (mean of 3500 mg/kg, range of 520–9000 mg/kg) (Table 2; complete concentration data are given in ref *16*). ΣPAH concentrations in runoff from coal-tar-sealed lots were significantly higher than in runoff from other surface types (Kruskal–Wallis test of comparisons, hypothesis of no difference between groups rejected for $p < 0.05$). PAH concentrations from coal-tar-sealed lots also were much higher, in most cases by orders of magnitude, than PAH concentrations in other urban sources such as tire particles, motor oil, and weathered asphalt (Figure 1; note that this figure uses a different summation of PAH). ΣPAH concentrations in runoff from the sealed test plots were generally lower than those from the sealed parking lots, but the difference was not statistically significant, and concentrations from unsealed surfaces, with the exception of one outlier, were similar for test plots and parking lots.

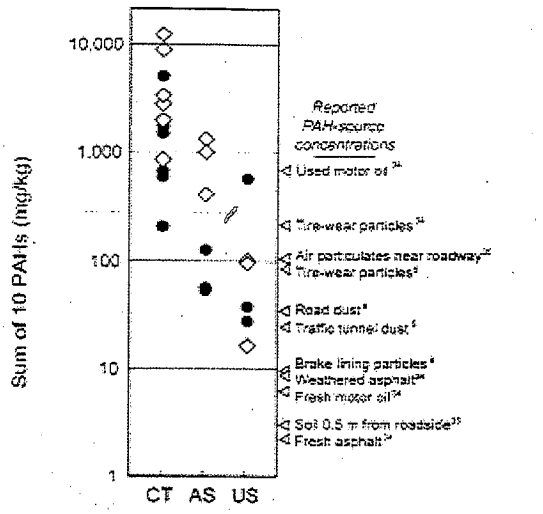

FIGURE 1. Sum of 10 PAHs (fluoranthene, pyrene, benz[*a*]anthracene, benzo[*a*]pyrene, benzo[*e*]pyrene, indeno[1,2,3-*cd*]pyrene, chrysene, benzo[*b*]fluoranthene, benzo[*k*]fluoranthene, and benzo[*ghi*]perylene) in particles in runoff from simulated rainfall on coal-tar emulsion sealcoat (CT), asphalt emulsion sealcoat (AS), and unsealed cement and asphalt (US) parking lots (◇) and test plots (●). Parking lots were sampled once, and test plots were sampled three times. Concentrations for other PAH sources reported in the literature also are indicated. These 10 PAHs were summed for this graph to facilitate comparison between experimental and reported concentrations.

Concentrations of ΣPAH in the scrapings ranged from 9500 to 83000 mg/kg for coal-tar-emulsion-sealed surfaces (including test plots) and from 110 to 2000 mg/kg for asphalt-emulsion-sealed surfaces (Table 2). Scrapings of two unsealed asphalt parking lots had ΣPAH concentrations of 7.1 and 20 mg/kg. Scrapings were observed under light and electron microscopy (Figure S2, Supporting Information).

Concentrations of total dissolved PAH (ΣPAH_{diss}, computed as the sum of the same PAHs as in ΣPAH excluding 2-methylnaphthalene; nondetections treated as zeros) for the test plots were about an order of magnitude greater in samples from the coal-tar-sealed test plots than concentrations in samples from the asphalt-sealed test plot, which in turn were about an order of magnitude greater than those from the unsealed test plot (Table 2). Nine of the 16 PAHs analyzed for were detected (complete data are in ref *16*). Higher weight PAHs—benzo[*b*]fluoranthene, benzo[*k*]fluoranthene, benzo[*a*]pyrene, indenopyrene, benzo[*ghi*]perylene, benz[*a*]anthracene, and dibenz[*ah*]anthracene—were not detected at laboratory reporting levels ranging from 1.7 to 3.4 μg/L. Four PAHs (acenaphthylene, acenaphthene, chrysene, and fluorene) were detected only in runoff from the coal-tar-sealed test plots; anthracene was detected in runoff from all the sealed test plots but not from the unsealed site. A similar suite of PAHs were detected at those parking lots for which the filtrate was analyzed (Table 2; complete data are in ref *16*).

Concentrations of ΣPAH in the commercially available sealant products and surface scrapings exceeded those of

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TABLE 2. Concentrations of PAH in Washoff Samples, Scrapings, and Unapplied Sealcoat Product[a]

	washoff samples		scrapings	product	
	ΣPAH, mg/kg	ΣPAH_{diss}, μg/L	ΣPAH, mg/kg		ΣPAH(dry), mg/kg
Test Plots					
$CT_{TP}1$, 8/12/03		21	83000	CT_PA	34000
$CT_{TP}1$, 8/21/03	1700	14		CT_PB	113000
$CT_{TP}1$, 9/9/03	530			CT_PC	202000
$CT_{TP}1$, 9/26/03	460	6.9		CT_PD	86000
				CT_PE	49000
$CT_{TP}2$, 8/12/03		11	11000	CT_PF	61000
$CT_{TP}2$, 8/21/03	1200	7.3			
$CT_{TP}2$, 9/9/03	4000			AS_PA	6600
$CT_{TP}2$, 9/26/03	140	3.8		AS_PB	1300
				AS_PC	300
AS_{TP}, 8/12/03		1.3	110		
AS_{TP}, 8/21/03	96	1.2			
AS_{TP}, 9/9/03	40				
AS_{TP}, 9/26/03	28	0.64			
$UNSAS_{TP}$, 8/12/03		0.16			
$UNSAS_{TP}$, 8/21/03	410	0.34			
$UNSAS_{TP}$, 9/9/03	25				
$UNSAS_{TP}$, 9/26/03	14	0.17			
Parking Lots					
$CT_{PL}1$	2000	NA	25000		
$CT_{PL}2$	9000	5.4	15000		
$CT_{PL}3$	2000	7.1	11000		
$CT_{PL}4$	1300	12	9500		
$CT_{PL}5$	520	2.3	9900		
$CT_{PL}6$	5900	16	17000		
$AS_{PL}1$	250	NA	340		
$AS_{PL}2$	830	NA	2000		
$AS_{PL}3$	770	5.1	420		
$UNSCON_{PL}1$	75	NA	NA		
$UNSCON_{PL}2$	69	NA	NA		
$UNSAS_{PL}1$	64	NA	7.1		
$UNSAS_{PL}2$	7.2	0.24	20		

[a]Sums are as defined in the text. NA = not analyzed, CT = coal-tar-based emulsion, AS = asphalt-based emulsion, UNSAS = unsealed asphalt pavement, and UNSCON = unsealed concrete pavement.

the particulates in the washoff. Concentrations of ΣPAH in commercially available coal-tar-based sealcoat products ranged from 3.4 to 20 wt %, compared to 0.03 to 0.66 wt % for asphalt-based sealcoat products analyzed (Table 2; complete data in Table S1, Supporting Information).

Yields of ΣPAH (mass of ΣPAH per unit area of parking lot) computed for the simulated rainfall followed patterns similar to those of concentrations. Complete data for yields can be found in Table S2 in the Supporting Information. As with the concentrations, there was a wide range in the yields for a given surface type, in most cases more than an order of magnitude. The mean yield from coal-tar-sealed lots exceeded that from asphalt-sealed lots by more than a factor of 2, although this difference was not statistically significant (Kruskal–Wallis test of comparison, $p < 0.05$). However, the mean yield from sealed lots (asphalt and coal tar combined) exceeded that from unsealed lots by a factor of 50, and the difference was statistically significant.

Discussion

Runoff from parking lots typically is contaminated with PAHs from leaking motor oil, tire particles, vehicle exhaust, and atmospheric fallout, and it is not surprising that the mean concentration of ΣPAH in particles washed off each of the different surface types exceeded the probable effect sediment quality guideline. However, the large differences between

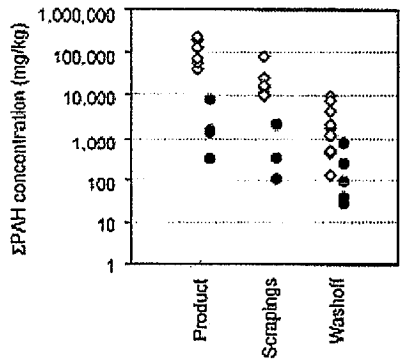

FIGURE 2. Comparison of ΣPAH concentrations in commercially available sealcoat products, scrapings from parking lots, and particles in washoff from parking lots for coal tar (◇) and asphalt (●) based sealants.

concentrations for the different surface types suggest that abraded sealant products are a potentially important (and heretofore unrecognized) contributor to PAH contamination in urban and suburban water bodies.

Comparison of Medium, Aging, and Vehicle Use on Concentrations and Yields. For both coal-tar- and asphalt-emulsion-based sealants, the ΣPAH concentration decreased from the unapplied sealant products to the scrapings to the washoff samples, as did the difference in concentration between the coal-tar-based and asphalt-based sealant samples (Figure 2). The difference in the median ΣPAH concentration between the coal-tar-based and asphalt-based sealants was 70-fold for the products analyzed and decreased to 40-fold for the scrapings and to a factor of about 8 for the washoff samples. Although the chemical changes between the product pre- and postapplication were not the focus of this study, the decrease in ΣPAH concentrations from the scrapings to the washoff particulates and the magnitude of the difference between the coal-tar-sealed lots and the asphalt-sealed lots can be attributed to dilution of abraded particles with less contaminated street dust and the greater abrasion of the asphalt-sealed compared to the coal-tar-sealed surfaces. A simple mass balance, assuming dilution of the coal tar scrapings (median ΣPAH concentration of 13000 mg/kg) by street dust (median ΣPAH concentration of 50 mg/kg) at a proportion of 1 part abraded particles to 7 parts street dust, results in the concentration found in the washoff. If the proportion of abraded particles is increased for the asphalt lots on the basis of the increased yields measured for asphalt-sealed lots (assuming that the greater median particle yield of 320 mg/m^2 from asphalt-sealed lots versus 200 mg/m^2 from coal-tar-sealed lots results from increased abrasion), the concentration found in the washoff from asphalt-sealed lots is well approximated.

The effect of aging of sealants on concentration over the short term (7 weeks) was evident at the test plots (Figure 3a). Overall, the concentration of ΣPAH and ΣPAH_{diss} in the washoff from each test plot decreased over the 7 week period following application. In one instance ($CT_{TP}2$, second sampling of washoff) ΣPAH exceeded that previously sampled, but in all cases the concentration at the end of the period was less than that at the beginning. The PAH assemblage changed over the same period as well, as represented by a comparison of higher molecular weight (MW) to lower MW PAHs. In the particulate samples the ratio of higher MW PAHs (represented by benzo[*a*]pyrene + chrysene) to the lower MW PAHs (represented by fluorene + phenanthrene; these two PAHs were chosen as they were detected in most of the samples) increased at all of the sealed test sites. As the lower MW PAHs are more volatile and soluble than the higher MW PAHs, volatilization and leaching of the lower MW PAHs

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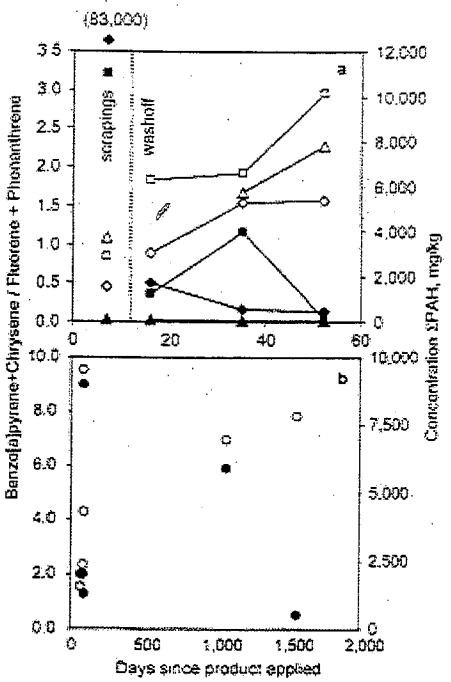

FIGURE 3. ΣPAH concentrations (closed symbols) and PAH ratios of higher and lower molecular weight PAHs (open symbols) (a) in scrapings and particles washed off coal-tar-sealed test plots (□, ◇) and an asphalt-sealed plot (△) and (b) as they relate to the age of coal-tar sealant in samples from parking lots in use.

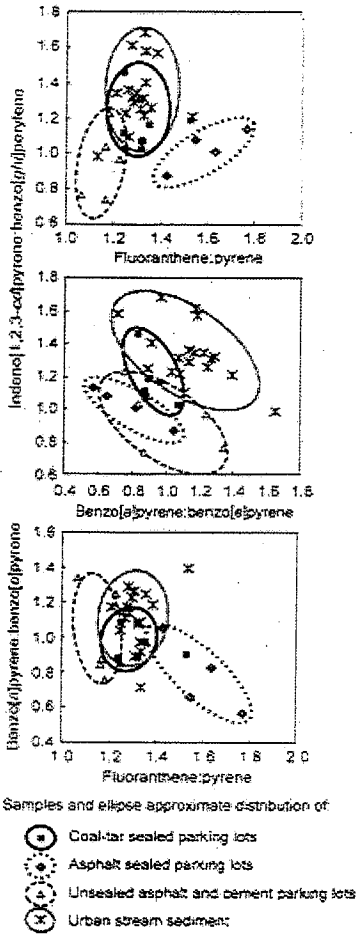

FIGURE 4. Comparison of indicator ratios of PAHs in particles washed from parking lots with coal-tar emulsion sealcoat, asphalt emulsion sealcoat, and unsealed asphalt pavement and concrete pavement, and in suspended sediment collected from four urban streams after storms.

from the newly applied sealant might be responsible for some of the decrease in concentration. For the parking lots, only coal-tar-sealed lots represented a range of ages, and for these lots there was no relationship between concentration or higher MW to lower MW PAH ratio and age of the sealant (Figure 3b). This might be because the parking lots were each sampled only once; the very wide range in PAH content between products, even those of a similar kind, may mask the effect of aging when time-series data are not available. Although the data are limited, they suggest that lots with older sealant tend to have a higher ratio of higher MW to lower MW PAHs, and that that ratio may reach a plateau after a period of time.

Comparison of the yields from the parking lots to those from the test plots, which receive no vehicle traffic, demonstrates the importance of abrasion of sealcoat by vehicles on ΣPAH yield: the mean ΣPAH yield was 20 and 160 times greater for the coal-tar-sealed and asphalt-sealed parking lots, respectively, than for the analogous test plots. This does not appear to be attributable to use patterns, although traffic counts were not made: the coal-tar-sealed lots are a mix of lots in constant use throughout the day (e.g., shopping center) and those with all-day parking (e.g., office), which are assumed to receive less use than those in constant use; all of the asphalt-sealed lots are all-day parking.

Environmental Implications. Given the extremely elevated concentrations of PAHs in particles washed from sealed parking lots, how important is this contribution to the total mass of PAHs in urban streams? To answer this question, we compared the PAH assemblages and estimated PAH loads associated with particulates in parking lot runoff to those associated with suspended sediment collected during storm flow in four streams: Williamson Creek (Austin, TX) (*18*) and influent streams to Echo Lake, Fosdic Lake, and Lake Como (Fort Worth, TX) (*26*). These four streams are in highly urbanized watersheds (land use for the Austin watershed is about 65% urban, and for the three Fort Worth watersheds is more than 90% urban; full land use is given in Table S3, Supporting Information); the streams are ephemeral, and urban runoff is assumed to comprise a large component of storm flow.

PAHs comprise a large group of compounds, and PAH assemblage is often used to infer PAH sources (*27*). Differences in PAH assemblages can be investigated by computing the ratios of selected PAHs (*28, 29*). The best indicator ratios of coal tar as a PAH source have been identified as fluoranthene:pyrene, indeno[1,2,3-*cd*]pyrene:benzo[*ghi*]perylene, and benzo[*a*]pyrene:benzo[*e*]pyrene (*30, 31*). In graphs that combine these ratios, similarities and differences between parking lot and stream samples are apparent (Figure 4): ratios in the urban stream sediment group match those in runoff from coal-tar-sealed lots more closely than they do those from asphalt-sealed lots and from unsealed lots (asphalt and cement). We found these ratios were far more effective at distinguishing between the different parking lot samples and stream samples than ratios indicative of combustion versus noncombustion sources, or other approaches such as comparison of parent compound distribution (*32*). Although alkylated PAH homologues were analyzed (including C1–C5 homologues of the MW 128, 178, 202, 228, and 252 PAHs), their interpretation did not assist in discriminating between PAHs from the different parking lot surfaces.

The relative amount of similarity between groups of samples, as defined by the ratios, was quantified through

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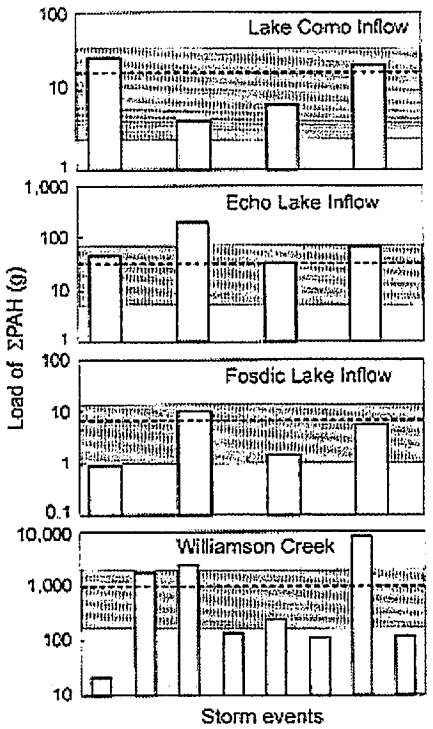

FIGURE 5. Comparison of estimated event loads of ΣPAH from sealed parking lots and measured instream storm-event loads for four urban watersheds. The interquartile range of estimated loads is shown in gray shading, on the basis of 25th and 75th percentile yields computed for sealed parking lots; the mean estimated load is indicated by a dashed line. Measured instream loads for four to eight individual events are shown as bars.

discriminant function analysis. In discriminant function analysis, each significant independent variable adds to discrimination between multiple groups. The three ratios (fluoranthene:pyrene, indeno[1,2,3-*cd*]pyrene:benzo[*ghi*]-perylene, and benzo[*a*]pyrene:benzo[*e*]pyrene) were entered into the analysis as the independent variables, with the different types of samples (coal-tar-emulsion-sealed lots, asphalt-emulsion-sealed lots, unsealed lots, and urban stormflow stream sediments) defining four groups of dependent variables. All three variables were shown to contribute significantly to discrimination between the groups ($p < 0.001$). The distances between the centroids of the groups were determined by computing the squared Mahalanobis distance, which is a measure of the distance between two points in the space defined by two or more correlated variables. The centroid of the group defined by the suspended sediment from urban streams is closest to the centroid of the coal-tar-based sealant group, next closest to that of the unsealed lot group, and farthest from that of the asphalt-based sealant group (squared Mahalanobis distances of 5.7, 13.0, and 25.0, respectively). Thus, on the basis of the three ratios diagnostic of coal-tar sources, the PAH assemblage of the suspended sediment from the urban streams most closely resembles that of the coal-tar-based sealant group, supporting the hypothesis that coal-tar-based sealants are an important source of PAHs in urban streams.

Moving to a mass-balance approach at the watershed scale for each of the four urban watersheds, we compared measured storm-event stream loads of ΣPAH to those estimated to be contributed by sealed parking lots. Digital land-use maps that included parking lots were provided by the Cities of Austin and Fort Worth and were updated using recent aerial photography and site inspections. Sealed and

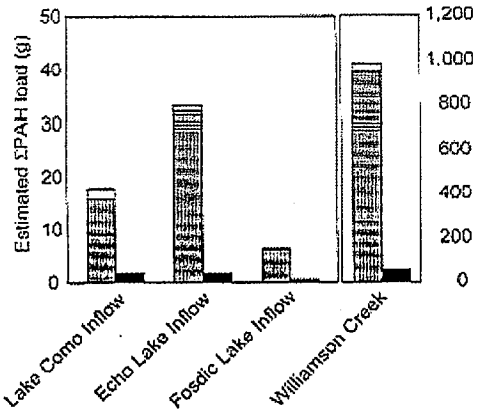

FIGURE 6. Comparison of event loads of ΣPAH for four urban watersheds estimated for parking lots in their current (2004) state (sealed by gray bars and unsealed by white bars) and projected loads if all existing parking lots were unsealed (black bars). Loads were estimated on the basis of the yields from the runoff experiments and the area of parking lots in each watershed.

unsealed lots were identified by site inspection. We computed the hypothetical storm-event load generated by sealed parking lots in each watershed by multiplying the mean yield for sealed parking lots (coal-tar and asphalt emulsion sealcoat combined) determined from the runoff experiments by the sealed parking lot area of each watershed. We assumed that the 2 mm of water applied for the field tests mobilized all available particles, and that all runoff from parking lots entered storm sewers and was delivered to the stream. Although there is substantial variation in event loads for each stream (*18, 26*), for all four watersheds the estimated ΣPAH loads contributed by sealed parking lots are similar in magnitude to measured stream loads, even though sealed parking lots cover only 1−2% of each watershed (Figure 5). These results might explain why an investigation carried out in Marquette, MI, found that runoff from commercial parking lots contributed 64% of the PAH load to the urban watershed studied (*33*).

What would be the effect on PAH loading to these watersheds if parking lots were not sealed? For each of the four watersheds, we compared the ΣPAH load contributed by parking lots (computed on the basis of the aerial extent of unsealed and sealed parking lots) to that obtained by applying the average yield for unsealed lots to all parking lots (Figure 6). We estimate that the ΣPAH load from parking lots in these watersheds would be reduced to 5−11% of the current loading if all lots were unsealed.

With the exception of the sealcoat itself, unsealed parking lots receive PAHs from the same urban sources as do sealed parking lots—e.g., tire particles, leaking motor oil, vehicle exhaust, atmospheric fallout—yet the average yield of PAHs from sealed parking lots is 50 times greater than that from unsealed lots. PAH assemblages and estimated loads further suggest that sealed parking lots could be dominating PAH loading in watersheds with commercial and residential land use. The implications of these results extend beyond Texas to the rest of the United States and Canada, where parking lot sealcoat is used extensively, and to other countries where sealcoat is being introduced. Previously identified urban sources of PAHs, such as automobile exhaust and atmospheric deposition, have been difficult to control or even quantify because of their nonpoint nature. In contrast, sealed parking lots are point sources, and use of the sealant is voluntary and controllable.

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Supporting Information Available

Two figures and three tables. This material is available free of charge via the Internet at http://pubs.acs.org.

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THE UNIVERSITY OF ARIZONA. TUCSON, ARIZONA

THE DEPARTMENT OF RISK MANAGEMENT & SAFETY

Polychlorinated Byphenyls (PCBs)

Background

PCB's are a subset of the synthetic organic chemicals known as chlorinated hydrocarbons. Between 1926 and 1977, PCB-containing products were manufactured for applications demanding stable, fire-resistant, heat-transfer properties. The most extensive use of PCBs occurred in dielectric fluids. Such fluids typically have the following characteristics: heavy oil appearance, high boiling point, high chemical stability, high flash point, low electrical conductivity, and low water solubility. PCBs were also used as plasticizers and additives in lubricating and cutting fluids. PCB's are clear to yellow colored oily liquids or solids. Overheated PCB material from a ruptured capacitor may be black in color. UA applications include electrical transformers, large high- and low-voltage capacitors and fluorescent lamp fixture ballasts.

During the 1970s, federal legislation mandated the elimination of PCBs from distribution in commerce. To minimize the potential for adverse health effects caused by PCBs and other substances, Congress passed the Toxic Substances Control Act (TSCA), which strictly regulates all aspects of PCB use.

EPA regulations affecting the management, removal and disposal of PCB materials began to impact the UA in the early 1980's.

Small, inexpensive, qualitative test kits can be used to determine the presence of chlorine in suspect liquids. If shown to be positive, quantitative information is available through fluid sampling and subsequent, commercial analytical testing.

PCB Transformers

These units may range in size from old, pole mount units, kettle-type pots to very large 5000 KVA units that contain over 1100 gallons of dielectric fluid. Most transformers can be found in basement equipment rooms or electrical vaults and tunnels. The UA historically has employed two management strategies for large transformers. The first is replacement. Typically, during electrical upgrade projects older PCB transformers are removed and replaced with the dry, pad mount variety. The second strategy is called retro-filling. The PCB containing fluid is replaced a number of times with a non-PCB fluid. In theory, over a period of time measured in years, all PCB's should "leach out" of the transformer carcass. After a given number of retro-fill cycles the transformer was filled with a Non-PCB replacement dielectric fluid. This method had very mixed results. Transformers with a PCB content less than 50 ppm are considered to be "Non-PCB."

PCB Capacitors

As part of building electrical systems, large PCB capacitors have been removed and shipped to disposal facilities. Proper disposal typically includes high temperature incineration.

PCB Light Ballasts

The majority of fluorescent light ballasts manufactured prior to 1979 contain about a teaspoon of concentrated PCB's sealed inside the capacitor. The capacitor is usually surrounded by a tar-like potting material and is enclosed in the steel ballast box. When a ballast fails, the internal capacitor may rupture and leak PCB's. The U.S. Environmental Protection Agency banned the further manufacture of equipment containing PCB's in 1979. **LIGHT BALLASTS MANUFACTURED AFTER 1979 DO NOT CONTAIN PCB's AND ARE LABELED "Non-PCB's**

PCB light ballasts are shipped off-site for proper recycling/disposal. What cannot be recycled is disposed of through high temperature incineration. UA PCB wastes ARE NOT landfilled.

For questions or assistance with PCB's contact the Environmental Safety Officer, Lloyd Wundrock at 621-1590 or lloydw@email.arizona.edu.

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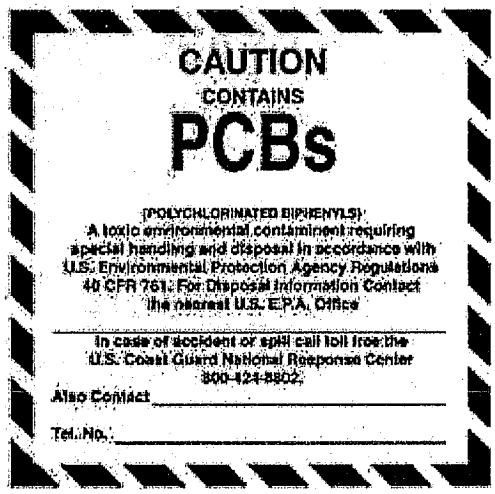

EPA provides various paths for the public to access information about PCBs. On this website you may access information about PCBs and their health effects. If you would like to learn more about the laws and regulations that govern PCBs, EPA maintains a listing of the laws and regulations applicable to PCBs. If you have a question about the PCB regulations, EPA has developed interpretive guidance in the format of question and answer documents. EPA maintains lists of approved companies that handle PCB wastes. This lists include: storage and disposal companies, alternative decontamination procedures and scrap metal recovery ovens. EPA also maintains two databases - PCB Activity Database (PADS) and Transformer Registration and applicable forms.

If you want to contact EPA Headquarters regarding a specific PCB topic or your regional PCB coordinator, please check our "Contact Us" page.

This website also links to other EPA and Federal web pages containing information about PCBs and other waste programs.

PLEASE NOTE: Some of the documents mentioned in this Section are in Adobe's Portable Document Format (PDF). To view or print them you will need to have the Adobe Acrobat Reader program installed on your computer. The Reader can be downloaded and used with no charge; check here for more information on the Adobe Acrobat Reader.

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U.S. Environmental Protection Agency

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Types of Pesticides

Pesticides are often referred to according to the type of pest they control. Another way to think about pesticides is to consider those that are chemical pesticides or are derived from a common source or production method. Other categories include biopesticides, antimicrobials, and pest control devices.

Chemical Pesticides

Some examples of chemically-related pesticides follow. Other examples are available in sources such as Recognition and Management of Pesticide Poisonings.

Organophosphate Pesticides - These pesticides affect the nervous system by disrupting the enzyme that regulates acetylcholine, a neurotransmitter. Most organophosphates are insecticides. They were developed during the early 19th century, but their effects on insects, which are similar to their effects on humans, were discovered in 1932. Some are very poisonous (they were used in World War II as nerve agents). However, they usually are not persistent in the environment.

Carbamate Pesticides affect the nervous system by disupting an enzyme that regulates acetylcholine, a neurotransmitter. The enzyme effects are usually reversible. There are several subgroups within the carbamates.

Organochlorine Insecticides were commonly used in the past, but many have been removed from the market due to their health and environmental effects and their persistence (e.g. DDT and chlordane).

Pyrethroid Pesticides were developed as a synthetic version of the naturally occurring pesticide pyrethrin, which is found in chrysanthemums. They have been modified to increase their stability in the environment. Some synthetic pyrethroids are toxic to the nervous system.

Biopesticides

Biopesticides are certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals. For example, canola oil and baking soda have pesticidal applications and are considered biopesticides. At the end of 2001, there were approximately 195 registered biopesticide active ingredients and 780 products. Biopesticides fall into three major classes:

(1) **Microbial pesticides** consist of a microorganism (e.g., a bacterium, fungus, virus or protozoan) as the active ingredient. Microbial pesticides can control many different kinds of pests, although each separate active ingredient is relatively specific for its target pest[s]. For example, there are fungi that control

certain weeds, and other fungi that kill specific insects.

The most widely used microbial pesticides are subspecies and strains of Bacillus thuringiensis, or Bt. Each strain of this bacterium produces a different mix of proteins, and specifically kills one or a few related species of insect larvae. While some Bt's control moth larvae found on plants, other Bt's are specific for larvae of flies and mosquitoes. The target insect species are determined by whether the particular Bt produces a protein that can bind to a larval gut receptor, thereby causing the insect larvae to starve

(2) **Plant-Incorporated-Protectants (PIPs)** are pesticidal substances that plants produce from genetic material that has been added to the plant. For example, scientists can take the gene for the Bt pesticidal protein, and introduce the gene into the plant's own genetic material. Then the plant, instead of the Bt bacterium, manufactures the substance that destroys the pest. The protein and its genetic material, but not the plant itself, are regulated by EPA.

(3) **Biochemical pesticides** are naturally occurring substances that control pests by non-toxic mechanisms. Conventional pesticides, by contrast, are generally synthetic materials that directly kill or inactivate the pest. Biochemical pesticides include substances, such as insect sex pheromones, that interfere with mating, as well as various scented plant extracts that attract insect pests to traps. Because it is sometimes difficult to determine whether a substance meets the criteria for classification as a biochemical pesticide, EPA has established a special committee to make such decisions.

Pest Types

Pesticides that are related because they address the same type of pests include:

Algicides
Control algae in lakes, canals, swimming pools, water tanks, and other sites.

Antifouling agents
Kill or repel organisms that attach to underwater surfaces, such as boat bottoms.

Antimicrobials Antimicrobials
Kill microorganisms (such as bacteria and viruses).

Attractants
Attract pests (for example, to lure an insect or rodent to a trap). (However, food is not considered a pesticide when used as an attractant.)

Biopesticides
Biopesticides are certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals.

Biocides
Kill microorganisms.

Disinfectants and sanitizers
Kill or inactivate disease-producing microorganisms on inanimate objects.

Fungicides
Kill fungi (including blights, mildews, molds, and rusts).

Fumigants
Produce gas or vapor intended to destroy pests in buildings or soil.

Herbicides
Kill weeds and other plants that grow where they are not wanted.

Insecticides
Kill insects and other arthropods.
Miticides (also called acaricides)
Kill mites that feed on plants and animals.
Microbial pesticides
Microorganisms that kill, inhibit, or out compete pests, including insects or other microorganisms.
Molluscicides
Kill snails and slugs.
Nematicides
Kill nematodes (microscopic, worm-like organisms that feed on plant roots).
Ovicides
Kill eggs of insects and mites.
Pheromones
Biochemicals used to disrupt the mating behavior of insects.
Repellents
Repel pests, including insects (such as mosquitoes) and birds.
Rodenticides
Control mice and other rodents.

The term pesticide also includes these substances:

Defoliants
Cause leaves or other foliage to drop from a plant, usually to facilitate harvest.
Desiccants
Promote drying of living tissues, such as unwanted plant tops.
Insect growth regulators
Disrupt the molting, maturity from pupal stage to adult, or other life processes of insects.
Plant growth regulators
Substances (excluding fertilizers or other plant nutrients) that alter the expected growth, flowering, or reproduction rate of plants.

Pest Control Devices

What about pest control devices? EPA also has a role in regulating devices used to control pests. More specifically, a "device" is any instrument or contrivance (other than a firearm) intended for trapping, destroying, repelling, or mitigating any pest. A mousetrap is an example of a device. Unlike pesticides, EPA does not require devices to be registered with the Agency. Devices are subject to certain labeling, packaging, record keeping, and import/export requirements, however.

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6. ORGANOCHLORINE PESTICIDES AND RELATED COMPOUNDS

6.1 SUMMARY

Organochlorine (OC) pesticides (DDT, toxaphene, dieldrin, and chlordane) were widely used in the Central Valley until the 1970s. OC pesticide residue are still widespread in the Central Valley. Many OC pesticides have been banned over time. Because of their characteristics and behavior in the environment, however, residuals still are being detected through monitoring. This section addresses OC pesticides that are no longer used in California and other related compounds. Control of OC pesticides currently in use is the jurisdiction of the DPR. The OC pesticides are persistent in the environment and are characteristically associated with the organic component of small particles, such as in sediment. Also persistent in the environment are polychlorinated biphenyls (PCBs), which were used as a dielectric (an electric insulator); and dioxins and dioxin-like compounds, which are predominantly associated with combustion compounds containing chlorine. The body burden of OC pesticides, PCBs, and dioxins in aquatic organisms represents an integration of the routes by which that organism is exposed. Exposure can occur through the food chain, direct contact with water or sediments, or other routes. OC pesticides, PCBs, and dioxins are a concern to water quality because they tend to bioaccumulate and can be toxic or carcinogenic to aquatic species and humans. This section identifies OC pesticide concerns, OC pesticide levels found in the Delta, and proposed actions that can minimize impacts associated with these pesticides. PCB pollution is somewhat common in the urban environment and is also common in larger predatory fish. Dioxins and dioxin-like compounds are listed on the CWA Section 303(d) list for impairing the San Francisco Bay and part of the Bay-Delta. PCB and dioxin pollution and remediation will be further addressed by the CALFED Program as more is known and as experts can be assembled to address sources of impairment and remedial strategies.

Many OC pesticides have been banned over time. Because of their characteristics and behavior in the environment, however, residuals still are being detected through monitoring.

6.2 OBJECTIVE

The objective is to reduce concentrations of OC pesticides in biota in the San Joaquin and Sacramento Rivers and the Delta, which will require reducing the transport of OC pesticides from agricultural lands to the rivers. The measure of success will be lower levels of OC pesticides in biota as determined from

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monitoring. PCB, dioxin, and dioxin-like compound concentrations and environmental (including public health) impacts will be monitored and solutions devised, if feasible.

6.3 PROBLEM DESCRIPTION

One of the most comprehensive sources of information to characterize problems associated with regionwide OC pesticides is the joint SWRCB/DFG Toxic Substances Monitoring Program (TSMP). Results from other important studies also are included in this report.

The TSMP has been monitoring pollutants in aquatic life since 1976. Twenty-two sites were monitored by the TSMP in the Bay-Delta watershed for 5 years. Of these sites, the Sacramento River near Hood and the San Joaquin River near Vernalis were monitored for 10 years. Most of the sites monitored revealed continually high levels of metals or OC pesticides in tissue samples. OC pesticides were widely used in the Central Valley in the 1950s and 1960s. Use has declined greatly since the early 1970s, and several OC pesticides have been banned. DDT was widely used as a general-purpose insecticide until it was banned by the EPA in 1972. DDT and its breakdown products, DDD and DDE, are very persistent and result in bioaccumulative toxic effects on fish and birds. Toxaphene replaced many DDT uses until it was banned for most uses in 1982. Dieldrin was banned for all uses except termite control in 1974, and banned for all uses in 1987. Chlordane was banned for all uses except termite control in 1983, and banned for all uses in 1988.

OC pesticides were widely used in the Central Valley in the 1950s and 1960s. Use has declined greatly since the early 1970s, and several OC pesticides have been banned.

Chlordane was found to exceed the 300 parts per billion (ppb) U.S. Food and Drug Administration's (FDA's) action level in channel catfish from the San Joaquin River near Vernalis and in carp from Paradise Cut near Tracy. DDT was found to exceed the FDA's action level of 5,000 ppb in channel catfish near Vernalis and in carp from Paradise Cut. DDT also was found at relatively high levels in carp from the Sacramento River near Hood. Concentrations of OC pesticides were generally much lower in bed sediment and biota in the Sacramento River Basin compared to the San Joaquin River Basin.

All fish fillet samples collected from the San Joaquin River near Vernalis from 1978 to 1987 exceeded recommended safe levels for fish-eating wildlife set by the National Academy of Science/National Academy of Engineering (NAS/NAE) for total DDT (the sum of DDD, DDE, and DDT), chlordane, and toxaphene. Fish fillet samples collected from the major east side tributaries to the San Joaquin River (the Merced, Tuolumne, and Stanislaus Rivers) also exceeded NAS/NAE-recommended levels for total DDT, chlordane, and toxaphene. Recently, the

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toxaphene concentration in a whole carp from the Colusa Basin Drain in the Sacramento River Basin exceeded the NAS/NAE-recommended level.

Concentrations of OC pesticides in bed sediment and clams of west side tributaries were consistently higher than those in east side tributaries of the San Joaquin River. A 1998 USGS study concluded that concentrations of OC pesticides in biota, and perhaps in bed sediment of the San Joaquin Valley, have declined from the concentrations measured in the 1970s and 1980s but remain high compared to other regions of the United States.

In a study comparing winter storm transport of OC pesticides to irrigation season transport in the San Joaquin River Basin, instantaneous loads of OC pesticides at the time of sampling were substantially greater during the winter storm. However, due to the infrequent occurrence of sizable winter storms, overall transport was probably similar or greater during the irrigation season. As expected, most transport of OC pesticides during the winter storm runoff was in the suspended sediment. The suspended fractions (the ratio of OC pesticide concentration in suspended sediment in μg/l to total OC pesticide concentration in the water column in μg/l) ranged from 0.52 to 0.98 for chlordane, dieldrin, total DDT, and toxaphene. With lower overland flow and streamflow velocities and subsequently lower suspended sediment concentrations during the irrigation season, the suspended fractions ranged from only 0.14 to 0.87 μg/l. Most calculated whole-water concentrations of p,p'-DDT, chlordane, dieldrin, and toxaphene during both the winter storm runoff and the irrigation season exceeded EPA's chronic criteria for the protection of fresh-water aquatic life.

PCBs were used in industry as a dielectric compound, such as in transformers in the municipal electric industry. PCBs are lipophilic (soluable in oils but not water) and persist in the environment. It is thought that most of the PCBs in the environment are in sediment. Fish tissue from the rivers and the Bay all contain levels of PCB. The levels vary, depending on the type and age of fish and the location of the habitat.

PCBs were used in industry as a dielectric compound, such as in transformers in the municipal electric industry. Fish tissue from the rivers and the Bay all contain levels of PCB.

These compounds are persistent in the environment even after they have been carried offsite and into the estuary. In some cases, not necessarily in the Bay-Delta, disturbed sediment reintroduces these compounds at high concentrations, which leads to fish kills and other impacts on habitat. It is unclear whether any mitigation is feasible on sediments for two reasons:

- Mitigation by removal would disturb sediment and create the very situation to be avoided.
- Costs associated with remediation would be prohibitive.

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The impacts of allowing current levels of OC pesticides to reside in Bay-Delta sediment, coupled with long-term declines in pesticide levels in fresh sediment, should be weighed against other mitigation measures if the solutions presented here fail to meet the stated objective.

6.4 APPROACH TO SOLUTIONS

A large portion of the OC pesticide transport is associated with suspended sediment during both winter storm runoff and the irrigation season, especially for total DDT (suspended fraction of 0.87 μg/l in the irrigation season and 0.98 μg/l in winter storm runoff). Thus, a likely solution to reducing transport of OC pesticides to the San Joaquin and Sacramento Rivers is to reduce the transport of sediment from the agricultural fields, especially the fine-grained sediments from the west side of the valley. Irrigation season sediment losses are much easier to control than those due to winter storm runoff because the runoff from irrigation is contained within furrows and the water source causing the runoff is controllable.

A large portion of the OC pesticide transport is associated with suspended sediment during both winter storm runoff and the irrigation season. Irrigation season sediment losses are much easier to control than those due to winter storm runoff because the runoff from irrigation is contained within furrows and the water source causing the runoff is controllable.

6.4.1 Priority Actions

1. It is recommended that CALFED support conservation efforts to help achieve the Water Quality Program objectives.

   The conservation practices shown on the following page (either singly or in combination) have proven to be cost-effective methods of achieving significant water quality improvements through reducing tailwater runoff that contains sediments, pesticides, and nutrients to water bodies or conveyance systems in the area. When combined in a "whole-farm plan" as provided by the NRCS, additional benefits include reduced electrical energy consumption; improved water conservation; improved water infiltration; and, in some cases, improved air quality, improved biodiversity, and improved crop yields.

2. It is proposed that CALFED help support additional research on the widespread use of PAM as a BMP (and other related erosion-control agents) to control erosion and improve aquatic habitats.

   A new conservation practice has been developed concurrently by the USDA Agricultural Research Service, UC Riverside, and UC Cooperative Extension. The use of high-quality polyacrylamide (water-soluble, anionic, high molecular weight PAM) as defined in the NRCS Field Office Technical Guide

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virtually halts irrigation-induced erosion, eliminates sedimentation, and keeps farm chemical residues on the farm. PAM is added to irrigation water at rates less than 10 ppm and is strongly attracted to soil particles, which results in preserving soil structure, maintaining infiltration rates, and flocculating any soil particles that may become suspended. This practice results in reduced volumes of tailwater runoff that is sediment free, with virtually no residues leaving the farm.

Conservation Practices to Achieve Water Quality Improvements

Conservation Practice	Process	Effects	
Tailwater ditch tarps	Decreases slope	Reduces ditch erosion	Traps sediment
Land leveling	Decreases slope	Reduces water velocity	Reduces erosion
Cutback stream	Reduces runoff	Reduces water flow when water reaches furrow end	
Surge irrigation	Reduces runoff	Automates water management	Reduces erosion
Sprinkler germination	Reduces water	Eliminates pre-irrigation	Reduces erosion
Drip irrigation	Reduces water	Automates water management	Reduces erosion
Shorten length of run	Reduces stream	Reduces water volume	Reduces erosion
Gated surface pipe	Reduces runoff	Improves water management	Reduces erosion
Vegetated filter strip	Stabilizes soil	Reduces water velocity	Traps sediment
Cover crop	Stabilizes soil	Reduces water velocity	Reduces erosion
Grassed waterway	Stabilizes soil	Reduces water velocity	Reduces erosion
Conservation tillage	Stabilizes soil	Reduces water velocity	Reduces erosion
Sediment basin	Reduces runoff	Reduces water velocity	Traps sediment
Tailwater return system	Reduces water	Returns water to farm	Reduces sedimentation
Irrigation management	Reduces water	Improves water management	Reduces erosion
Nutrient management	Reduces inputs	Improves water management	Reduces runoff
Integrated pest management	Reduces inputs	Improves water management	Reduces runoff
Tailwater management	Reduces runoff	Improves water management	Reduces sedimentation

3. It is proposed that CALFED support projects that will recreate the stream channels and increase the size of flow structures, such as culverts, to help achieve reduction in OC pesticides.

   Most of the BMPs listed above apply only to reducing the inputs of OC pesticides during the irrigation season and do not address the problem of winter storm transport. A few of the BMPs would be effective year-round (such as a vegetated filter strip, cover crop, and grassed waterway). In addition, some flooding occurs in west side tributaries to the San Joaquin River, especially in Hospital and Ingram Creeks, that may be preventable. The lack of channel capacity to carry even moderate winter storm runoff forces much of the flow onto freshly-plowed agricultural land. This greatly

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increases the transport of sediment and OC pesticides to the San Joaquin River during winter storm events.

4. Financial incentive programs should be tied to a whole-farm approach that addresses water use, water quality, soil health and erosion, and reduced chemical use. This approach will avoid shifting environmental problems from one medium to another, and also will help focus resources on techniques with multiple benefits. The USDA program described in the West Stanislaus case study demonstrates that such an approach can be extremely effective in achieving water conservation and water quality benefits.

5. Strategies should be developed to implement conservation measures and fund local conservation efforts in the following manners:

   a. The state and federal governments should consider providing a permanent source of funding for RCD pollution prevention and resource conservation programs. RCDs are a valuable, underutilized resource. RCDs were formed as an independent local government liaison between the federal government and private landowners. When motivated and given the necessary resources, RCDs can play a valuable role in offering technical assistance and promoting sustainable farming practices. However, many RCDs have no source of income and are thus severely limited in the conservation assistance that they can offer.

   When motivated and given the necessary resources, RCDs can play a valuable role in offering technical assistance and promoting sustainable farming practices.

   b. The CALFED Program should condition the receipt of any Program benefits by agricultural water users on implementation of conservation measures, including water conservation and water quality benefits.

   c. Major engineering works, including urban development, inter-state highways, large canals, creek alignments and dams and diversions, geologic tectonic activity, and other changes in these landscapes, may contribute to additional erosion and sedimentation of the river systems and the Bay-Delta. These works should be examined.

   d. CALFED could contribute to an existing delivery system of "locally led conservation" through RCDs and NRCS, resulting in immediate positive water quality benefits. Farmers have responded positively to USDA's new EQIP cost-share program, which provides for whole-farm planning and cost sharing to address the water quality resource concerns. This program is available throughout the CALFED area but is severely under-funded. Many existing high-priority applications will not be implemented because of the high expense of installing the measures and the limited NRCS funding.

   Farmers have responded positively to USDA's new EQIP cost-share program, which provides for whole-farm planning and cost sharing to address the water quality resource concerns.

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6. CALFED should monitor the environmental and public health impacts of PCBs in the Bay-Delta. If it appears that solutions to the pollution are feasible, a PCB Work Group could be formed to address possible solution strategies and CALFED's future involvement.

6.4.2 *Information Needed*

Projects that provide information needed should be supported based on priorities set by CALFED work groups and administration. Governmental and private efforts should be sought for contributions in this effort to control OC pesticide-laden sediment. Some potential projects include the following.

1. Data from continued monitoring efforts.

   Scientific and technical needs associated with the problem of OC pesticides in the Bay-Delta and watershed include the need for continued monitoring of levels in biota and of sources in the basins. More data are needed on sources of OC pesticides in the Sacramento River Basin, similar to the information developed for the San Joaquin River Basin.

   The TSMP continues to be one of the few overviews of the impacts of toxic substances in the environment. Regional elevations can be detected and put in perspective, although the TSMP is limited in detecting quickly changing types of contaminants or acutely toxic materials. Predatory fish are long lived and may travel considerable distances. A single fish with an elevated tissue concentration of a particular toxic substance cannot be linked with certainty to a potential source. However, repeated detections over many years in the same watershed can be revealing. Only through sustained monitoring can significant problems be distinguished from an isolated and highly contaminated individual specimen.

The TSMP continues to be one of the few overviews of the impacts of toxic substances in the environment.

   The CMARP's support for the TSMP sampling site at Vernalis would offer the opportunity to examine fish whose body burdens of toxic substances integrate contaminants from all of the San Joaquin River tributaries. Whenever elevated levels of toxicants appear at Vernalis, additional samples from upstream of the San Joaquin River and its tributaries could be taken to trace the contaminant to a source region. Once a source region was determined, watershed-based source control efforts could be initiated.

2. Design and assessment of various BMPs to reduce OC pesticides.

   A better understanding is needed of the effectiveness of various proposed BMPs to control sediment losses during the irrigation season. Some BMPs

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also need to be developed to reduce sediment losses during winter storm runoff.

3. Relationship between soil fertility and pest management.

   Additional research is needed on the relationship between soil fertility, pest management, and water use. Farmers in case studies found that soil fertility was key to reducing chemical inputs. Some also found that an extensive soil-building program could reduce water use.

4. Efficient irrigation technologies.

   Additional research dollars should be directed toward improving efficient irrigation technologies. Continued advances in technology are possible and should be aggressively pursued.

5. Agricultural runoff and water quality stressors.

   Continued research and technology transfer is needed to respond to increasing concerns related to surface water runoff from agricultural lands and their contribution to water quality stressors in the Delta.

6. Winter flood control and control of OC pesticide-laden sediment.

   The relationship of OC pesticide control with flood control measures to protect farmland should be studied. Projects should be encouraged where flood control measures also control off-site migration of OC pesticides.

6.4.3 Existing Activities

The TSMP was designed to follow the fate of pesticides in the California environment. This cooperative program, involving DFG and the SWRCB, has been monitoring pollutants in aquatic life since 1978. Although procedures have changed over time, the program continues to characterize the degree to which aquatic organisms and food chains are exposed to toxic materials and contaminants.

The TSMP was designed to follow the fate of pesticides in the California environment. This cooperative program, involving DFG and the SWRCB, has been monitoring pollutants in aquatic life since 1978.

Initially, benthic invertebrates, forage and predator fish, and sediments were analyzed at each site. Sediment sampling soon was dropped because of unsatisfactory results. Pollutants found during sediment analyses related more closely to the quantity of runoff from year to year than to the quantities emitted from point or non-point sources. Therefore, the program focused on the analysis of toxic contaminants in organisms. The body burden of toxic material in organisms represents an integration of the routes by which that organism is

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exposed to pollutants. A predatory fish, for example, may accumulate toxins directly through contact with the water or sediments, or by ingestion of smaller organisms with similar routes of accumulation.

The TSMP used several measures to put pollution in perspective. Human health concerns were reflected by using FDA MCLs, which would address concerns about the chronic human health effects of toxic substances consumed in foodstuffs. Wildlife concerns were assessed by considering the NAS/NAE-recommended maximum concentrations of toxic substances in fish tissue. Other reference levels were drawn from the United Nations Food and Agriculture Organization, and an internal standard reflecting elevated data from the range of samples collected during the program.

Since 1991, farmers in western Stanislaus County have participated in a very successful USDA water quality initiative project called the West Stanislaus Hydrologic Unit Area. The purpose of the project is to accelerate the voluntary implementation of BMPs through a locally led process, with financial, technical, and educational assistance from the USDA. Primary agencies include the West Stanislaus RCD, USDA Farm Service Agency, NRCS, and UC Cooperative Extension. Participation has grown to more than 25 local, state, and federal agencies that assist farmers in reducing off-site impacts from irrigation-induced erosion and sedimentation of the impaired San Joaquin River and Delta.

Since 1991, farmers in western Stanislaus County have participated in a very successful USDA water quality initiative project called the West Stanislaus Hydrologic Unit Area.

The CVRWQCB funded the West Stanislaus Sediment Reduction Plan (PLAN) that (1) benchmarked existing conditions and solutions, (2) provided practical self-evaluation tools and BMPs, and (3) defined an implementation strategy. The PLAN documented that up to 95% of the sediment leaving farmed fields could ultimately reach the San Joaquin River. Several hundred copies of the PLAN have been distributed to farmers. The PLAN has been used as a template in similar landscapes in nearby counties with similar resource concerns. All conservation practices are well defined in the NRCS Field Office Technical Guide, as well as standards, specifications, and performance measures.

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U.S. Environmental Protection Agency

Pesticides: Organophosphates

Process
Chemical Status
Federal Register Notices
Getting Involved
Other Information Resources

Organophosphate Pesticide Information

Chlorpyrifos Summary

Note: The complete revised risk assessment for chlorpyrifos was released for public comment on 8/16/00.

Uses

- Food uses for chlorpyrifos are: cranberries, strawberries, citrus, apples, figs, pears, nectarines, cherries, peaches, plums, grapes, almonds, pecans, walnuts, onions, peppers, kale, broccoli, brussels sprouts, cabbage, cauliflower, collards, cucurbits, asparagus, roots/tubers, corn, tomatoes, lentils, beans, peas, sorghum, tobacco, wheat, alfalfa, peanuts, soybeans, sunflower, cotton, sugar beets, mint, and bananas.
- Chlorpyrifos is also used as a termiticide; mosquitocide; a treatment for lawns, turf and ornamentals; an indoor crack and crevice and spot treatment; as a pet collar; as a treatment for pasture, woodland and lots/farmsteads; and as a cattle eartag.
- Use of chlorpyrifos in and around homes and in non-residential settings will be eliminated or phased-out by the chlorpyrifos manufacturers. Further, apple use will be restricted and use on tomatoes will be eliminated.
- Chlorpyrifos is not currently a restricted use pesticide. It is applied by the following methods: aerial, chemigation, groundboom, tractor-drawn granular spreader, airblast sprayer, low & high pressure hand wands, hydraulic hand-held sprayer, shaker can, bulbous duster, belly grinder, push-type spreader, large tank sprayer, compressed air sprayer, hose-end sprayer, aerosol sprayer, hand, pet collars and eartags.
- An estimated twenty to twenty-four million pounds of chlorpyrifos are expected to be applied annually. Approximately 50% of the use of chlorpyrifos is in agricultural settings and 50% of the use is in non-agricultural settings. An estimated 24% of all use of chlorpyrifos is as a termiticide.
- Mitigation is expected to reduce the total use of chlorpyrifos by as much as 50% when fully implemented based on available use data from the late 1990's.

Health Effects

- Chlorpyrifos can cause cholinesterase inhibition in humans; that is, it can overstimulate the nervous system causing nausea, dizziness, confusion, and at high exposures, respiratory paralysis, and death.

Risks

Dietary risk from food is below levels of concern based on risk mitigation.

- The acute and chronic risk assessments are highly refined using USDA Pesticide Data Program (PDP) data and FDA monitoring data that reflects actual use of pesticides for most commodities.
- Prior to mitigation, at the 99.9th percentile exposure there were acute risks of concern for the most exposed sensitive population sub-groups, consisting of all infants, children 1-6 years old, children 7-12 years old and females.
- Use of chlorpyrifos on apples, tomatoes and grapes have been mitigated to address acute dietary risks.
- After mitigation, at the 99.9th percentile, acute risks are not of concern for the most highly exposed population sub-group, children 1-6 years old.
- Chronic dietary risk is not of concern.

Residential risks have been mitigated.

- Prior to mitigation, post application re-entry risks and mixer/loader/applicator risks for residents are of concern for all exposure scenarios. These risk estimates are based on chlorpyrifos-specific studies supplemented by the Agency's SOPs for estimating residential exposure.
- To address residential risks, use of chlorpyrifos in and around homes and in non-residential settings will be eliminated or phased-out by the chlorpyrifos manufacturers.
- After mitigation residential risks are not of concern.

Worker risks are moderate and have been mitigated in some cases.

- For mixers, loaders, and applicators, risks for some exposure scenarios, including residential applications, are of concern even with maximum Personal Protection Equipment (PPE)/engineering controls, using data from chlorpyrifos-specific studies and the Pesticide Handlers Exposure Database.
- Restricted Entry Intervals (REIs) ranging from 1 to 10 days (with most of them being 1 day) would be necessary for various crops and activities to address post application re-entry risks. Typical labels currently require 12-24 hour REIs.
- As part of the mitigation, the chlorpyrifos registrants have agreed to voluntarily place the new REIs on all agricultural products. This will address post application worker risks.

Drinking water risk is below the levels of concern.

- A drinking water assessment that relies heavily on monitoring data determined that acute and chronic exposure from drinking water is not of concern based on the mitigation. Additionally, the voluntary mitigation mentioned earlier will mitigate drinking water exposures.

- Some localized applications of the subterranean termiticide use within 100 feet of wells have resulted in contamination of individual drinking water wells as evidenced by 251 reported contamination incidents from 1992-1997. In some instances, high levels of contamination have occurred. The risk assessment using high-end concentrations from these incidents conservatively estimates risks in these localized areas as very high. Incidents of this kind have been decreasing steadily since the issuance of the PR Notice on termiticides in 1996.

Aggregate risk is not of concern based on risk mitigation.

- The short-term and intermediate-term aggregate risks do not exceed the Agency's level of concern. Chronic aggregate risks do not raise a concern when all of the uncertainties and mitigation are considered.

Ecological risks are moderate.

- The risk assessment indicates that risk to birds, fish and mammals are high and that risks to aquatic invertebrates is very high.

- The mitigation of residential uses is expected to have some beneficial impact on risks to both aquatic and terrestrial organisms.

Chlorpyrifos Documents

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Last updated on Tuesday, August 17th, 2004
URL: http://www.epa.gov/oppsrrd1/op/chlorpyrifos/summary.htm

U.S. Environmental Protection Agency

Pesticides: Organophosphates

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Organophosphate Pesticide Information

Diazinon Summary

December 5, 2000

Use/Usage:

Over 13 million lbs of diazinon are applied annually. Use is on a variety of agricultural corps and livestock (about 20% of usage), on turf and for residential control of various insects indoors and outdoors (about 80% of usage). For non-ag use, the largest share is in homeowner outdoor insect control for turf and gardens (39%). Other large usage is in lawn care operators (19%) and pest control operators (11%). Indoor homeowner use is also registered. California, Texas and Florida are states with the most significant usage. Diazinon is about 1% of the Pest Control Operator (PCO) market for indoor insecticides.

Formulations:

Diazinon is registered as dust, granules, wettable powders, seed dressings, emulsifiable solutions, impregnated materials, encapsulated materials, concentrates and ready-to- use solutions.

Toxicity:

Diazinon endpoints are based on plasma, red blood cell and/or brain cholinesterase inhibition for all exposure routes and durations. Because route specific toxicity studies are available, dermal and inhalation absorption factors are not necessary. For inhalation, the standard uncertainty factor of 100 was applied with an extra 3X uncertainty factor due to the lack of a NOAEL in a rat 21-day inhalation study. Therefore, for inhalation exposures of all durations, an MOE of 300 is acceptable. For dermal short-term exposure, the target MOE of 100 is acceptable. For intermediate- and long-term dermal exposure, a 3X safety factor was added to account for the extrapolation from a 21-day dermal exposure to a longer term exposure. For intermediate- and long-term dermal exposure, a target MOE of 300 is acceptable.

Food Risks:

Acute and chronic dietary risk from food are acceptable (highest sub-population is 63% for acute and 22% for chronic (children 1-6 years old).

Water Risks:

Diazinon parent is moderately mobile and persistent. Based on monitoring data, there is no risk concern for either groundwater or surface derived drinking water exposure for chronic or acute. Modeling data indicate a possible concern for infants and children age 1-6 (acute), and children 1-6 and females age 13+ (chronic) from surface derived drinking water only. Water estimates do not include metabolites, since toxicity and monitoring data for these are lacking.

Residential Risks:

The Agency has concerns for potential childrens' exposures in the home. Potential routes of exposure for children may include inhalation of vapors and airborne particles and dermal contact.

Occupational Risks:

Occupational "handler" exposure to diazinon can occur during mixing, loading and application activities. Postapplication exposure may occur during scouting, irrigation, cultivation, harvesting and handling seeds. The majority of occupational risk estimates for handlers exposed to diazinon exceed the Agency's level of concern, even with personal protective equipment (PPE) and/or engineering controls. The majority of postapplication exposures exceed EPA's level of concern at the currently established restricted entry interval (REI) of 24 hours.

Ecological Risks:

Diazinon is highly toxic to birds, mammals, honey bees and other beneficial insects. It is also very highly toxic to freshwater fish and invertebrates following acute exposure. The endangered species levels of concern are exceeded for terrestrial wildlife, aquatic life and terrestrial plants.

Incidents:

Diazinon is one of the leading causes of acute insecticide poisoning for humans and wildlife. For humans, the rate of incidents is not high relative to its large volume of usage. The majority of incidents occur in the home. It also is one of the top causes of bird kill incidents.

Diazinon Documents

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Last updated on Tuesday, August 17th, 2004
URL: http://www.epa.gov/pesticides/op/diazinon/summary.htm

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NorCalSETACNews

Newsletter of the Northern California Regional Chapter of the Society of Environmental Toxicology and Chemistry.....Summer 2005

2005 Annual Meeting Review

NorCal SETAC held its annual technical meeting this year on May 3-4 at the University of California, Berkeley campus. Nicole David of the San Francisco Estuary Institute chaired the program and Josh Gravenmier hosted the meeting, which included four short courses, 33 platform presentations in 9 sessions, and 16 poster presentations. At the meeting the Chapter also was proud to announce Donald Crosby as its second Emeritus member. So many people come together to make the NorCal SETAC Meeting possible and our sincerest thanks go to everybody who helped make the 2005 Meeting another success.

Overall 150 people attended NorCal's 15th Annual Meeting and we have learned much from all the talks and posters, as well as from organizing another year of the conference. Session topics included Pacific Estuarine Ecosystem Indicator Research Findings, NPDES Testing: Recent Developments, Pyrethroids, Bioaccumulation Effects, Contaminant Monitoring and Modeling, Effects of Pest Control Measures, and Biomarkers and Effects. We would like to thank the session chairs Susan Anderson, Diane Griffin, Don Weston, David Ostrach, Karen Taberski, Ben Greenfield, and Jennifer Hayworth and the plenary speakers Bridgette DeShields, Edmund Smith, and Tracy Collier for their excellent contribution to the Meeting.

Mingling and breakfast treats before Platform Sessions.

Many people offered us guidance and support including Don Weston and Steve Owen from the department of integrative biology at UC Berkeley and Rachel Butler from Conference Services. We are now not only looking ahead to planning the 2006 Annual Meeting but also to planning a dinner meeting in September and another bioassessment workshop in the fall, so please check your email and the NorCal SETAC newsletter for announcements and stay tuned.

Barbara Washburn and Katie Springman hard at work at the registration desk

More meeting photos on pages 6-7!

Board Seeking Nominees for November Election

The NorCal SETAC Board of Directors is soliciting nominations for the 2006 Board. Directors are required to serve a three-year term, participate in one of the Board committees, and be a member of both NorCal and SETAC NA. The Board meets for a 1/2 day every other month. More information about the Board committees can be obtained at www.norcalsetac.org <http://www.norcalsetac.org/> .

If you are interested or know someone who would be, please send nominations via e mail to Emilie Reyes at ereyes@waterboards.ca.gov.

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Current NorCal SETAC Newsletter policy is to not solicit commentaries, but to consider printing commentaries as letters to the editor or as special sections when they are submitted and appropriate.

Website Features

As a member of NorCal SETAC you have exclusive access to many of the features offered on our website. Each member has a unique username and password that can be used to log on to the members only area of the website. Once logged on, members can search the directory for information about other NorCal members, modify their member record, and post job openings, resumes, and classified ads. If you don't have your username and password, you can enter your e-mail address on the website and it will be e-mailed to you or send an e-mail request to info@norcalsetac.org.

Newsletter Advertising Rates 2005

Size	Dimensions	Rate/ 1 issue	Rate/3 issues	Annual
Business card	2" x 3.5"	$20	$50	$80
1/8 page	3.5" x 2.25"	$25	$63	$100
1/4 page	3.5" x 4.75"	$50	$125	$200
1/2 page	7.5" x 4.75"	$100	$250	$400
1 page	7.5" x 10"	$200	$500	$800

*Annual Package: 3 issues+ Annual Program+ Membership Directory

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This newsletter is published three times per year and circulated to all members This distribution is an excellent opportunity for your company to advertise its services or products to the appropriate audience.

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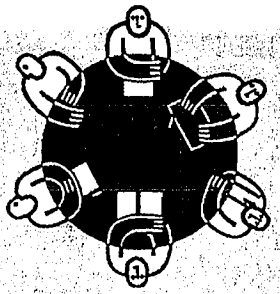

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We would like to recognize and honor our 2005 Sustaining Members:

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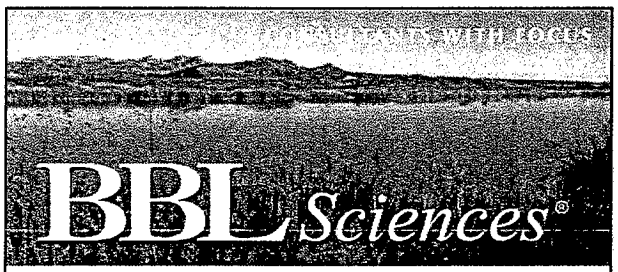
Aquatic Biological Assessment Workshops

The standardization of ecological assessments for use in California water quality management began with the development of the California Stream Bioassessment Procedure (CSBP) in 1993. Since then, the procedure has been calibrated with U.S. EPA procedures used throughout the west and has become the standard for the State Water Resources Control Board's Surface Water Ambient Monitoring Program (SWAMP).

The Northern California Chapter of the Society of Environmental Toxicology and Chemistry (NorCal SETAC) in collaboration with the Aquatic Toxicology Program at the School for Veterinary Medicine, UC Davis, is offering a set of workshops on conducting bioassessments in California. These workshops have been offered throughout California by Jim Harrington* using the instruction manual entitled "Measuring the Health of California Streams and Rivers" (Harrington & Born, 2000) and the latest bioassessment protocols approved by SWAMP.



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Part 1 will be conducted on September 7-9, 2005, at UC Davis

This workshop begins with one day of classroom presentations and discussion on Designing Rapid and Fully Integrated Freshwater Ecological Assessments. The next two days are conducted in the field with demonstrations of Physical/Habitat Assessments for Water Quality Projects and Sampling Biotic Communities in California Rivers and Streams. This workshop will provide the participant with an understanding of bioassessment design and prepare them for using the CSBP.

Part 2 will be conducted on December 19-21, 2005 at UC Davis

This workshop will provide the participants with an understanding of the laboratory procedures used in bioassessment and how to use the information in water resource management. Using the samples collected in Part 1, each participant will work on teams to perform Family-Level Taxonomic Identification of Freshwater Invertebrates. Throughout the laboratory exercise, there will be examples on how to Insure Data Quality and then based on this "real data" set, each participant will Calculate and Interpret Biological Metrics. Finally, there will be presentations and a discussion of Current Topics on the Use of Freshwater Ecological Assessments in Water Quality Regulation.

These two workshop parts are designed to be independent of each other. However, it is recommended to take both parts in the same year and if possible, in sequence. There will be a separate SETAC certificate for each workshop. The cost for each 3 day workshop is $300. The cost for both Part 1 and Part 2 is $600.

For registration and further information please contact:
David Crane (dcrane@OSPR.DFG.CA.GOV) and/or Inge Werner at iwerner@ucdavis.edu.

** The instructor is a Staff Environmental Scientist for California Department of Fish and Game. He has been directing the development of bioassessment in California since 1993, is a member of several U.S. EPA workgroups on integrating biological assessment into water quality regulation and is a contributing author of the SETAC Pellston Workshop entitled "Ecological Assessment of our Aquatic Resources: Application, Implementation, and Interpretation" (ISBN 1-88-611-56-2).*

Northern California Regional Chapter
Society of Environmental Toxicology and Chemistry

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Thursday, September 22nd Dinner Meeting

"Current Topics in California Bioassessment"

Featured Guest Speaker

Peter Ode, Ph.D.

DFG Aquatic Bioassessment Laboratory

Northern California SETAC is pleased to be hosting a dinner meeting featuring guest speaker Dr. Peter Ode from the Department of Fish and Game's Aquatic Bioassessment Laboratory on Thursday, September 22 at 6:00 pm at Rio City Cafe in Sacramento. **Dr. Ode, a research biologist with the ABL, will present an overview of the application of freshwater bioassessment techniques in California and discuss recent developments in the field.**

Dr. Ode received a bachelor's degree from Allegheny College and a Ph.D. in Entomology from Cornell University. Since joining the Aquatic Bioassessment Laboratory in 1995, Dr. Ode has been involved in nearly all aspects of developing and promoting freshwater bioassessment methodologies for use in statewide water quality assessment. Because biological assemblages integrate the water quality and habitat stressors occurring in watersheds, bioassessments provide a direct measure of stream health. Recent advances in bioassessment research are rapidly expanding the potential uses for bioassessment techniques in a variety of aspects of water quality monitoring and reporting. Dr. Ode will discuss the current state of bioassessment science in California and describe topics of current and future research.

Where:	When:	How Much:
River City Cafe 1110 Front Street Sacramento, CA 95814 (916) 442-8226	Thursday, September 22, 2005 Registration: 5:45 to 6:00 p.m. Dinner: 6:00 to 7:00 p.m. Speaker: 7:00 to 8:00 p.m.	Cash Only – Pay at Registration Professional Members - $23 Student Members - $15 Non-members - $28

Dinner choices include: a dinner salad AND a choice of pasta primavera (penne pasta with assorted fresh seasonal vegetables sautéed and tossed in a zesty tomato sauce), grilled chicken breast (boneless skinless chicken breast with grapes, walnuts, and a chardonnay cream sauce, served over parmesan polenta), or pork medallions (medallions of pork marinated in garlic, thyme, and olive oil, grilled and served with sundried cherry and port wine demi, parmesan polenta and mixed vegetables) PLUS cheesecake dessert AND a non-alcoholic beverage (coffee, tea, or soda). Alcoholic beverages can be purchased separately.

Space is limited, so make your reservations early!

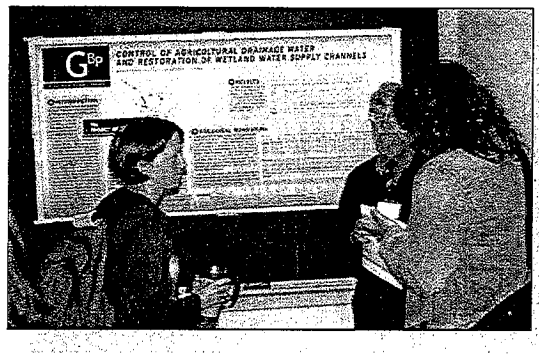
RSVP by September 10, 2005. Please contact Stephanie Fong (916-464-4822; swfong@waterboards.ca.gov) to RSVP or if you have any questions. Cancellations after September 15th will incur a $25 fee.

A011480

May 3-4, 2005...in pictures...

Emilie Reyes, Stephanie Fong, and Inge Werner working the registration desk.

Tom Grovboug presenting paper on SF Bay Area Cyanide criteria.



Discussion at one of the many posters.

Taking a break from the session.

Cheers Josh!

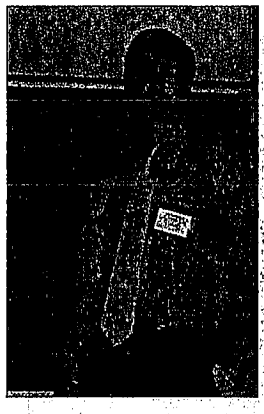
Enjoying lunch on the grounds at UCB's Clark Kerr Campus.

Ed and Bobbie Smth

A011481

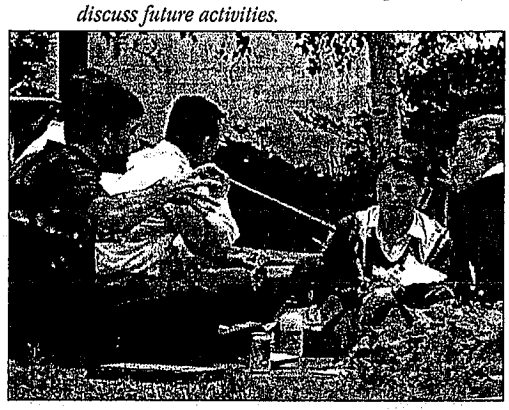
...and more.

Bridgette DeShields and Ben Greenfield



Richard Looker on copper and nickel.

Josh Gravenmier, Dan Glaze and Bridgette DeShields discuss future activities.



Enjoying a break on the Plaza.

Plenary speaker, Dr. Tracy Collier

Great food at the post-meeting cocktail hour.

David Crane and Stephanie Fong

Inge Werner, Diane Griffin and Jeanine Phillips at the sustaining members luncheon.

A011482

Diversified Perspectives

Analyses of Pyrethroid Pesticides at Low Levels by GC/MS

Peter W. Halpin, Caltest Analytical Laboratory, Napa CA (Pete_Halpin@Caltestlabs.com)
Richard Heines, Caltest Analytical Laboratory, Napa CA (Richard_Heines@Caltestlabs.com)

Pyrethroid pesticides are not new, but are being used more frequently as replacements for the organophosphorus pesticides Diazinon and Chlorpyrifos. Pyrethroids were expected to bring less inadvertent run-off toxicity than the pesticides they replaced, but newer evidence indicates that they cause toxicity in the sediment portion of the stream, and that dissolved levels may cause sub-lethal stresses to fish.

Pyrethroid Pesticides are also gaining more attention as recent toxicity studies indicate much lower thresholds of toxicity than indicated in existing Water Quality Goals. Generally speaking the analysis of Pyrethroid pesticides has been limited to reporting levels higher than the concentrations of interest for many analytes. More recently at least two non-commercial labs have provided reporting limits in the 0.01 to 0.05 ug/L range. Environmentally relevant reporting limits would ideally be in the single ng/L range, and 0.1 ng/L for permethrin and cypermethrin. Currently there are no regulatory approved methods.

The analytes of interest at this point seem to be represented by the following list:
Bifenthrin, Cyfluthrin, Cyhalothrin, Cypermethrin, Esfenvalerate/Fenvalerate, Fluvalinate, Fenpropathrin, Permethrin, Resmethrin, Tralomethrin/Deltamethrin.

Three existing analytical techniques are in use, and discussed in the literature. They are HPLC (High Pressure Liquid Chromatography) by EPA Draft Method 1660, GC/ECD (Gas Chromatography with Electron Capture Detector), and GC/MS-SIM (Gas Chromatography with Mass Spectrometer operated in the Single Ion Monitoring mode of narrow range scanning).

EPA's Draft Method 1660 lists reporting limits in the 2.5-5 ug/L range, with MDLs in the 1-2 ug/L range. This HPLC method is solely reliant on retention time for analyte identification. Confirmation is by retention time match on a dissimilar column. Many existing Water Quality Goals are in the 50 to 180 ug/L range making the HPLC method appear to be an appropriate choice for some pyrethroid monitoring. However, the Water Quality Goals are 0.002ug/L for Cypermethrin and 0.03 ug/L in freshwater and 0.001 ug/L in saltwater for Permethrin. For Water Quality Goals at these levels the reporting limits provided in the HPLC method are 1000 to 5000x too high.

The most recent toxicology data indicates a need for reliable quantitation of pyrethroids in the low ng/L range in water, and sub ug/Kg for sediments.

Gas Chromatography with an Electron Capture Detector (GC/ECD) is the most commonly used method of analyses of pyrethroids because of the extreme sensitivity of the detector. Analyte identification is limited to retention time match and identification of multiple isomers for some analytes. Reporting limits for this method are 5-80 ng/L. This method has been used in government and university labs. GC/ECD confirmation of analyte identity is based on retention time match for the analyte on a dissimilar column. Where possible, results have been confirmed with mass spectrum analyses, but GCMS sensitivity has not been low enough to confirm at the same reporting levels as the ECD.

The GC/MS-SIM method used by Caltest is not single ion monitoring, but a narrow-range scan for three masses of each analyte. The analyte of concern is qualitatively identified by relative retention time and the ratio of the quantitation ion abundance to the qualifying ion abundance. The third ion is used for monitoring purposes, and only needs to be present. This is considered three-dimensional data while GC provides two-dimensional data. The three dimensional data provides more confidence in identification.

Reporting limits in water are 5-10 ng/L, and 0.33ug/Kg wet wt. in sediment. Known problems include the inability to separately identify or quantitate Esfenvalerate/Fenvalerate, and Deltamethrin/Tralomethrin. These compounds should be reported together as they are indistinguishable by the GC and GCMS methods.

Caltest's reporting levels are based on a 1-Liter sample with methylene chloride extraction concentrated to 1mL final volume in water, and 30g sediment extracted by cold-sonication using methylene chloride and acetone with a final volume extract at 2ml. Cold sonication is used due to the analytes being thermally unstable.

Caltest's Pyrethroid List of Analytes and Water Quality Goals

Pyrethroid Analyte	*CVRWQCB Water Quality Goal (lowest of all categories) ug/L	Caltest Aqueous RL ug/L	Caltest Sediment RL ug/Kg	Hold Time in Reagent Water per USGS	Storage Stability Study by CA Dept. of Food and Agriculture
Bifenthrin (Biphenthrin)	110	0.005	0.33	>28 days	Stable thru 13days. Degradation by 30 days. Between 13 days and 30 is undetermined
Cyfluthrin (Baythroid)	180	0.01	0.33	15 days	Stable thru 13days. Degradation by 30 days. Between 13 days and 30 is undetermined
Cyhalothrin	35	0.005	0.33	3 days	3 days
Cypermethrin	0.002	0.005	0.33	15 days	Stable thru 13days. Degradation by 30 days. Between 13 days and 30 is undetermined
Fenvalerate (Pydrin)	175	0.005	0.33		Stable thru 13days. Degradation by 30 days. Between 13 days and 30 is undetermined
Fluvalinate	70	0.005	0.33		
Fenpropathrin (Danitol)	180	0.01	0.33		
Permethrin	0.03freshwater 0.001saltwater	0.005	0.33		3 days
Resmethrin	210	0.01	0.33		
Tralomethrin	53	0.005	0.33		

Hold Times added from USGS Water-Resources Investigations Report 01-4098 published 2001;
Storage Stability Study by CA Dept. of Food and Ag. as part of "Determination of Pyrethroids in Sediment Water" document:EMON-SM-52-7 Dated 09/04/2003
*State of California's Central Valley Regional Water Quality Control Board
Reporting Limit (RL) by Caltest using GCMS SIM, November 2004

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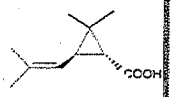
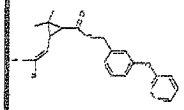
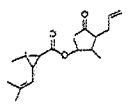
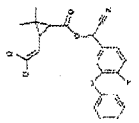
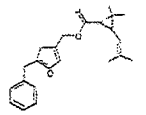
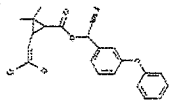
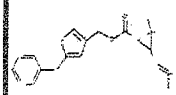
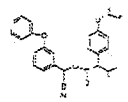
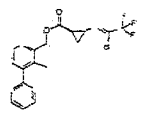
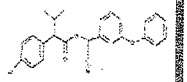
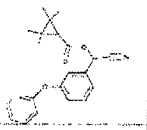
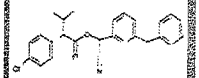
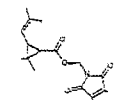
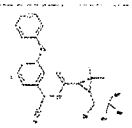
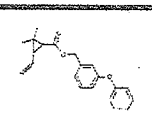
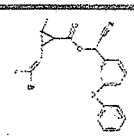
The importance of the GC/MS-narrow range scan method is reporting limits low enough to be relevant to toxicity ranges demonstrated in recent studies, and the ability to identify the analyte with confidence even in complex matrixes. Because the mass spectral analyses provides an additional level of confidence in analyte identification, GC/MS is preferred over GC/ECD when the reporting limits by GC/MS are adequate. Additionally, it can be used as a filter to in effect 'remove' interferences and identify a peak that is partially obscured by interferences, which can't be done with conventional GC/ECD. Where the sensitivity of the mass spec meets data quality objectives, or at least meets the sensitivity of an alternative method, the mass spec is usually the better choice.

Pyrethroids are of interest in many matrixes, clean water, dirty run-off, industrial wastewater, and sediments. The robust mass-filtering capability of the mass spec makes it ideal to handle the demands of multiple matrix effects.

Co-author, Richard Heines developed the GCMS narrow range scan method referred to in this article.

PYRETHROID STRUCTURES

Pyrethroid	Compound Structure	Pyrethroid	Compound Structure
1. Natural Pyrethrums		9. Permethrin	
2. Allenthrin		10. Cyfluthrin	
3. Bioresmethrin		11. Cypermethrin	
4. Resmethrin		12. Flucythrinate	
5. Bifenthrin		13. Fenvalerate	
6. Fenprorathrin		14. Esfenvalerate	
7. Tetramethrin		15. Tralomethrin	
8. Sumithrin		16. Deltamethrin	

NorCal SETAC Scholarship Program

The NorCal SETAC Graduate and Undergraduate Research Scholarship Awards are awarded to exceptional student members within our membership boundaries that are studying in the area of environmental toxicology and chemistry. Successful applicants must demonstrate their potential to carry out research projects related to the goals of NorCal SETAC.

NorCal SETAC will again be able to fund these scholarships in 2005 and the best proposals for this year will receive $2,000 (graduate) or $1,000 (undergraduate) for their research. The request for proposals will be announced soon on the NorCal SETAC website (www.norcalsetac.org). Completed applications will be due by August 31, 2005. The awardees will be notified by November 1, 2005 and awards will be dispensed within 30 days of notification. Awardees are expected to present their research at a NorCal SETAC meeting.

A011485

Advanced Techniques for the Analysis of Pyrethroid Pesticides

David B. Crane, Abdou Mekebri and Gloria Blondina, California Department. of Fish and Game, Office of Spill Prevention and Response, Fish and Wildlife Water Pollution Control Laboratory, Rancho Cordova, CA (dcrane@ospr.dfg.ca.gov)

Gas chromatography (GC) with electron capture detection (ECD) has been the benchmark for the routine analysis of legacy pesticides and PCBs for many years. This instrumentation has also been used for the analysis of pyrethroid pesticides because the electron capture detector is extremely sensitive for these compounds resulting in very low instrument detection limits. Minimum detection limits (MDLs) for pyrethroids at the low parts per trillion (ppt) range for water samples and low parts per billion (ppb) range for sediment samples are routine. While the detector is not specific for these analytes, when used with two capillary columns with different stationary phases, useful data can be generated. Problems with this method of analysis include the potential for severe background (chemical) response for "dirty" samples such as surface water and sediments unless rigorous extract cleanup techniques are employed and the time consuming and tedious data analysis required to obtain accurate results from the two sets of retention time data acquired from the two different GC columns.

In the 1980s, affordable bench top gas chromatography-mass spectrometry (GC-MS) systems using electron impact ionization (EI) were introduced that allowed mass spectral confirmation of analytes from reproducible fragmentation patterns when samples were analyzed using "full scan" mode (mass range of approximately 50-600 atomic mass units). Full scan MS is an excellent technique for samples containing target analytes at high enough concentrations to be detected by this technique, which can be an order of magnitude less sensitive than GC-ECD. Selected ion monitoring (MS-SIM), where three ions are monitored, dramatically improves the instrument's sensitivity for standards but most of the spectral information is lost. This loss of spectral information results in a loss of selectivity and can cause analyte identification and quantitation difficulties with "dirty" samples. Selected ion monitoring has been used for many years for the analysis of semi-volatile target compounds and if the sample extracts are clean (free of chemical interferences), the method can produce low-level, accurate and reproducible results.

The introduction of ion trap mass spectrometry technology resulted in improved instrument detection limits using full scan MS analysis without sacrificing the spectral information necessary for accurate analyte identification and quantitation. Ion trap GC-MS improved the instrument detection limits compared to conventional GC-MS but they are still not as low as GC-ECD instrumentation.

Gas chromatography and liquid chromatography interfaced with mass spectrometry are the methods of choice for environmental sample analysis. Advanced mass spectrometry techniques such as negative chemical ionization (NCI), MS/MS and MSn that were once only available with very expensive research instrumentation are now available with moderately priced bench top GC-MS systems. These techniques have greatly improved instrument detection limits over conventional GC-MS analysis and MS/MS techniques have greatly improved analyte selectivity and lowered instrument detection limits by reducing the chemical interferences that are associated with "dirty" samples.

Negative chemical ionization, especially NCI-SIM can dramatically reduce detection limits for halogenated analytes even below the detection limits achievable using GC-ECD. NCI-SIM offers the best signal to noise results for standards of any of the above MS techniques. However, due to the lack of specificity, NCI suffers from the same potential chemical interference problems as GC-ECD. Extracts from "dirty" samples produce very noisy spectral results making analyte identification and accurate quantitation difficult or impossible.

Tandem mass spectrometry (MS/MS) using electron impact ionization is less sensitive than ion trap MS, MS-SIM, NCI-MS and NCI-SIM for clean standards. However, MS/MS provides the selectivity needed to produce clean and reproducible spectra providing spectral information used for positive identification and accurate quantitation of all of the analytes in a sample. By lowering or eliminating the chemical background present in

A011486

"dirty" samples, the signal to noise with MS/MS is increased making it one of the most sensitive MS techniques. NCI-MS/MS is even more sensitive than MS/MS for some halogenated analytes.

Chemists at the California Department of Fish and Game, Water Pollution Control Laboratory (WPCL) have successfully used dual column GC-ECD following extensive extract cleanup procedures for the analysis of pyrethroid pesticides. Using GC-ECD with dual 60 meter capillary columns (DB5 and DB17MS), we have separated the different pyrethroid pesticide isomers. Method detection limits as low as 2-10 ng/L for water samples and 1-3 ng/g (dry weight) for sediment samples have been achieved using this technique. We have also used ion trap MS/MS techniques to analyze and confirm the pyrethroid pesticides lambda cyhalothrin and bifenthrin in surface water and sediment samples at very low concentrations achieving estimated MDLs of 0.2-0.5 ng/L for water samples and 0.2-0.5 ng/g for sediment samples.

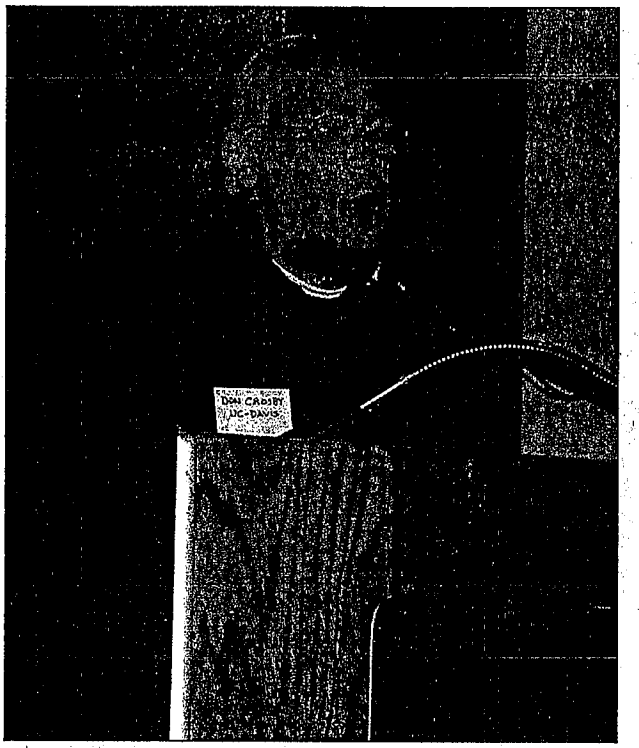
We are currently developing MS/MS methods using a triple stage quadrapole (TSQ) GC-MS equipped with NCI. In the next few months we will be developing and evaluating both GC-MS/MS and NCI-MS/MS methods for the analysis of trace levels of pyrethroid pesticides in surface water, sediment and tissue (plant and fish) samples. Based on the results of our earlier work with the analysis of bifenthrin and lambda cyhalothrin using ion trap MS/MS techniques we anticipate that the TSQ instrument will produce accurate results for sub-ppt concentrations of pyrethroid pesticides in water and sub-ppb concentrations in sediment and tissue. We also plan to investigate the use of liquid chromatography-tandem mass spectrometry (LC-MS/MS) for the analysis of pyrethroid pesticides.

Student Presenters at Annual Meeting

Pictured above are some of the students who presented their work at the 2005 meeting. Close to 15 student presentations were made at the annual meeting on a variety of interesting topics, ranging from modeling of atmospheric PAHs, effects of pyrethroids on salmon, ecotoxicogenomics, to the analysis of imperviousness in landscape scale risk assessment. A total of six monetary awards were given to students who made either poster or platform presentations. The awards were based on the clarity, approach, originality, and style of presentation. This year, faculty were contacted at all regional institutions of higher education with an environmental science program in order to encourage more participation by students. We plan to broaden outreach to students and increase their participation at future meetings.

A011487

Don Crosby named as 2nd Emeritus Member



At the Annual Meeting the Chapter also named Dr. Donald Crosby to join Ed Smith as its second Emeritus member. Don had his first paper on pesticide chemistry published in the JACS at age 20 and earned his doctorate in 1954 from the California Institute of Technology, Pasadena.

In 1961 he began a distinguished career at University of California, Davis when he was asked to form its first toxicology department. A few years later (1967) he coined the name "Environmental Toxicology" for the department, the first such use as a department name anywhere. As a professor until 1991, he sponsored over 40 PhD and MS students and was awarded the title of Professor Emeritus in 1991.

Don had over 220 technical papers published,, has authored 3 books and co-authored 3 others.

Importantly Don was also a founding member of both SETAC (NA) as well as our NorCal SETAC chapter.

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A011488

Info...News...Facts...

EPA Publishes the Methods Innovation Rule in the Federal Register as Final on June 14, 2005

The U.S. EPA published the Methods Innovation Rule (MIR) in the Federal Register as a Final Rule on Tuesday, June 14, 2005. Promulgation of the MIR removes the unnecessary requirements in the RCRA regulations to use only SW-846 methods. With the exception of about 25 method-defined parameters, which are still incorporated by reference in the RCRA regulations at 40 CFR 260.11, SW-846 methods are now guidance. View or download at http://clu-in.org/techpubs.htm

OEHHA adds two new chemicals to list of chemicals known in the state of CA to cause cancer or reproductive toxicity

The Office of Environmental Health Hazard Assessment (OEHHA) of the California Environmental Protection Agency is adding 2-bromopropane (2-BP) (CAS No. 75-26-3) and 1-hydroxyanthraquinone (CAS No. 129-43-1) to the list of chemicals known to the state to cause cancer or reproductive toxicity for purposes of the Safe Drinking Water and Toxic Enforcement Act of 1986 (Health and Safety Code section 25249.5, Proposition 65). The listing of 1-hydroxyanthraquinone is effective May 27, 2005 and the listing of 2-bromopropane (2-BP) is effective May 31, 2005. http://www.oehha.ca.gov/prop65/prop65_list/2bp1hydroxynot.html

OEHHA Publishes Memorandum on the Re-Evaluation of the PHG for Inorganic Mercury

Under the Calderon-Sher California Safe Drinking Water Act of 1996, the Office of Environmental Health Hazard Assessment (OEHHA) develops public health goals (PHGs) for regulated chemicals in drinking water and reviews and updates the risk assessments every five years (Health and Safety Code Section 116365(e)(1). This memorandum represents an update of the literature review and reevaluation of the existing PHG for inorganic mercury (OEHHA, 1999). OEHHA's re-evaluation supports the previous PHG derivation in 1999, and concludes that the PHG for inorganic mercury should remain at 1.2 ppb. http://www.oehha.ca.gov/water/phg/hgmemo0505.html

OEHHA Publishes Memorandum on the Re-Evaluation of the PHG for Lindane

Under the Calderon-Sher California Safe Drinking Water Act of 1996, the Office of Environmental Health Hazard Assessment (OEHHA) develops public health goals (PHGs) for regulated chemicals in drinking water and reviews and updates the risk assessments every five years (Health and Safety Code Section 116365(e)(1). This memorandum represents an update of the literature review and reevaluation of the existing PHG for lindane (OEHHA, 1999). OEHHA's re-evaluation supports the previous PHG derivation in 1999 (0.2 ppb). http://www.oehha.ca.gov/water/phg/lindaneupdate.html

ITRC Publishes Technical Guideline on Mitigation Wetlands

Characterization, Design, Construction, and Monitoring of Mitigation Wetlands (WTLND-2). This report was published by the Interstate Technology and Regulatory Council (ITRC). To promote the long-term sustainability of mitigation wetlands, this guidance provides developers, consultants, regulators, and communities with example checklists for evaluating and documenting habitat health and measuring other performance criteria of mitigation wetlands. http://www.itrcweb.org/Documents/WTLND-2.pdf

USACE Publishes Report on Regional Wetland Hydrology Indicators

The U.S. Army Corps of Engineers (USACE) ERDC Westland Regulatory Assistance Program has published a "Survey of Potential Wetland Hydrology Regional Indicators" by Chris V. Noble, Daniel J. Martel, and James S. Wakeley. The report provides an expanded list of hydrology indicators that could be used by Corps District staff delineating wetlands. http://libweb.wes.army.mil/uhtbin/hyperion/TN-WRAP-05-1.pdf

USEPA and USACE Publish Report on Long-Term Monitoring of Groundwater

Roadmap to Long-Term Monitoring Optimization (EPA 542-R-05-003). This document, produced by EPA and the U.S. Army Corps of Engineers (USACE), focuses on optimization of established long-term monitoring programs for groundwater. It discusses tools and techniques that concentrate on methods for optimizing the monitoring frequency and spatial distribution of wells.
View or download at http://clu-in.org/techpubs.htm

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USEPA Announces Availability of MTBE Guidance for LUST Sites

Monitored Natural Attenuation of MTBE as a Risk Management Option at Leaking Underground Storage Tank Sites (EPA 600-R-04-179). This report reviews the current state of knowledge on the transport and fate of MTBE in groundwater, with emphasis on the natural processes that can be used to manage the risk associated with MTBE in groundwater or that contribute to natural attenuation of MTBE as a remedy.
http://www.epa.gov/ada/download/reports/600R04179/600R04179.pdf

USEPA Announces Availability of Environmental Research Brief on Arsenic Groundwater/Surface Water Interactions

The Impact of Ground-Water/Surface-Water Interactions on Contaminant Transport with Application to an Arsenic Contaminated Site (EPA 600-S-05-002). This document provides a brief overview of the dynamics of chemical processes that govern contaminant transport and speciation during water exchange across the ground-water/surface-water transition zone and presents results from a field study examining the fate of arsenic during groundwater discharge into a shallow lake at a contaminated site.
http://www.epa.gov/ada/download/briefs/epa_600_s05_002.pdf

NOAA Releases Second Volume of Manual on Coastal Habitat Restoration Monitoring

The National Oceanic and Atmospheric Administration (NOAA) released volume 2 of Science-Based Restoration Monitoring of Coastal Habitats, which is a two volume manual that provides technical assistance, outlines necessary steps, and provides useful tools for the development and implementation of sound scientific monitoring of coastal restoration efforts. Habitats covered in this Manual include: water column, oyster reefs, kelp and other macroalgae, rocky shore, rock bottom, soft bottom, soft shoreline, submerged aquatic vegetation (marine, brackish, and freshwater), coastal marshes (marine, brackish, and freshwater), mangroves, deepwater swamps, and riverine forests.

Volume One: A Framework for Monitoring Plans Under the Estuaries and Clean Waters Act of 2000 (Public Law 160-457)

Volume Two: Tools for Monitoring Coastal Habitats
http://coastalscience.noaa.gov/ecosystems/estuaries/restoration_monitoring.html

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CONTAMINANT MONITORING AND RESEARCH PROGRAM

Final Project Report

Investigations of Sources and Effects of Pyrethroid Pesticides in Watersheds of the San Francisco Estuary

CONTRIBUTION NO. 523
JANUARY 2007

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INTRODUCTION

Sarah Lowe, SFEI

The primary purpose of this Proposition 13, PRISM Grant project was to investigate pyrethroids in sediments and their potential impact on benthic organisms. In recent years the US EPA has restricted the use of organophosphate (OP) pesticides for home use. As a consequence, the use of alternative pesticides such as pyrethroids is increasing in Bay Area watersheds. Pyrethroids are highly insoluble and are primarily associated with sediments in aquatic systems. Research has shown that greater than 90% of pyrethroid mass entering aquatic systems is associated with particles (e.g. suspended sediments) within 1 hour of application. Sediment-associated invertebrates such as amphipods are the most sensitive benthic organisms to these insecticides.

This project was developed to accomplish three separate tasks to

- screen a subset of tributaries that drain into the San Francisco Estuary for potential for sediment toxicity and evaluate pyrethroid concentrations in those tributaries,
- develop LC50s for a few pyrethroids for estuarine amphipods used in sediment toxicity testing in the region, and
- develop Toxicity Identification Evaluations (TIEs) for sediments toxicity tests that would sort out toxicity caused by pyrethroid compounds from other possible causes.

These tasks are linked by the common goal to increase our understanding sediment contamination and how it might affect estuarine amphipods of the San Francisco Estuary. By studying the current condition of sediment contamination in Estuary tributaries, filling in information gaps on the sensitivity of estuarine amphipods to specific compounds of local concern, and developing laboratory methods to determine the possible agents responsible for causing the observed sediment toxicity, this study provides needed information to begin to address what might be causing the persistent sediment toxicity to amphipods observed in the Regional Monitoring Program for Water Quality (RMP) since the programs inception in 1993, and of concern to environmental managers.

In-kind funding from the San Francisco Estuary Institute's Regional Monitoring Program for Water Quality (RMP) made it possible to broaden the scope of the PRISM Grant tributary screening study, from a focused characterization of sediment toxicity and pyrethroid pesticides, to include additional toxic pollutants listed in the California Toxics Rule (including metals, petroleum hydrocarbons, chlorinated and brominated hydrocarbons and pesticides) and more recent pollutants of concern (the flame retardants polybrominated diphenyl ethers (PBDEs)). This report also includes results from the RMP Exposure and Effects Pilot Study, which developed LC50s for the same estuarine amphipods reported in this study for three pyrethroid pesticides, to include three additional compounds of concern in the Estuary (copper, fluoranthene, and chlorpyrifos).

This report is separated into three chapters that present the reporting deliverables for the three project tasks mentioned above. Each chapter includes the associated references, tables, and figures at the end of each chapter.

A011500

Appendices A, B, and C present supporting documentation related to the ambient sediment sampling study, project task 3.10 (Chapter 1), and include sampling event photos, a summary of the quality assurance review, and a table of sampling results. Appendix D contains the agenda and meeting notes from two TIE workshops convened under this grant as part of the TIE development study, task 3.30 (Chapter 3).

Chapter 1. Ambient Sediment Sampling, Chemical analyses, and Toxicity Assays. This chapter reports on work performed under task 3.10 of this PRISM Grant.

A field study of six tributaries that drain into the San Francisco Estuary was conducted during the wet season of 2004-2005 (November and April) to determine if sediments entering the Estuary were toxic to ecologically relevant benthic amphipods. This study characterized contaminant levels in sediments, and the potential for toxicity. Sediments at one South Bay tributary (San Mateo Creek) were significantly toxic, warranting a Toxicity Identification Evaluation (TIE) to evaluate the possible causes of the observed toxicity.

In-kind funding for this study was provided by the RMP – Episodic Toxicity Program (2005), which provided enough funding to support two sampling events and the ability to analyze a larger suite of toxic pollutants (not part of the scope of this PRISM Grant). Results from the combined study are presented in this report.

Chapter 2. Relative Sensitivities of Toxicity Test Protocols With the Amphipods *Eohaustorius estuarius* and *Ampelisca abdita* to Sediment Spiked With Copper, Chlorpyrifos, Fluoranthene, Bifenthrin, Cypermethrin, and Permethrin. This chapter reports on work performed under task 3.20 of this PRISM Grant.

This study developed dose-response information (LC50s) for three pyrethroids (cypermethrin, permethrin, and bifenthrin) using standard EPA sediment toxicity test species: the amphipods *Eohaustorius estuarius* (an estuarine species used by the RMP's long term monitoring program) and *Ampelisca abdita* (an infaunal species found in the Estuary).

The RMP – Exposure and Effects Pilot Study (2004) conducted a separate study to develop LC50s for these same estuarine test species for copper, fluoranthene, and chlorpyrifos. Those results are presented in this report.

Chapter 3. Development of Toxicity Identification Evaluation (TIE) Methods for Pyrethroid Pesticides. This chapter reports on work performed under task 3.30 of this PRISM Grant.

Developed Toxicity Identification and Evaluation (TIE) procedures for sediment toxicity tests targeting pyrethroid pesticides.

A011501

CHAPTER 1. AMBIENT SEDIMENT SAMPLING, CHEMICAL ANALYSES & TOXICITY ASSAYS

Sarah Lowe, SFEI

The field monitoring study reported in this chapter covers work performed under Task 3.10: *Ambient Sediment Sampling, Analyses, and Toxicity Assays under this PRISM Grant # 041355520 AND additional work performed by the Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP) Episodic Toxicity Monitoring Program (2004-05). This work constitutes a jointly funded study to investigate sediment contamination, and the potential for sediment toxicity, during two sampling events (November 2004 and April 2005), in the lower freshwater and intertidal reaches of six tributaries around the San Francisco Estuary.*

1.1 INTRODUCTION

This project was designed to begin to address two current environmental concerns affecting the San Francisco Estuary. One is to investigate the possible causes of persistent sediment toxicity observed in the Estuary by the RMP Status and Trends program since it's inception in 1993 (SFEI 2003), and the other is concern over the fate and potential effects of pyrethroid pesticides on the environment as their use increases in watersheds around the Estuary (SFEI 2003; Amweg, Weston, and You. 2006).

Regulations restricting the use of the organophosphate pesticides diazinon and chlorpyrifos by the US Environmental Protection Agency in 1998 resulted in the decline in sales of those products in California during the period of 1999-2003. Several water toxicity studies in tributaries around the San Francisco Estuary documented a decline in the frequency of toxicity to water column species, and this is thought to be related to a decline in organophosphate pesticide use (SFEI 2003, Ruby, 2005). During this same period, the sales of pyrethroid pesticides have increased. Because of their tendency to accumulate in sediments, there is growing concern over the potential for sediment toxicity in sediments of the Estuary due to pyrethroid pesticides.

The RMP's-Status and Trends Monitoring Program has demonstrated seasonal differences in the frequency of sediment toxicity observed in the Estuary. Between 1993 and 1999 52% of the sediment toxicity samples collected during the winter sampling period (February) were toxic to amphipods while 15% of the samples collected during the summer sampling period (August) were toxic (Figure 1.1).

The RMP- Exposure and Effects Pilot Study (EEPS) toxicity workgroup met periodically between 2002 and 2003 to discuss the findings from the RMP's toxicity programs including the Episodic Toxicity Monitoring Program, which had been monitoring regional tributaries for aquatic toxicity during stormwater runoff events. The workgroup considered evidence of reduced occurrences of aquatic toxicity in the region and the shift in pesticide use patterns, and recommended that this program be adapted to investigate sediment toxicity in Estuary tributaries in 2004. Concurrent with this recommendation, SFEI was awarded the current PRISM grant to study several issues related to pyrethroids in sediments of the system. Resources from the PRISM and Episodic Toxicity Monitoring Program were combined for this field study designed to measure pyrethroid concentrations and associated sediment toxicity in six Estuary tributaries.

A011502

The focus of this study task was to evaluate if sediments from six tributaries around the Estuary were toxicity to freshwater and estuarine amphipods, and to characterize pyrethroid concentrations in those sediments. Recently deposited bedded surface sediments were collected for toxicity and chemical analyses.

Toxicity tests and chemical analyses were conducted on collected and homogenized sediment. Besides pyrethroid analyses, a suite of toxic pollutants listed in the California Toxics Rule (including metals, petroleum hydrocarbons, chlorinated and brominated hydrocarbons and pesticides) were characterized along with sediment grain-size, total organic carbon, and more recent pollutants of concern (including polybrominated diphenyl ethers (PBDEs)). While this PRISM grant focused on toxicity and pyrethroids, the RMP provided additional funding to enable a more complete characterization of contamination in tributary sediments.

Collaborating Laboratories

Laboratories that participate in the RMP Status and Trends Monitoring Program participated in this study to ensure consistency in sampling and analytical methods with the long-term data from the Estuary collected by the RMP (Table 1.1). One exception was for the sediment trace organics analyses in sediments, which was conducted by the California Department of Fish and Game's Water Pollution Control Laboratory (CDFG-WPCL) analyzed. This laboratory has worked closely with the UC-Davis toxicologists at the Marine Pollution Studies Laboratory at Granite Canyon (UCD-MPSL) on TIE development and dose-response studies prior to this study and was contracted to continue working with UCD-MPSL on tasks 2 and 3 of this Grant. Because of this CDFG-WPSL was contracted to perform the sediment trace organic analyses for the ambient sediment study in the tributaries.

1.2 METHODS

Two stations were selected in each of six San Francisco Estuary tributaries characterized by different mixes of urban and agricultural land-use practices (Figure 1.2). In general, tributaries in the North Bay drain mixed urban, rural, and some agricultural land-use types. Tributaries in the South Bay, while largely rural and agricultural in the upper watersheds, they pass through highly urbanized regions with varying degrees of industry, in their lower reaches, before reaching the San Francisco Estuary. An effort was made to locate stations that had been previously sampled as part of other studies and that contained depositional areas comprised of fine-grained sediments. The three North Bay tributaries selected were Petaluma River, Napa River, and Suisun Creek. The three South Bay tributaries were San Mateo Creek, Coyote Creek, and San Lorenzo Creek. Appendix A presents photos from each station during each sampling event. Most of these tributaries have one or more reservoirs in their upper watersheds.

The State Surface Water Ambient Monitoring Program – Region 2 has monitored three of the six selected tributaries (Petaluma, Suisun, and San Mateo), and described their watershed characteristics in detail in their workplans (SWAMP, 2001; SWAMP 2002). The RMP monitored Coyote Creek at two stations as a Pilot Study between 1996 and 1999 (Leatherbarrow et al., 2002). The Napa River was monitored by the RMP – Episodic Toxicity Monitoring Program (SFEI, 2003). Brief watershed land use

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descriptions follow starting with the Petaluma River watershed in the North Bay and moving clockwise around the Bay (Figure 1.2):

The Petaluma River watershed encompasses 97 square miles and contains rural, agricultural and limited residential and commercial land use. The lower watershed contains about 11% open space including marshes. Agricultural practices predominately poultry production, dairies, livestock, sheep, and horse farms (on large ranchettes dispersed throughout the watershed; SWAMP, 2002).

Napa River watershed encompasses 426 square miles and contains rural, agricultural and limited urban areas include residential and commercial land use. Vineyards and orchards are the dominant agricultural practices in this watershed. The lower reaches include grasslands, and marshes (NCRCD website).

Suisun Creek watershed encompasses 57 square miles and is largely agricultural and limited residential and commercial land use. Orchards are agricultural practices in this watershed. The lower reaches include grasslands, and marshes.

San Lorenzo Creek is in Alameda and Contra Costa Counties. The Lower watershed is surrounded by residential and industrial land use as the creek passes through the cities of Castro Valley and San Lorenzo. Urban runoff from storm drains is the major source of summer flow. The creek is highly channelized in the lower, urban reaches that drain into the Estuary.

The Coyote Creek watershed has historically been dominated by agricultural land use and still contains the largest contiguous area of agricultural land in the South Bay, Santa Clara Basin (Leatherbarrow et al. 2002; SCBWMI 2000). Urbanized land use in the lower watershed comprises about 12 %.

San Mateo Creek watershed encompasses 33 square miles and includes several reservoirs. Below the lowest reservoir, Crystal Creek Reservoir, the creek flows through rural and urban- residential areas followed by dense urban residential and commercial land use. Impervious surface estimates in the lower reaches of the creek are 38% and have lead to high bank erosion during large storm events (SWAMP, 2002).

The sampling stations were located in the lower reaches of each tributary with an "Upper" station in the freshwater reach just above the head-of-tide, and a "Lower" station within tidal reach.

Field sampling was conducted twice during the winter of 2004-2005. Samples were collected after the first rain of the winter in order to capture the potential effects of dry season pesticide usage (November - 2004). The second sampling occurred in late spring (April - 2005), after the winter rains and coinciding with the presumption of increased spring pesticide applications in urban and agricultural settings. USGS stream gauge data, available on the web, were used to determine if there was sufficient rainfall to warrant sampling ($\geq$ 0.5"; Table 1.2).

Bedded surface sediments (~2cm) were collected targeting recently deposited sediments for analysis of toxicity, grain-size and total organic carbon (TOC), and

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chemistry. Table 1.3A lists all the target parameters that were analyzed and their expected method detection limits (MDLs).

The original study design required chemical concentrations of toxic pollutants to be measured in sediment from all the Upper stations of each tributary, and only measured at the Lower stations that demonstrated significant toxicity to amphipods. The San Mateo Creek Lower station was the only Lower station that was toxic in this study, and it was toxic only in November 2004. However, some of the chemistry laboratories analyzed additional Lower station samples, so additional chemistry data are reported for those Lower stations that were not toxic. Additional results are reported at all the Lower stations for mercury, methyl-mercury (for all samples for both sampling periods), and for the trace organic contaminants (for all the April samples).

One toxicity identification evaluation (TIE) was included in this study task to try out the TIE methods developed in task 3 of this project (Chapter 3) on an ambient field sample. The San Mateo Creek Upper station was evaluated by TIE methods because it was the most significantly toxic station initially sampled, and it proved to be consistent, and severely toxicity in most subsequent tests (section 1.7).

Methods for collecting field samples, sample handling, and laboratory analyses are described in the project's Quality Assurance Project Plan (Lowe and Anderson, 2005). A brief summary is presented here.

Sample Collection and Handling

Sample collection was conducted by Applied Marine Science (AMS - Livermore, CA) and the San Francisco Estuary Institute (SFEI). Sample collection, handling, and laboratory methods were the same as those employed by the RMP Status and Trends program (SFEI, 2001) with the exception that the sample collection was performed by scooping only 1-2 cm of sediments directly from the creek bed rather than using a ponar grab and scooping out 5 cm of sediment. The PRISM QAPP (SFEI, 2005) describes the equipment and sampling protocols in more detail than presented below.

Sample containers were cleaned and prepared by the analyzing laboratory, or were factory pre-cleaned, and were delivered to AMS at least one week prior to the start of sampling.

It was critical that sample contamination be minimized during collection. All sampling equipment (i.e., compositing bucket and scoops) was composed of a non-contaminating, Kynar material and was thoroughly cleaned before each use. Sampling personnel wore polyethylene gloves whenever taking or processing samples to avoid contact contamination. In addition, airborne contamination was avoided by keeping sample containers, sample scoops, and compositing bucket appropriately covered (with aluminum foil) when not in use. Sampling equipment was cleaned with soap, acid, and methanol at each sampling site prior to sample collection.

Five liters of fine-grained sediment was collected from depositional areas in the creeks. The composite sample was homogenized (by careful stirring) and aliquoted into sample containers for all analyses with the exception of the mercury and methyl-mercury samples. Undisturbed sediment, collected using the scoops, was placed directly into several small sample containers, and kept in the dark. All chemistry and ancillary

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samples were stored on dry ice immediately after collection. Toxicity samples were stored on wet-ice.

Samples were shipped to the analytical laboratories in insulated coolers and were prepared, handled, stored, and transported in a manner that minimized bulk loss, analyte loss, contamination, or biological degradation.

Analytical Methods
Sediment chemistry analyses were comparable to those employed by the RMP Status and Trends Monitoring Program (SFEI, 2001) and complied with data reporting expectations of the PRISM QAPP (Lowe and Anderson, 2005). Extraction and analytical methods, target method detection limits, and data quality objectives employed by this study are listed by parameter (or parameter type) in Table 1.3B.

Reporting
Summaries of the field sampling results are presented in this report as bubble maps and schematic box plots. A color gradient was used in the maps to depict the range of reported concentrations (note that the axes of some parameters do not represent the *full* range of measurements as some concentrations were disproportionately high). A circle symbol (o) indicates PRISM tributary study results and a square symbol (□) indicates RMP Status and Trends 2004-2005 results within the Estuary. Results that did not pass the QA/QC review process are not shown.

The schematic box plots present tributary results for both the Upper and Lower stations for each tributary, and the North Bay (Suisun and San Pablo Bay) and South Bay (South and Lower South Bay) regions of the Estuary as defined by the RMP Status and Trends Program (SFEI 2006). Figure 1.3 displays the statistical components represented in the box plots. The horizontal line inside the box represents the median, and the mean is indicated by a blue dot. The top and bottom of the box represent the 3rd quartile (75th percentile) and the 1st quartile (25th percentile), respectively. The distance between these two is the interquartile range (IQR). A whisker is drawn from the upper edge of the box to the maximum value within the upper fence and from the lower edge of the box to the lowest value within the lower fence. The term "fence" refers to the distance from the 25th and 75th percentiles expressed in terms of the IQR. For example, the lower fence is located at 1.5×IQR below the 25th percentile, and the upper fence is located at 1.5×IQR above the 75th percentile. The fences are not displayed in the plots in this report; however, observations that fall beyond these fences (outliers) are indicated by a square symbol

Sediment toxicity tests included the 10-d growth and survival protocol for the freshwater amphipod *Hyalella azteca* (U.S. EPA 2000) for sediments collected in upper stations, and the 10-d survival protocol for the estuarine amphipod *Eohaustorius estuarius* in the tidally influenced lower stations (U.S. EPA, 1995). The complete laboratory report for the sediment toxicity tests is included in Appendix D and contains a detailed description of the methods, QA/QC control measures, and data analysis methods.

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1.3 QUALITY ASSURANCE/QUALITY CONTROL

A complete Quality Assurance/Quality Control (QA/QC) review of the analytical results showed that most results were within the data quality objectives (DQOs) outlined in the PRISM QAPP. Five DQOs were evaluated in this review: completeness, sensitivity, precision, accuracy, and blank contamination. Table 1.4 summarizes the analytical results that were outside the target DQOs. All individual field sample results and laboratory replicates in the database were appropriately qualified according to this QA review. A complete QA/QC summary is reported in Appendix B.

1.4 RESULTS

Tables 1.5a & 1.5b summarize of the field monitoring results for toxicity, sediment quality, trace elements and sums of and trace organic contaminants. Summary statistics are shown at the bottom of the tables along with regional average concentrations of In-Bay samples collected by the RMP Status and Trends program between 2004-2005. Appendix C lists all the study field sample results. The data have been compiled into a relational database comparable to SWAMP data formats (as they are defined at the time of this report), and are available upon request to SFEI.

Amphipod survival ranged from 5 to 100 percent with no toxicity observed in the Northern Estuary tributaries in either sampling period (Table 1.5a, Figure 1.4). Of the six tributaries sampled, San Mateo Creek showed sediment toxicity to amphipods at both the Upper (freshwater) and Lower (inter-tidal) stations sampled in both November (19 % and 39 % survival[1] respectively) and April (5 % and 33 % survival respectively). As a result of the persistent toxicity observed at the San Mateo Creek Upper station sediments from this location were used in the TIE presented in section 1.7 below. San Lorenzo Creek Upper station was toxic to amphipods in November (57 % survival), and the Coyote Creek Upper station in April (79 % survival).

Sediment grainsize (% Fines) and total organic carbon (TOC) ranged from 18-100 and 0.5-3.3% respectively (Figures 1.5-1.6). Average %Fines were similar in both the northern and southern tributaries (64% and 50%respectively, with an average of 57%). The lowest percentage of Fines observed in San Lorenzo Creek Upper station in November-2004. TOC concentrations were higher in April than in November with the highest concentrations found in San Mateo Creek, San Lorenzo Creek, and Napa River.

The San Mateo Creek Upper station had the highest concentrations of PAHs, PCBs, DDTs, Pyrethroids, methyl-mercury, nickel, and zinc of the tributaries sampled (Tables 1.5a and 1.5b, Figures 1.7-1.20).

Legacy contaminants, including sum of PAHs, PCBs and DDTs, were detected at all stations (Figures 1.7-1.9). Average sum of PAHs in the North Bay tributaries were about half the average RMP North Bay concentrations (2004-2005; Table 1.5b), while South Bay tributary averages were similar to the RMP South Bay average (2004-2005). Average North Bay tributary concentrations of the sum of PCBs were the same as the RMP North Bay average (3 µg/kg). However, average South Bay tributary concentrations for the sum of PCBs were three times higher than the RMP South Bay average (17 and 6 µg/kg respectively). Average North Bay tributary sum of DDT

[1] % Survival normalized to control.

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concentrations were three times higher than the RMP North Bay average (7 and 2.1 µg/kg respectively), while the South Bay tributary average was fourteen times higher than the RMP South Bay average (21 and 1.5 µg/kg respectively). The San Mateo Creek Upper station had the highest concentrations of sum of PCBs and sum of DDTs during the November and April sampling periods (35 and 34 ug/kg PCBs, and 64 and 37 µg/kg DDTs respectively).

Six of thirteen pyrethroid compounds currently in use, were analyzed in this study as these were the considered the more prevalent (and detectable) compounds at the time of the initial study plan. The target compounds were: bifenthrin, cyfluthrin, cypermethrin, esfenvalerate, lambda-cyhalothrin, and permethrin (Table1.5b, Figures 1.10-1.11). Only four of these six pyrethroids were detected in the ambient samples (esfenvalerate, and lambda-cyhalothrin were below detection in all samples), with bifenthrin being the most prevalent compound detected. This finding is consistent with another study conducted in the region during the same time period (Amweg *et al.,* 2006). Sum of Pyrethroids were detected in sediment from all six tributaries in the November samples, and four of the tributaries in the April samples (no pyrethroids were detected in Petaluma River or Suisun Creek in April).

The San Mateo Creek Upper station was the only location where four of the six pyrethroids analyzed were found above detection limits of 1-2 µg/kg (Figure 1.11). The San Mateo Creek Upper station had the highest concentrations of bifenthrin, and permethrin in November (10.3 and 20.5 µg/kg respectively). Cypermethrin and cyfluthrin were only found at the San Mateo Creek Upper station in November (4.2 and 8.6 µg/kg respectively).

Bifenthrin was the only pyrethroid detected in all six tributaries at least once. Detected concentrations ranged from 1.1 to 6.7 µg/kg in the North Bay tributaries, and 1.0 to 10.3 µg/kg in the South Bay tributaries. Permethrin was detected in four samples from three tributaries (Suisun Creek, San Mateo Creek, and San Lorenzo Creek) in the November samples (Figure 1.11).

Average Sum of PBDE concentrations for the South Bay tributaries were more than two times higher than the average North Bay tributary concentrations (8.4 and 3.6 µg/kg respectively; Table 1.5b and Figure 1.12). The RMP only reported BDE 47 concentrations in 2005. Therefore the North and South Bay tributary concentrations for PBDEs are compared to RMP North Bay and South Bay results (2004-2005) based only on that compound (Figure 1.13). The North Bay tributary BDE 47 concentrations were similar to the RMP North Bay results (2004-2005) with the exception of Petaluma River which was higher than the 75th percentile of the RMP North Bay data (2004-2005). South Bay tributary concentrations were significantly higher than the RMP South Bay concentrations (2004-2005) with San Lorenzo Creek having the broadest range of concentrations.

Average trace element concentrations in the North Bay tributaries were higher than the RMP North Bay average (2004-2005) for silver, mercury, methyl-mercury, and lead (ratios ranged from 2.3 – 3.5; Table 1.5a). Methyl-mercury and lead were the only average South Bay tributary trace element concentrations that that were nearly twice as high as the RMP South Bay average (2004-2005; ratios were 1.9 and 1.8 respectively). In general, arsenic, cadmium, iron, and selenium sediment concentrations were higher in the Estuary than in the tributaries studied (Table 1.5a).

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San Mateo Creek had the highest concentrations of four metals in April (copper (67 mg/kg), methyl-mercury (5.31 µg/kg), nickel (197 mg/kg), and zinc (228); Table 1.5a, Figures 1.15, 1.18, 1.19, and 1.20)). Napa River had the highest mercury concentration in April (1.53 mg/kg: two times higher than the next highest concentrations measured in this study; Figure 1.17). Methyl mercury was high in Suisun Creek in November and Napa River in April. Suisun Creek and Petaluma River had the highest magnesium concentration (1134 and 1115 mg/kg respectively) (Table 1.5, Figure 1.7).

As mentioned above, San Mateo Creek showed the lowest amphipod survival in this study and was targeted for implementing a TIE evaluation using recently developed techniques to identify if pyrethroid pesticides were contributing to the observed toxicity. The following section describes that effort.

1.5 TOXICITY IDENTIFICATION EVALUATION – SAN MATEO CREEK UPPER

Sediments at both upper and lower San Mateo Creek were significantly toxic to amphipods in November 2004 and April 2005 (Table 1.5a). Additional sediment was collected in May 2005 for initial TIE exposures (Tables1.6 and 1.7). Sediment and interstitial water from the San Mateo Creek Upper station (SANMATCRKUP) was significantly toxic to *Hyalella azteca*. Although the interstitial water was significantly toxic at full strength, it contained less than 2 toxic units, and the signal was not considered to be sufficiently strong for a TIE. The San Mateo Creek Lower sample (SANMATCRKLWR) collected at this time was not significantly toxic to warrant conducting a TIE. In addition, subsequent samples collected from SANMATCRKLWR later in the year continued to demonstrate no or weak toxicity, so no TIEs were conducted at this station (Table 1.7).

TIE Methods

Because of consistent toxicity was observed in sediments from the San Mateo Creek Upper station, a Toxicity Identification Evaluation (TIE) was conducted on sediment from this station. The following solid-phase TIE treatments were performed on undiluted sediment. Treatment blanks consisted of laboratory formulated sediment that underwent the same treatment as the sample. Formulated sediment was prepared using equal parts Salinas River, California reference site sediment and clean, kiln-dried sand (#60, RMC Pacific Materials, Monterey, CA, USA). The sediment was amended with 0.75% organic peat moss (Uni-Gro, Chino, CA, USA). One kilogram (dry weight) of formulated sediment was prepared by combining 500g reference sediment, 500g sand, and 7.5g peat with 350 mL clean dilution water. Phase I TIE treatments consisted of additions of amendments to the sediment, or treatments of the overlying water. Sediment amendments included Ambersorb and SIR-300. Overlying water treatments consisted of addition of carboxylesterase enzyme, bovine serum albumin (BSA), and piperonyl butoxide (PBO). The baseline treatment was also performed at a colder temperature to provide additional evidence of toxicity due to pyrethroids. Phase II TIE procedures consisted of separating the Ambersorb from the sediment, extracting it with solvent, and spiking control water with the acetone eluate as a toxicity return procedure. Sediment was analyzed for three classes of pesticides (organochlorine, organophosphate, and pyrethroid pesticides), PAHs, and metals in San Mateo Creek Upper sediment in conjunction with this initial TIE, as well as in the Ambersorb acetone eluate generated for the Phase II TIE procedures.

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The following is a summary of the solid-phase TIE methods:
• Baseline - Toxicity test on un-manipulated sample. Five 250-mL replicate beakers each containing approximately 50g sediment and 200 mL clean dilution water.

• Ambersorb 563® (Rohm and Haas, Spring House, PA, USA), a carbonaceous, non-polar resin, was prepared by rinsing it thoroughly with Nanopure® water. Ten percent Ambersorb by wet weight was added to sediment (Kosian *et al.* 1999, West *et al.* 2001). Treated sediment was homogenized for 24 hours on a roller apparatus and loaded into exposure chambers. A dilution blank was created by combining test sediment with 10% formulated sediment, and an Ambersorb blank was created by adding 10% Ambersorb to formulated sediment. At test termination the sediment was sieved through a series of screens ranging from 250-400 μm to retain the Ambersorb. The Ambersorb was then eluted by loading a column with approximately 7.5g resin and pumping 10 mL of acetone through the column at a rate of 1 mL per minute. Post-column acetone was collected in a 50 mL beaker and evaporated to a final volume of one mL. The final volume was combined with 100 mL clean dilution water to create the eluate sample for toxicity testing with *H. azteca*. The 100 mL water volume was chosen because *H. azteca* are tolerant of 1% acetone, and we are attempting to maximize the return of toxicity and contaminants. The magnitude of toxicity and the concentrations of contaminants in the Ambersorb eluate sample are used in the weight-of-evidence for determining the cause of toxicity. They demonstrate the presence of toxicity and contaminants in the original sediment sample, but are not necessarily reflective of the actual sediment of interstitial water concentrations. An Ambersorb elution blank was prepared by performing the above treatments on Ambersorb that had been combined with formulated sediment. A 1% acetone blank was also tested.

• SIR-300 (ResinTech, West Berlin, NJ) is a macroporous weak acid cation exchange resin based on the iminodiacetate acid functional group, which has chelating properties for heavy metal ions even in conditions with high calcium concentrations. After preparation, SIR-300 can be mixed into sediment to reduce cationic metal bioavailability (Burgess *et al.* 2000). Ten percent SIR-300 (wet weight) was added to the sediment in a 500 mL mixing jar. Treated sediment was homogenized for 24 hours on a roller apparatus, and loaded into exposure chambers. A dilution blank was created by combining test sediment with 10% formulated sediment, and an SIR-300 blank was created by adding 10% SIR-300 to formulated sediment. At test termination the sediment was sieved through a series of screens ranging from 250-400 μm to retain the SIR-300. The SIR-300 was then eluted by loading a column with approximately 7.5g resin and pumping 10 mL of 1N hydrochloric acid through the column at a rate of 1 mL per minute. Post-column acid was combined with 100 mL clean dilution water and neutralized to create the eluate sample for toxicity testing with *H. azteca*. An SIR-300 elution blank was prepared by performing the above treatments on SIR-300 that had been combined with formulated sediment. An acid blank was also tested.

• The enzyme carboxylesterase (Sigma-Aldrich, St. Louis, MO) hydrolyzes ester-containing compounds such as pyrethroids to their corresponding acid and alcohol, which are generally not toxic (Wheelock *et al.* 2004 and 2006). Carboxylesterase (500x) was added to the overlying water on the day of test initiation, six hours prior to the addition of amphipods. This allowed for interaction between the enzyme and pyrethroids. The enzyme was added based on units of activity. One 'x' of enzyme activity equals 0.0025 units of enzyme per mL of sample, therefore at 500x, 1.25 units per mL were added. Enzyme strength is unique for each lot purchased (Wheelock *et al.*

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2004). To control for the binding of contaminants to the protein base of the enzyme, a separate set of replicates was treated with bovine serum albumin (BSA). Reduction of toxicity by the enzyme, and not the BSA, confirms the presence of pyrethroids. The enzyme and protein treatments were given daily booster shots of BSA and carboxylesterase.

• Piperonyl butoxide (Sigma-Aldrich, St. Louis, MO) is used to block the metabolic activation of acetylcholinesterase-inhibiting organophosphate pesticides (Ankley and Collyard, 1995). It is also a potent synergist of pesticide toxicity, because it inhibits their metabolism (Ware 1989, Kakko *et al.* 2000). The PBO treatment contained 500 µg/L of PBO in the water overlying the sediment. Decreased toxicity with the addition of PBO suggests the presence of organophosphate pesticides. Increased toxicity with the addition of PBO suggests the presence of pyrethroids. There is also some evidence that PBO increases toxicity caused by DDT (Brandt *et al.* 2002), but we are unaware of specific studies exposing *H. azteca* to mixtures of PBO and DDT.

• An additional baseline treatment was conducted at 15°C because the toxicity of some organochlorine and pyrethroid pesticides increases with decreasing temperature (Ware 1989).

TIE Physical and Chemical Measurements

Water quality parameters of dissolved oxygen, pH and conductivity were measured using a Hach SensION© selective ion meter with appropriate electrodes; and ammonia was measured using a Hach 2010 spectrophotometer. Temperature was measured using a continuously recording thermograph and thermometer. Concentrations of the organophosphate pesticides chlorpyrifos and diazinon were measured using enzyme-linked immunosorbent assays (ELISA, Strategic Diagnostics Inc, Newark, DE).

Sediment was analyzed for three classes of pesticides, organochlorine compounds (U.S. EPA Method 8081), pyrethroids (U.S. EPA Method 1660), and organophosphates (U.S. EPA Method 8141). All analyte identifications were confirmed by gas chromatography-mass spectrophotometer or liquid chromatograph-mass spectrophotometer. Acetone eluates of the Ambersorb and methanol eluates of the HLB treatments were also analyzed for the same three classes of pesticides. Ambersorb eluates were further analyzed using direct injection of the pure solvent into the gas chromatograph. Sediment was also analyzed for metals (US EPA Method 1638) and polycyclic aromatic hydrocarbons (PAHs US EPA Method 8270).

TIE Data Interpretation

Treatment blanks were evaluated to determine if sample manipulations added toxic artifacts. Treatment data were then compared to one another based on organism response.

TIE Results

Amphipod survival in the baseline SANMATCRKUP sample was 16% (Table 1.8). All treatment blanks conducted as part of this TIE demonstrated acceptable survival. Ten and 20% dilution blanks increased survival to 22% and 40%, respectively. Addition of 10% Ambersorb to the sediment increased survival to 42%. While Ambersorb alone increased amphipod survival, complete mortality was observed when Ambersorb was combined with the cation exchange resin SIR-300. An acetone elution of the Ambersorb

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returned toxicity when the acetone was spiked into clean dilution water, indicating the toxicity was caused by an organic contaminant.

Addition of the carboxylesterase enzyme to the sediment overlying water increased amphipod survival to 60%. Addition of PBO to the sediment overlying water caused complete mortality. Decreasing test temperature from 25°C to 15°C also caused complete mortality, and decreased the efficiency of the enzyme treatment. Reduction of toxicity with carboxylesterase and increase of toxicity with PBO and reduced temperature characterize the cause of toxicity as a pyrethroid.

A second solid-phase TIE was conducted with the enzyme treatment and this TIE included addition of bovine serum albumin (BSA). BSA is added to account for toxicity reduction resulting from the binding of contaminants to the protein base of the enzyme (Table 1.9). Baseline survival was 24% in untreated SANMATCRKUP sediment and the addition of the enzyme increased survival to 72%. Addition of BSA increased survival to 60%, which was not significantly different from the enzyme treatment. Reduction of toxicity with the addition of BSA suggests that the some of the reduction of SANMATCRKUP sample toxicity could have been due to reduced contaminant bioavailability, rather than the esterase activity of the enzyme.

A third solid-phase TIE was conducted to determine if addition of greater Ambersorb mass further reduced toxicity of SANMATCRKUP sediment. Three Ambersorb additions were tested, 10%, 15% and 20%. Baseline survival was 2% (Table 1.10). The addition of 10% Ambersorb increased survival to 28%, but the addition of 15% Ambersorb only increased survival to 10%. Addition of 20% Ambersorb increased survival to 52%, but this response was not significantly different from the 20% dilution blank, indicating that the increase in survival could be due to dilution alone. Acetone elution of both 10% and 20% Ambersorb treatments returned toxicity to clean dilution water, suggesting that toxic concentrations of organic chemicals were eluted from the Ambersorb.

Sediment was analyzed for organochlorine, organophosphate, and pyrethroid pesticides, PAHs, and metals, and the 10% Ambersorb acetone extract from the third solid-phase TIE was analyzed for organochlorine, organophosphate, and pyrethroid pesticides. The sediment contained concentrations of two pyrethroids, cyfluthrin and cypermethrin, several metals, and organochlorine pesticides (Table 1.11). The solid-phase concentration of cyfluthrin was below the sediment LC50 (Amweg *et al.* 2005). The concentration of cypermethrin in this sample was below the LC50 for cypermethrin, based on a 10 day exposure, reported by Maund *et al.* (2002). The organic carbon normalized total DDT concentration, was well below the effects threshold of Nebeker *et al.* (1989). Concentrations of chromium and nickel were also above their PEC values, but because SIR-300 did not reduce toxicity, it is unlikely metals played a significant role in the cause.

The acetone extract of the Ambersorb contained toxic concentrations of cyfluthrin, DDD (p,p'), and DDT (p,p') (Table 1.7). The concentration of cyfluthrin was approximately 9 times the top 10th percentile water-only LC50 (Solomon *et al.* 2001, Amweg *et al.* 2005), and the concentrations of DDD (p,p'), and DDT (p,p') were greater than the water-only LC50s reported by Hoke *et al.* (1994).

It should be noted that although several chemicals were detected in both the sediment and Ambersorb eluates, the concentrations in the Ambersorb eluate sample may not

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reflect their concentrations in the sediment interstitial water. Interstitial water chemical concentrations were not measured in this study.

San Mateo Creek UPPER TIE Summary

Identifying chemicals responsible for sediment toxicity requires multiple lines of evidence that combine chemical analyses with the results of solid-phase and interstitial water TIEs. Toxicity of San Mateo Creek Upper sediment was greatly reduced with the addition of the carbonaceous resin Ambersorb in two solid-phase TIEs. In both cases, acetone extracts of the Ambersorb were highly toxic when spiked into clean water. These results suggest that toxic concentrations of organic chemicals were present in San Mateo Creek Upper sediment.

Sediment toxicity was reduced when the carboxylesterase enzyme was added to sediment overlying water in two TIEs, and these results suggest pyrethroid pesticides were partly responsible for toxicity. However, toxicity was also reduced with the addition of Bovine Serum Albumin, a protein source added to differentiate between the esterase activity of the enzyme, and reduction in pyrethroid toxicity due to its binding to the enzyme surface. BSA reduced sediment toxicity to a lesser degree than the enzyme, suggesting that both sorption and esterase activity reduced sample toxicity. Partial reduction of toxicity by the enzyme suggests that pyrethroids are partly responsible.

Two other lines of evidence support the conclusion that pyrethroids are partly responsible for toxicity of San Mateo Creek Upper sediment. Toxicity greatly increased with the addition of the metabolic inhibitor PBO, and toxicity increased when the sample was tested at lower temperature. However, previous studies have suggested that DDT is more toxic at lower temperatures (Ware *et al.* 1989), and PBO may also potentiate toxicity of this pesticide.

Chemical analyses of San Mateo Creek Upper sediment conducted in conjunction with the TIE showed two pyrethroids in the sample, cyfluthrin and cypermethrin. Concentrations of both pyrethroids were lower than their respective LC50s. In addition DDT metabolite concentrations were below LC50 values. Concentrations of cyfluthrin, DDD (p,p'), and DDT (p,p') in the Ambersorb eluates were above published water-only LC50 values.

The solid-phase TIE treatments characterized the cause of toxicity as due to an organic chemical. Additional Phase II treatments (enzyme and BSA) and solid-phase and Ambersorb eluate chemical analyses identified pyrethroid pesticides as the possible cause of toxicity. The TIE evidence also suggest DDT metabolites could have played a role in sediment toxicity at this site. Sediments in the San Mateo Creek Upper station demonstrate temporal variability in pyrethroid concentrations. For example, samples from November 2004 contained four pyrethroids, and bifenthrin concentrations at this time were within the toxic range. No pyrethroids were detected in the April 2005 samples, but cyfluthrin and cypermethrin were detected in the May 2005 samples used in the TIE. Additional monitoring at this site would be useful to document sources of contaminants and their variability. TIEs conducted in conjunction with monitoring designed to better document temporal variability would be useful to more fully differentiate causes of sediment toxicity in San Mateo Creek.

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1.6 CONCLUSIONS

This study characterized sediments from six Bay Area tributaries for the potential to cause toxicity to amphipods, grain-size, total organic carbon, a suite of toxic pollutants including pyrethroids and compounds used as flame retardants (PBDEs). Sampling and analytical methodologies were comparable to the RMP-Status and Trends program. The results provide a base-line, description of selected pyrethroid concentrations in urban tributaries in 2004-2005 around the Estuary, when sales of those pesticides have been increasing in recent years.

Of the six tributaries studied, only the South Bay tributaries were toxic to amphipods during the two sampling events (Nov-2004 and April-2005). San Mateo Creek was toxic to both freshwater and estuarine amphipods during both sampling events, and had the lowest % survival and highest contaminant concentrations for important legacy and emerging pollutants. The TIE performed on sediments from the Upper station of San Mateo Creek indicated that the toxicity was possibly caused by pyrethroids and/or DDT metabolites. Two other sediment samples were toxic in this study, San Lorenzo Creek Upper station in November-2004, and Coyote Creek Upper station in April-2005.

Pyrethroids were detected in all tributaries studied with higher concentrations observed in November than in April. Of the six pyrethroids measured, only bifenthrin and permethrin were found in more than one tributary. Only six of thirteen pyrethroids in use in California were measured in this study (because at the time of the project planning it was believed that the six targeted pyrethroids comprised the most prevalent and toxic compounds), making it difficult to accurately characterize the role of these compounds in evaluating the ecological condition of the targeted tributaries. The lack of a comprehensive pyrethroid analysis may partially explain the less definitive results of the TIE conducted at the San Mateo Creek Upper station as a more comprehensive chemical analysis of the confirmation sample, the Ambersorb acetone extract from the third solid-phase TIE, might have provided additional information to tease out the relative contributions of the organochlorine, organophosphate, and pyrethroid pesticides to observed toxicity in that sample.

In general, the South Bay tributary sediments (San Mateo Creek, San Lorenzo Creek, and Coyote Creek) were more toxic to amphipods and tended to have higher concentrations of measured contaminants (including: PAHs, PCBs, DDTs, pyrethroids, PBDEs, cadmium, methyl-mercury, nickel, and selenium) than the North Bay tributary sediments (Petaluma River, Napa River, and Suisun Creek). Average South Bay tributary concentrations of PCBs, DDTs, BDE 47, and methyl-mercury were much higher than average concentrations observed in the South Bay (RMP Status and Trends program (2004-2005), pyrethroids were not measured by the RMP so could not be compared).

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Table 1.1. Study Participants and Target Parameters.

Project Management, Logistics, Information Management	Ms. Sarah Lowe[1], Ms. Cristina Grosso, Mr. John Ross, Ms. Amy Franz, Mr. Predrag Stevonovich, and Dr. Donald Yee San Francisco Estuary Institute (SFEI), Oakland, CA
Logistics	Mr. Paul Salop, Mr. Bryan Bemis, and Ms. Basia Hajduczek Applied Marine Sciences (AMS), Livermore, CA
Sediment Trace Organic Chemistry PAHs, Alkylated PAHs, PCBs, Synthetic Biocides including: Chlordanes, HCHs, Cyclopentadienes, Pyrethroids	Dr. Dave Crane, Mr. Abdu Mekebri and Mr. Loc Nguyen California Dept. of Fish & Game, Water Pollution Control Laboratory (CDFG-WPCL), Rancho Cordova, CA
Sediment Trace Element Chemistry, & Ancillary Sediment Characteristics Ag, Al, As, Cd, Cu, Hg, meHg, Mn, Ni, Pb, Se, Zn; Grain-size, Total Organic Carbon, Total Nitrogen	Dr. Colin Davies and Ms. Elizabeth Madonick Brooks-Rand Ltd. (BRL), Seattle, WA
	Dr. Russ Flegal and Ms. Genine Scelfo UC Santa Cruz (UCSCDET), Santa Cruz, CA
Sediment Toxicity Testing 10-day amphipod tests	Mr. Brian Anderson[1], and Mr. Bryn Phillips Marine Pollution Studies Lab (UCD-MPSL), Granite Canyon, CA

[1] Principal Investigators

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Table 1.2. Station location information, date sampled, latitude/longitude, and stream gauge graphics.

Stream gauge graphics are from the USGS Real Time Stream Gauge website and show stream height prior to the November and April sampling events.

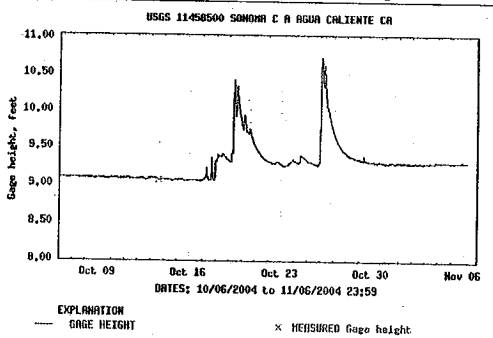
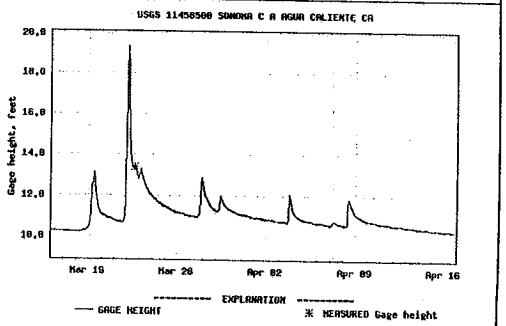
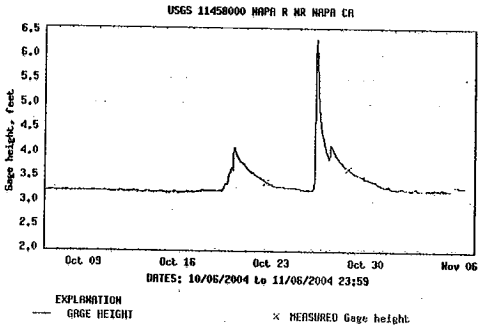
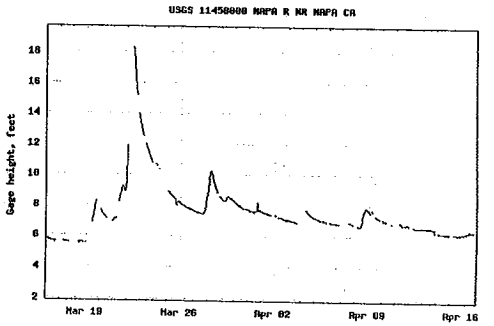
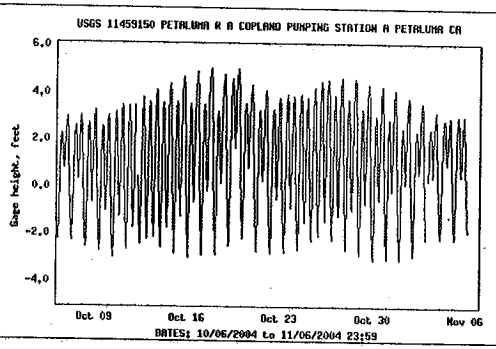
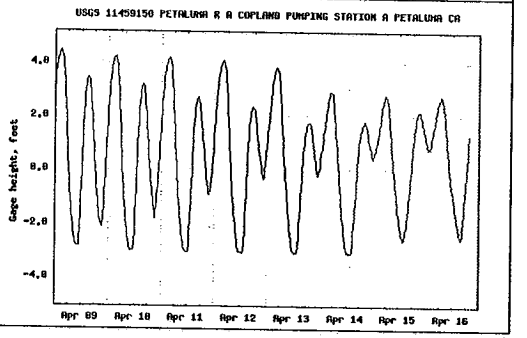
North Bay Tributaries	November Stream Gauge Heights	April Stream Gauge Heights
Suisun Creek Upper: (fresh water) (Rockville Rd and Willotta Dr. Suisun City, CA) Sampled the quieter, upstream portion of the Creek. Date Sampled: 11/3/2004 and 4/19/2005 NAD83 Latitude: 37.5696; Longitude: 122.3178		
Suisun Creek Lower: (tidal) (Chadbourne Rd. creek overpass just past Jacksnipe Rd. Suisun City, CA) Sampled the downstream side of the overpass. Date Sampled: 11/3/2004 and 4/19/2005 NAD83 Latitude: 37.5741; Longitude: 122.3065		
Napa River Upper: (fresh water) (1st Street at Copia. Napa, CA) Sampled River below the Northwest corner of parking lot. Date Sampled: 11/2/2004 and 4/19/2005 NAD83 Latitude: 38.3021; Longitude: 122.2816		
Napa River Lower: (tidal) (John F. Kennedy Park downstream of town. Napa, CA) Sampled off of wharf. Date Sampled: 11/2/2004 and 4/19/2005 NAD83 Latitude: 38.2655; Longitude: 122.2835		
Petaluma River Upper: (fresh water/tidal) (East Washington St. and Weller. Petaluma, CA) Date Sampled: 11/2/2004 and 4/20/2005 NAD83 Latitude: 38.2357; Longitude: 122.6371		
Petaluma River Lower: (tidal) (Gilardi's Lakeville Marina. Lakeville, CA) Date Sampled: 11/2/2004 and 4/20/2005 NAD83 Latitude: 38.1977; Longitude: 122.5476		

Table 1.2 (continued). Station location information

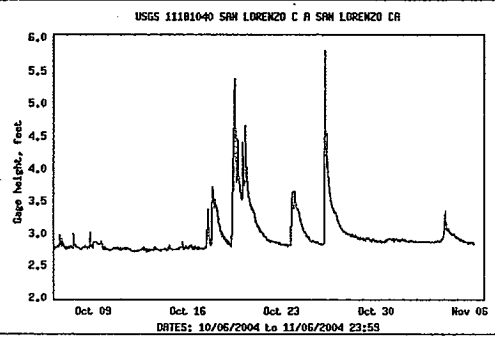
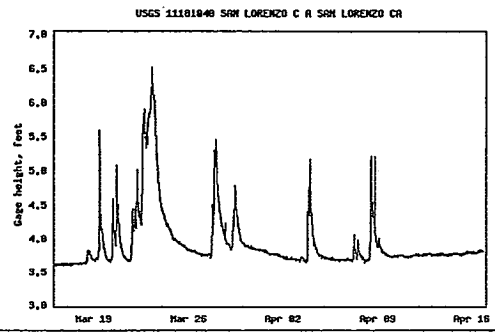
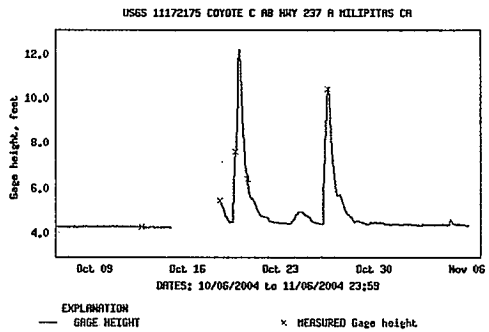
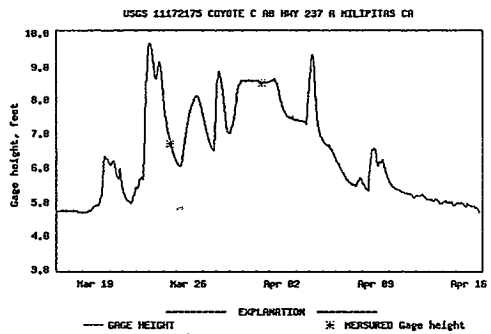
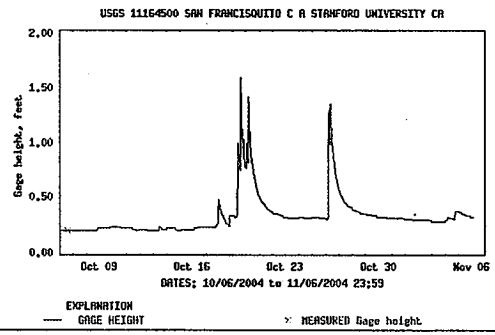
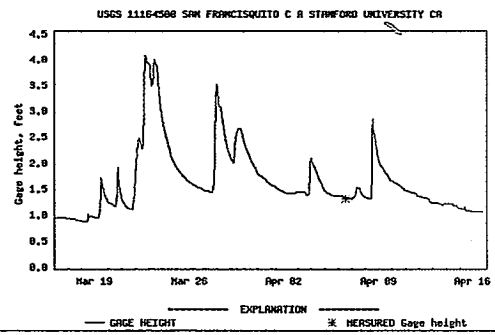
South Bay Tributaries	November Stream Gauge Heights	April Stream Gauge Heights
San Lorenzo Creek Upper: (fresh water) (Via Bregani and Madeline. San Lorenzo, CA) Date Sampled: 11/3/2004 and 4/20/2005 NAD83 Latitude: 37.6820; Longitude: 122.1431		
San Lorenzo Creek Lower: (tidal) (Via Murieta and Via Sorrento. San Lorenzo, CA) Date Sampled: 11/3/2004 and 4/20/2005 NAD83 Latitude: 37.6753; Longitude: 122.1542		
Coyote Creek Upper: (fresh water) (Murphy Ranch Rd. and Technology Dr. Milpitas, CA) Date Sampled: 11/1/2004 and 4/18/2005 NAD83 Latitude: 37.4183; Longitude: 122.9303		
Coyote Creek Lower: (tidal) (RMP station BW10, N. McCarthy Blvd./ just over the overpass heading south from Dixon Landing Rd. Milpitas, CA) Date Sampled: 11/1/2004 and 4/18/2005 NAD83 Latitude: 37.4534; Longitude: 121.9248		
San Mateo Creek Upper: (fresh water) (in Gateway Park, 3rd Ave. San Mateo, CA) Date Sampled: 11/4/2004 and 4/18/2005 NAD83 Latitude: 37.5696; Longitude: 122.3178		
San Mateo Creek Lower: (tidal) (3rd Ave. and J. Hart Clinton Drive. San Mateo, CA) Sampled under the creek overpass. Date Sampled: 11/4/2004 and 4/18/2005 NAD83 Latitude: 37.5741; Longitude: 122.3065		

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Table 1.3A. List of Parameters analyzed in the PRISM field study component.

Sediment Quality Parameters	**Reporting Units**
% clay (< 4 µm)	% dry weight
% silt (4 µm–62 µm)	% dry weight
% sand (2 mm > 62 µm)	% dry weight
% gravel (> 2 mm)	% dry weight
% solids	% dry weight
Total Organic Carbon	%

Toxicity Tests — Sediment	**Reporting Units**
(*Hyalella azteca, Eohaustorius estuarius)*	
Sediment Toxicity – (Amphipod) % Survival	%
Sediment Toxicity – (QA/QC measures: sulfide, pH, etc.)	various

Trace elements analyzed in sediment samples:
Target Method Detection Limits (MDLs) are in parentheses following the reporting units.

	Reporting Units (MDL) dry weight
Aluminum (Al)	mg/kg (200)
Arsenic (As)	mg/kg (0.2)
Cadmium (Cd)	mg/kg (0.001)
Copper (Cu)	mg/kg (2)
Iron (Fe)	mg/kg (200)
Lead (Pb)	mg/kg (0.5)
Manganese (Mn)	mg/kg (20)
Mercury (Hg)	mg/kg (0.00001)
Methyl-mercury (MeHg)	µg/kg (0.005)
Nickel (Ni)	mg/kg (5)
Selenium (Se)	mg/kg (0.01)
Silver (Ag)	mg/kg (0.001)
Zinc (Zn)	mg/kg (5)

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Table 1.3A (continued). Parameter List

Trace organic parameters in sediment (µg/kg dry weight):		
PAHS (Target MDL: 5 µg/kg)	**SYNTHETIC BIOCIDES** (Target MDL: 1 µg/kg)	**OTHER SYNTHETIC COMPOUNDS** (Target MDL: 1 µg/kg)
1-Methylnaphthalene	**Cyclopentadienes**	**PCB congeners (IUPAC numbers):**
2,3,5-Trimethylnaphthalene	Aldrin	8, 18, 28, 31, 33, 44, 49, 52, 56, 60, 66,
2,6-Dimethylnaphthalene	Dieldrin	70, 74, 87, 95, 97, 99, 101, 105, 110,
2-Methylnaphthalene	Endrin	118, 128, 132, 138, 141, 149, 151, 153,
Biphenyl		156, 158, 170, 174, 177, 180, 183, 187,
Naphthalene	**Chlordanes**	194, 195, 201, 203
1-Methylphenanthrene	alpha-Chlordane	
Acenaphthene	cis-Nonachlor	
Acenaphthylene	gamma-Chlordane	**Polybrominated Diphenyl Ethers (PBDEs):**
Anthracene	Heptachlor	017, 028, 047, 066, 085, 099, 100, 138,
Fluorene	Heptachlor Epoxide	153, 154,183, 190
Phenanthrene	Oxychlordane	
Benz(a)anthracene	trans-Nonachlor	
Chrysene		
Fluoranthene	**DDTs**	
Pyrene	o,p'-DDD	
Benzo(a)pyrene	o,p'-DDE	
Benzo(b)fluoranthene	o,p'-DDT	
Benzo(e)pyrene	p,p'-DDD	
Benzo(k)fluoranthene	p,p'-DDE	
Dibenz(a,h)anthracene	p,p'-DDT	
Perylene		
Benzo(ghi)perylene	**HCH**	
Indeno(1,2,3-cd)pyrene	alpha-HCH	
Dibenzothiophene	beta-HCH	
	delta-HCH	
	gamma-HCH	
	Pyrethroids:	
	Bifenthrin	
	Cyfluthrin	
	Cypermethrin	
	Esfenvalerate	
	Lambda-cyhalothrin	
	Permethrin	
	Other Synthetic Biocides	
	Chlorpyrifos (porewater only)	
	Diazinon (porewater only)	
	Hexachlorobenzene	
	Mirex	

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Table 1.3B. Laboratory analytical methods.

Laboratory methods used to analyze sediments from the PRISM field monitoring component. Some organic compounds are grouped by parameter type. Table includes the name of analyzing laboratory, laboratory methods, method detection limits (MDL), reporting units, and data quality objectives.

Sediment Chemistry	Laboratory[1]	Extraction Method	Analytical Method	Analytical Instrument	MDL	Units	Precision	Accuracy
Trace Elements							+/- 25%	+/- 25%
Ag	BRL	EPA Draft 1638M		ICPMS	0.001	mg/kg		
Al	BRL	EPA Draft 1638M		ICPMS	200	mg/kg		
As	BRL	BR-0020 rev.003 (EPA 1632 M)		HGAA	0.2	mg/kg		
Cd	BRL	EPA Draft 1638M		ICPMS	0.001	mg/kg		
Cu	BRL	EPA Draft 1638M		ICPMS	2	mg/kg		
Fe	BRL	EPA Draft 1638M		ICPMS	200	mg/kg		
Hg (total)	UCSCDET	Bloom & Crecelius, 1987		ICPMS	0.0001	mg/kg		
meHg	UCSCDET	SOP-CALFED.D07		ICPMS	0.01	ug/kg		
Mn	BRL	EPA Draft 1638M		ICPMS	20	mg/kg		
Ni	BRL	EPA Draft 1638M		ICPMS	5	mg/kg		
Pb	BRL	EPA Draft 1638M		ICPMS	0.5	mg/kg		
Se	BRL	BR-0020 rev.003 (EPA 1632 M)		HGAA	0.01	mg/kg		
Zn	BRL	EPA Draft 1638M		ICPMS	5	mg/kg		
%solids	All Chem labs	SM 2540B (EPA 160.3)						
Sediment Quality							+/- 25%	+/- 25%
Total Organic Carbon	UCSCDET		EPA 9060		0.02	%		
Total Nitrogen	UCSCDET		EPA 9060		0.001	%		
Grain Size (gravel, sand, silt, & clay)	UCSCDET		UCSCDET-GSZ	Sedigraph	0.1	%		

[1] See Table 1.1 for more laboratory information.

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Table 1.3B (continued). Laboratory methods used to analyze sediments from the PRISM field monitoring component. Some organic compounds are grouped by parameter type. Table includes the name of analyzing laboratory, laboratory methods, method detection limits (MDL), reporting units, and data quality objectives.

Sediment Chemistry (continued)	Laboratory[1]	Extraction Method	Analytical Method	Analytical Instrument	MDL	Units	Precision	Accuracy
Organic contaminants							+/- 35%	+/- 35%
Chlorpyrifos (pore water)	UCD-MPSL		ELISA SOP 3.3		0.05	ug/L		
Diazinon (pore water)	UCD-MPSL		ELISA SOP 3.3		0.03	ug/L		
PAHs	CDFG-WPCL	EPA 3545_3640A_3610B_3630C	EPA 8270M	GC-MS	5	ug/kg		
Polybrominated Diphenyl Ethers (PBDEs)	CDFG-WPCL	EPA 3545_3640A_3620B	EPA 8082M	GC-ECD*	1	ug/kg		
PCBs (Aroclors)	CDFG-WPCL	EPA 3545_3640A_3620B	Newman *et al.*, 1988			ug/kg		
PCBs (individual congeners)	CDFG-WPCL	EPA 3545_3640A_3620B	EPA 8082M	GC-ECD*	1	ug/kg		
Synthetic Biocides	CDFG-WPCL	EPA 3545_3640A_3620B	EPA 8081AM	GC-ECD*	1	ug/kg		
Sediment Toxicity								
Sed Tox (*H. azteca*)	UCD-MPSL	U.S. EPA 2000	10-day solid phase			%		
Sed Tox (*E. estuarius*)	UCD-MPSL	U.S. EPA 1994	10-day solid phase			%		

[1] See Table 1.1 for more laboratory information.

* GC-ECD with GC-MS confirmation

Table 1.4. Summary of analytes that were outside the acceptable data quality objectives.

Analytical results that were outside the acceptable data quality objectives (DQOs) based on the PRISM QAPP (Lowe and Anderson, 2005). Five DQOs were evaluated in the quality assurance review: completeness, sensitivity, precision, accuracy, and blank contamination.

Parameter Type	Analyte	November 2004	April 2005
PAHs	2,3,5-Trimethylnaphthalene	Poor Accuracy	
	Benzo(ghi)perylene		Blank Contamination
Alkylated PAHs	C1-Fluoranthenes_Pyrenes		Poor Accuracy
	C1-Fluorenes	Poor Accuracy	
	C1-Naphthalenes	Poor Accuracy	
	C1-Phenanthrenes_Anthracenes		Poor Accuracy
	C2-Naphthalenes	Poor Accuracy	
	C3-Naphthalenes	Poor Accuracy	
PCBs	PCB 008	Poor Accuracy	
	PCB 018		Blank Contamination
	PCB 028	Blank Contamination	Blank Contamination
	PCB 031	Blank Contamination	Blank Contamination
	PCB 044	Blank Contamination	Blank Contamination
	PCB 052	Blank Contamination	Blank Contamination
	PCB 066		Blank Contamination
	PCB 070	Blank Contamination	Blank Contamination
	PCB 095	Blank Contamination	Blank Contamination
	PCB 101	Blank Contamination	Blank Contamination
	PCB 110	Blank Contamination	Blank Contamination
	PCB 118	Blank Contamination	Blank Contamination
	PCB 138		Blank Contamination
Synthetic Biocides	p,p'-DDT	Poor Accuracy	Poor Accuracy
	alpha-Chlordane	Poor Accuracy	
	gamma-Chlordane	Poor Accuracy	Poor Accuracy
	delta-HCH		Poor Accuracy
	Endrin		Poor Accuracy
Trace Elements	Cd		Poor Accuracy

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Table 1.5a. Sediment toxicity, sediment quality, and trace element results from ambient sediment sampling (2004-2005).

Test Species: HYAL = *H. azteca*; EOHA = *E. estuarius*

Station Code	Month	Test Species	Toxic?	Mean % Survival [1]	% Fines (<63 um)	TOC	Ag	Al	As	Cd	Cu
						%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
			Average MDL ->				0.003	1	0.1	0.004	0.04
SUICRKUP	November	HYAL	no	72	55	1.0	0.24	56700	4.0	0.125	57
SUICRKLWR	November	EOHA	no	89	78	1.9					
PETRIVUP	November	HYAL	no	97	47	1.9	0.29	40923	2.9	0.21	34
PETRIVLWR	November	EOHA	no	89	98	2.0					
NAPRIVUP	November	HYAL	no	86	37	0.9	0.38	36175	5.4	0.185	33
NAPRIVLWR	November	EOHA	no	91	77	1.7					
SUICRKUP	April	HYAL	no	100	30	0.6	0.28	53838	9.5		52
SUICRKLWR	April	EOHA	no	84	68	1.8					
PETRIVUP	April	HYAL	no	93	44	2.4	0.30	58157	4.6		39
PETRIVLWR	April	EOHA	no	85	100	2.1					
NAPRIVUP	April	HYAL	no	99	44	1.3	0.62	66820	7.0		51
NAPRIVLWR	April	EOHA	no	98	86	3.1					
SANMATCRKUP	November	HYAL	Yes	19	42	2.0	0.28	42260	2.8	0.261	41
SANMATCRKLWR	November	EOHA	Yes	39	97	2.7	0.70	54560	7.3	0.394	34
SANLORCRKUP	November	HYAL	Yes	57	18	0.5	0.17	44636	2.5	0.166	20
SANLORCRKLWR	November	EOHA	no	93	46	1.6					
COYCRKUP	November	HYAL	no	85	32	0.7	0.19	46027	3.1	0.324	27
COYCRKLWR	November	EOHA	no	86	41	1.1					
SANMATCRKUP	April	HYAL	Yes	5	69	3.3	0.39	64422	6.0		67
SANMATCRKLWR	April	EOHA	Yes	33	99	2.5	0.68	89128	10.9		78
SANLORCRKUP	April	HYAL	no	100	35	3.0	0.35	41584	4.7		34
SANLORCRKLWR	April	EOHA	no	81	35	0.5					
COYCRKUP	April	HYAL	Yes	79	24	1.0	0.24	49860	5.2		29
COYCRKLWR	April	EOHA	no	86	67	1.7					
			Minimum	**5**	**18**	**0.5**	**0.17**	**36175**	**2.5**	**0.125**	**20**
			Maximum	**100**	**100**	**3.3**	**0.70**	**89128**	**10.9**	**0.394**	**78**
			Average both periods	**77**	**57**	**1.7**	**0.36**	**53221**	**5.4**	**0.238**	**43**
			Average North Bay Tribs	**90**	**64**	**1.7**	**0.35**	**52102**	**5.6**	**0.173**	**44**
			Average South Bay Tribs	**64**	**50**	**1.7**	**0.37**	**54060**	**5.3**	**0.286**	**41**
			RMP North Bay Average		71	1	0.14	31825	8.8	0.307	46
			RMP South Bay Average		85	1.2	0.26	42464	7.5	0.242	39

[1] % survival results normalized to the associated control samples.

A011526

Table 1.5a (continued). Sediment toxicity, sediment quality, and trace element results from ambient sediment sampling (2004-2005).

Station Code	Month	% Fines (<63 um)	TOC	Fe	Hg	MeHg	Mn	Ni	Pb	Se	Zn
			%	mg/kg	mg/kg	µg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Average MDL ->				143	0.0001	0.03	0.1	0.04	0.1	0.002	0.08
SUICRKUP	November	55	1.0	30253	0.06	0.18	1134	33	19	0.17	90
SUICRKLWR	November	78	1.9		0.20	2.19					
PETRIVUP	November	47	1.9	32695	0.30	1.18	686	64	37	0.12	112
PETRIVLWR	November	98	2.0		0.70	0.15					
NAPRIVUP	November	37	0.9	23158	0.70	0.21	845	55	63	0.09	123
NAPRIVLWR	November	77	1.7		0.35	0.68					
SUICRKUP	April	30	0.6	38891	0.04	0.34	837	61	21	0.17	110
SUICRKLWR	April	68	1.8		0.14	0.81					
PETRIVUP	April	44	2.4	33797	0.30	1.54	1115	69	34	0.07	134
PETRIVLWR	April	100	2.1		0.33	0.09					
NAPRIVUP	April	44	1.3	39306	1.53	0.45	816	98	87	0.11	157
NAPRIVLWR	April	86	3.1		0.28	3.1					
SANMATCRKUP	November	42	2.0	21238	0.14	1.35	567	125	48	0.06	146
SANMATCRKLWR	November	97	2.7	32695	0.25	2.41	778	124	59	0.38	198
SANLORCRKUP	November	18	0.5	9313	0.05	0.05	364	9	19	0.68	63
SANLORCRKLWR	November	46	1.6		0.08						
COYCRKUP	November	32	0.7	22168	0.11	0.05	523	83	23	0.35	123
COYCRKLWR	November	41	1.1		0.13	0.83					
SANMATCRKUP	April	69	3.3	36328	0.15	5.31	843	197	53	0.06	228
SANMATCRKLWR	April	99	2.5	60315	0.28	5.15	749	150	49	0.11	215
SANLORCRKUP	April	35	3.0	18902	0.05	0.3	647	33	43	0.16	184
SANLORCRKLWR	April	35	0.5		0.03	0.49					
COYCRKUP	April	24	1.0	25259	0.07	0.77	532	87	19	0.13	117
COYCRKLWR	April	67	1.7		0.17	0.72					
	Minimum	**18**	**0.5**	**9313**	**0.03**	**0.05**	**364**	**9**	**19**	**0.06**	**63**
	Maximum	**100**	**3.3**	**60315**	**1.53**	**5.31**	**1134**	**197**	**87**	**0.68**	**228**
Average both periods		**57**	**1.7**	**30308**	**0.27**	**1.23**	**745**	**85**	**41**	**0.19**	**143**
Average North Bay Tribs		**64**	**1.7**	**33016**	**0.41**	**0.91**	**906**	**63**	**43**	**0.12**	**121**
Average South Bay Tribs		**50**	**1.7**	**28277**	**0.13**	**1.58**	**625**	**101**	**39**	**0.242**	**159**
RMP North Bay Average		71	1	40061	0.18	0.26	673	86	17	0.206	116
RMP South Bay Average		85	1.2	36104	0.22	0.84	848	81	22	0.318	124

A011527

Table 1.5b. Sediment trace organic contaminant results from ambient sediment sampling (2004-2005).

Station Code	Month	% Fines (<63 um)	TOC	Sum of PAHs (SFEI)	Sum of PCBs (SFEI)	Sum of DDTs (SFEI)	Sum of PBDEs (SFEI)	Sum of Pyrethroids (SFEI)	Bifenthrin	Cyfluthrin	Cypermethrin	Permethrin
			%	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
	Average MDL ->			2	2	0.2	0.7	1.8	1	2	2	3
SUICRKUP	November	55	1.0	67	1	7	ND	6.8	3.6	ND	ND	3.2
SUICRKLWR	November	78	1.9									
PETRIVUP	November	47	1.9	601	7	4	1.9	6.7	6.7	ND	ND	ND
PETRIVLWR	November	98	2.0									
NAPRIVUP	November	37	0.9	240	3	12	ND	2	2	ND	ND	ND
NAPRIVLWR	November	77	1.7									
SUICRKUP	April	30	0.6	43	1	8	0	ND	ND	ND	ND	ND
SUICRKLWR	April	68	1.8	237	2	6	9.6	ND	ND	ND	ND	ND
PETRIVUP	April	44	2.4	534	2	2	2.1	ND	ND	ND	ND	ND
PETRIVLWR	April	100	2.1	1148	4	4	1.6	ND	ND	ND	ND	ND
NAPRIVUP	April	44	1.3	233	2	7	0	ND	ND	ND	ND	ND
NAPRIVLWR	April	86	3.1	442	4	9	2.8	1.1	1.1	ND	ND	ND
SANMATCRKUP	November	42	2.0	3035	35	64	7.9	43.6	10.3	8.6	4.2	20.5
SANMATCRKLWR	November	97	2.7	1643	11	13	7.9	10	6.7	ND	ND	3.2
SANLORCRKUP	November	18	0.5	1104	8	9	2.1	8.2	4.4	ND	ND	3.8
SANLORCRKLWR	November	46	1.6									
COYCRKUP	November	32	0.7	541	9	15	5.7	1.9	1.9	ND	ND	ND
COYCRKLWR	November	41	1.1									
SANMATCRKUP	April	69	3.3	1604	34	37	11.7	ND	ND	ND	ND	ND
SANMATCRKLWR	April	99	2.5	1550	19	16	10.1	2.4	2.4	ND	ND	ND
SANLORCRKUP	April	35	3.0	3015	16	26	23.0	2.1	2.1	ND	ND	ND
SANLORCRKLWR	April	35	0.5	804	4	5	2.2	ND	ND	ND	ND	ND
COYCRKUP	April	24	1.0	267	11	11	5.3	0.7	0.9	ND	ND	ND
COYCRKLWR	April	67	1.7	686	23	16	8.0	2	2	ND	ND	ND
	Minimum	**18**	**0.5**	**43**	**1**	**2**	**0.4**	**0.7**	**0.9**	**8.6**	**4.2**	**3.2**
	Maximum	**100**	**3.3**	**3035**	**35**	**64**	**23.0**	**43.6**	**10.3**	**8.6**	**4.2**	**20.5**
Average both periods		**57**	**1.7**	**937**	**10**	**14**	**6.0**	**7.3**	**3.7**	**8.6**	**4.2**	**7.7**
Average North Bay Tribs		**64**	**1.7**	**394**	**3**	**7**	**2.7**	**4.2**	**3.4**	**ND**	**ND**	**3.2**
Average South Bay Tribs		**50**	**1.7**	**1425**	**17**	**21**	**8.4**	**8.9**	**3.8**	**8.6**	**4.2**	**9.2**
RMP North Bay Average		71	1	677	3	2	na	na	na	na	na	na
RMP South Bay Average		85	1.2	1552	6	2	na	na	na	na	na	na

A011528

Table 1.6. History of sediment and interstitial water initial test toxicity at San Mateo Creek Upper (SANMATCRKUP).

Collection Date	Test Date	Survival (%)	SD (%)	Notes
11/4/2004	11/12/2004	19	24	Original EPTox Sample
4/18/2005	4/29/2005	4	5	Original EPTox Sample
5/18/2005	7/1/2005	18	11	Initial Sediment
5/18/2005	7/1/2005	47	31	Initial Interstitial Water
5/18/2005	8/2/2005	87	12	Initial Elutriate

Table 1.7. History of sediment and interstitial water initial test toxicity at Lower San Mateo Creek (SANMATCRKLWR).

* indicates significant toxicity.

Collection Date	Test Date	Survival (%)	SD (%)	Notes
11/4/2004	11/12/2004	37*	14	Original Prism Sample
4/18/2005	4/29/2005	33*	12	Original EPTox Sample
5/18/2005	7/1/2005	68	33	Initial Sediment for TIE1
5/18/2005	7/1/2005	100	0	Initial Interstitial Water 1
5/18/2005	7/22/2005	96	9	Initial Sieved Sediment 1
9/6/2005	9/23/2005	68	30	Initial Sediment 2
12/28/2005	1/6/2006	96	9	Initial Sediment 3
5/19/2006	5/26/2006	56*	33	Initial Sediment 4
5/19/2006	6/16/2006	80	23	TIE Baseline

A011529

Table 1.8. Mean percent survival and standard deviation (SD) of *H. azteca* in solid-phase SANMATCRKUP TIE 1.

	Solid-Phase Treatments		Acetone Eluate Treatments	
23°C Treatments	Mean	SD	Mean	SD
Baseline SANMATCRKUP	16	21		
SANMATCRKUP (10% SIR-	0	0		
Control (10% SIR-300)	96	5		
SANMATCRKUP (10%	42	8	0	0
Control (10% Ambersorb)	98	4	93	12
SANMATCRKUP (20%	0	0		
Control (20% Amendments)	100	0		
SANMATCRKUP (20% Control)	40	23		
SANMATCRKUP (10% Control)	22	15		
SANMATCRKUP (Enzyme)	60	29		
Control (Enzyme)	98	4		
SANMATCRKUP (PBO)	0	0		
Control (PBO)	98	4		
Control	100	0	100	0
15°C Treatments				
Baseline SANMATCRKUP	0	0		
SANMATCRKUP (Enzyme)	10	12		
Control (Enzyme)	94	9		
Control	98	4		

A011530

Table 1.9. Mean percent survival and standard deviation (SD) of *H. azteca* in solid-phase SANMATCRKUP TIE 2.

Treatments	Solid-Phase Treatments	
	Mean	SD
Baseline SANMATCRKUP	24	21
SANMATCRKUP (Enzyme)	72	27
Control (Enzyme)	100	0
SANMATCRKUP (BSA)	60	23
Control (BSA)	96	9
Control	100	0

Table 1.10. Mean percent survival and standard deviation (SD) of *H. azteca* in solid-phase SANMATCRKUP TIE 3.

Treatments	Solid-Phase Treatments		Acetone Eluate Treatments	
	Mean	SD	Mean	SD
Baseline SANMATCRKUP	2	4		
SANMATCRKUP (10%	28	13	0	0
SANMATCRKUP (15%	10	10		
SANMATCRKUP (20%	52	16	0	0
Control (20% Ambersorb)	96	5	70	23
SANMATCRKUP (20% Control)	50	19		
Control	98	4	100	0

A011531

Table 1.11. Concentrations of detected pesticides in SANMATCRKUP sediment. ND indicates not detected. NA indicates not analyzed. LC50 values are for *H. azteca*.

Chemical	SANMATCRK UP Sediment ng/g dry wt.	Sediment LC50 ng/g dry wt.	Ambersorb Eluate ng/L	Water LC50 ng/L
Cyfluthrin	2.64	13.7 [a]	112	12 [a, b]
Cyfluthrin µg/g oc	0.081	1.08 [a]		
Cypermethrin	1.75	18.0[†]	ND	5.3 [b]
Total Chlordane	ND		285	
DDD (p,p')	14.6	28 PEC	479	190 [c]
DDE (p,p')	62.4	31.3 PEC	480	1660 [c]
DDT (p,p')	41.6	62.9 PEC	292	70 [c]
Total DDT	118.6	572 PEC		
Total DDT µg/g oc	3.65	371 [d]		
Dieldrin	ND		381	
Arsenic	6.53	33 PEC	NA	
Cadmium	0.41	4.98 PEC	NA	
Chromium	168	111 PEC	NA	
Copper	54.2	260 [e]	NA	
Lead	42.1	128 PEC	NA	
Nickel	150	48.6 PEC	NA	
Zinc	200	459 PEC	NA	
Total Organic Carbon	3.25%			

[a] Amweg *et al.* (2005), [b] Solomon *et al.* (2001), [c] Hoke *et al.* (1994), [d] Nebeker *et al.* (1989), [e] MPSL Unpublished Data. [f] Maund *et al.* 2002. PEC indicates probable effects concentration (MacDonald *et al.* 2001).

A011532

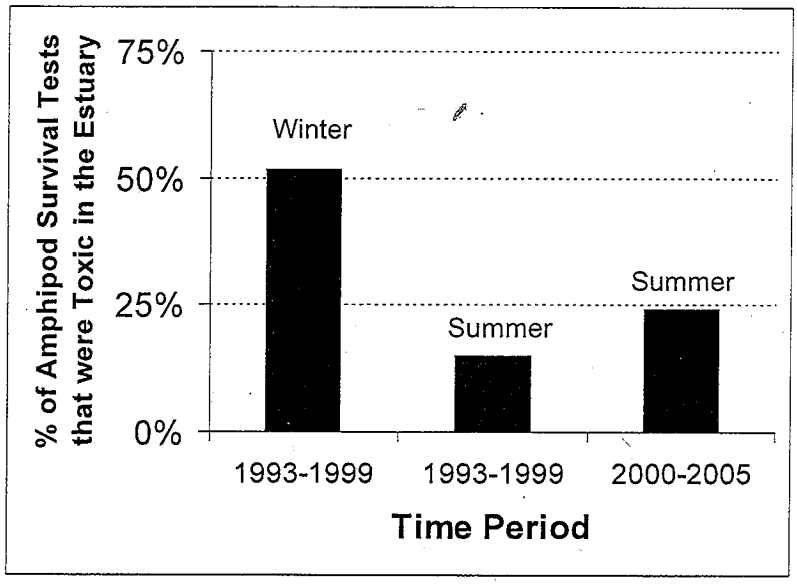
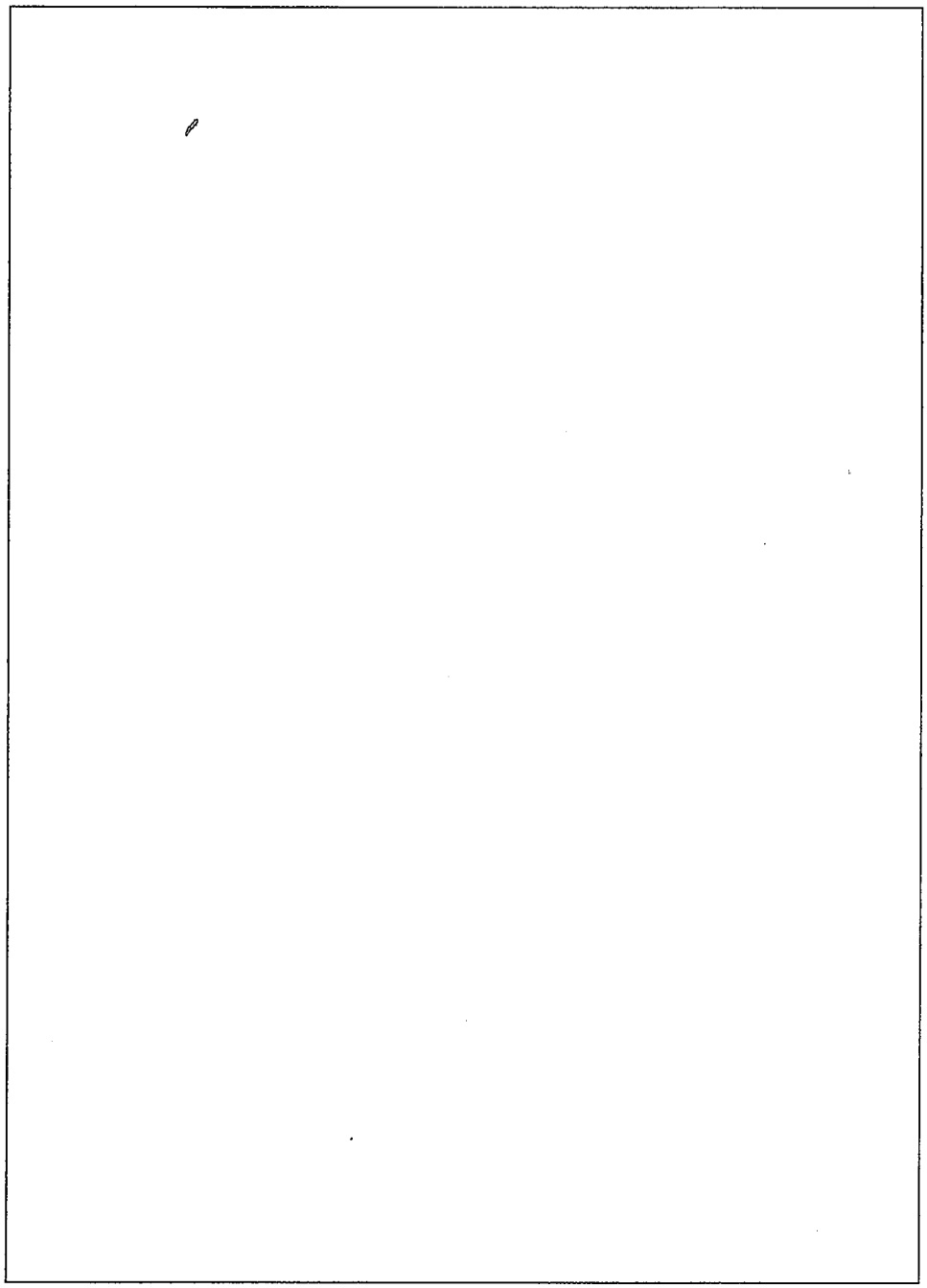


Figure 1.1. Percentage of sediment toxicity tests that were toxic to amphipods in the RMP Status and Trends Program (1993-2005).

Sediment samples were toxic to amphipods in the winter than in the summer between 1993 and 1999. Since 2000 the RMP only sampled the Estuary for sediment toxicity during the summer so a season comparison could not be evaluated.

A011533



North Bay Tributarie

Petaluma River
Upper (PETRIVUP) and
Lower (PETRIVLWR)
Stations

Napa River
Upper (NAPRIVUP) and
Lower (NAPRIVLWR)
Stations

Suisun Creek
Upper (SUICRKUP) and
Lower (SUICRKLWR)
Stations

South Bay Tributaries

San Mateo Creek
Upper (SANMATUP) and
Lower (SANMATLWR)
Stations

San Lorenzo Creek
Upper (SANLORCRKUP) an
Lower (SANLORCRKLWR)
Stations

Coyote Creek
Upper (COYCRKUP) and
Lower (COYCRKLWR)
Stations

Figure 1.2 Station Location map for the field study component of this PRISM grant.

Six tributaries were sampled at two locations each in November 2004 and April 2005. The "Upper" stations were located in the lower freshwater reaches of each tributary, while the "Lower" stations were located within the tidal prism of each tributary. Photos from the sampling events are presented in Appendix A, and Table 1.2 provides additional station and sampling information including: latitude/longitude, cross streets, dates sampled, and stream gauge information about each sampling event.

A011534

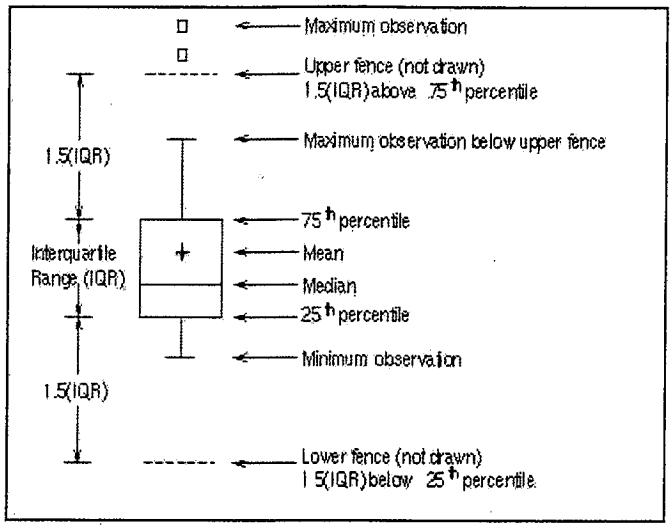


Figure 1.3. Illustration of a schematic box plot and its statistical components.

A011535

4041536

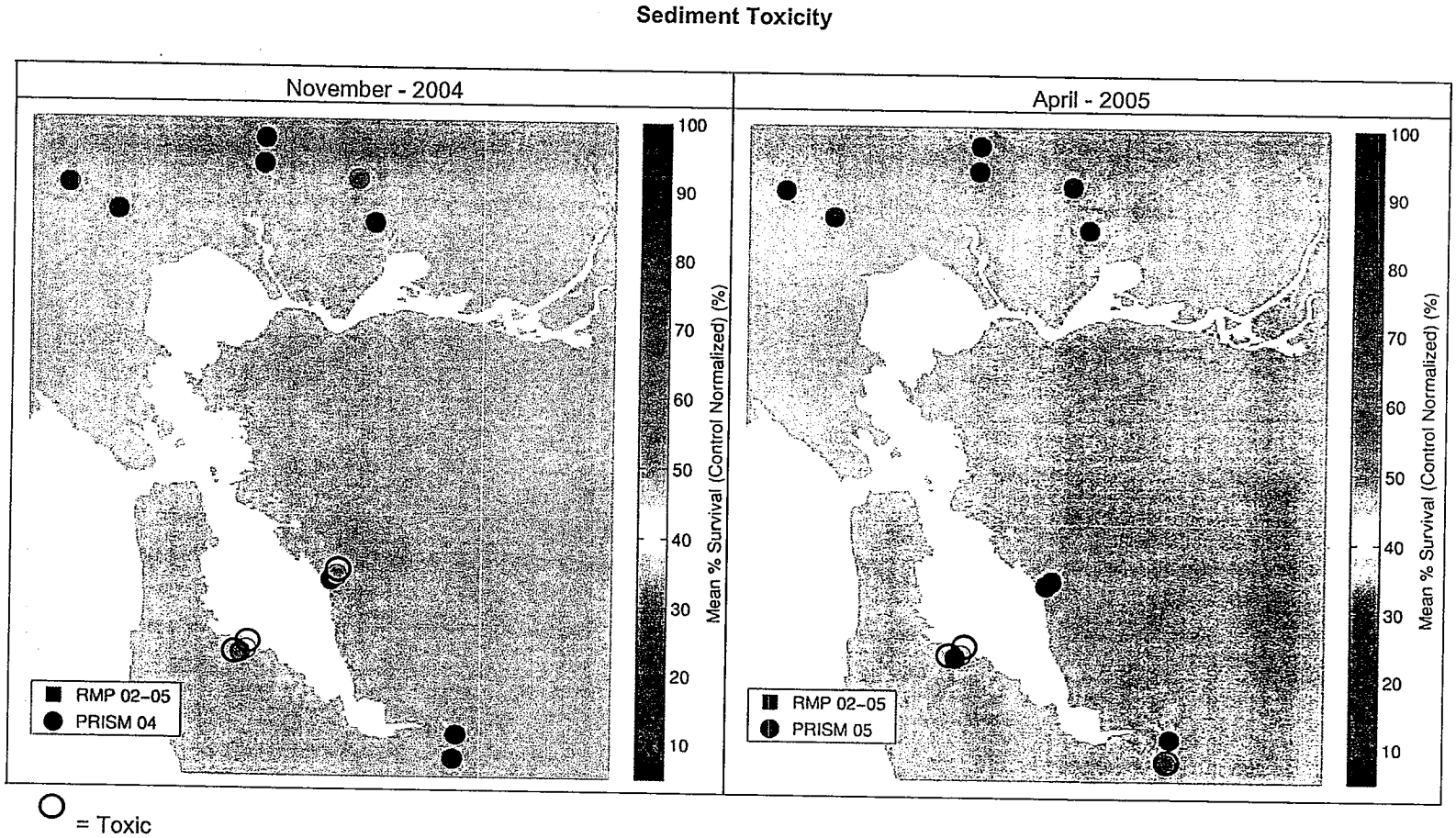


Figure 1.4. Amphipod sediment toxicity results in the tirbutaries (2004-2005).

10-day amphipod sediment toxicity results for both sampling periods at the "Upper" freshwater stations (test species was *H. azteca*), and the "Lower" estuarine stations (test species was *E. estuarius*). The mean% survival results shown here were normalized to the mean control% survival. San Mateo Creek showed sediment toxicity to amphipods at both the Upper and Lower stations sampled in both November and April (19%, 39%; 5%, 33% survival respectively). The San Lorenzo Creek Upper station sediment was toxic in November (57% survival) and the Coyote Creek Upper station was toxic in April (79% survival).

4137

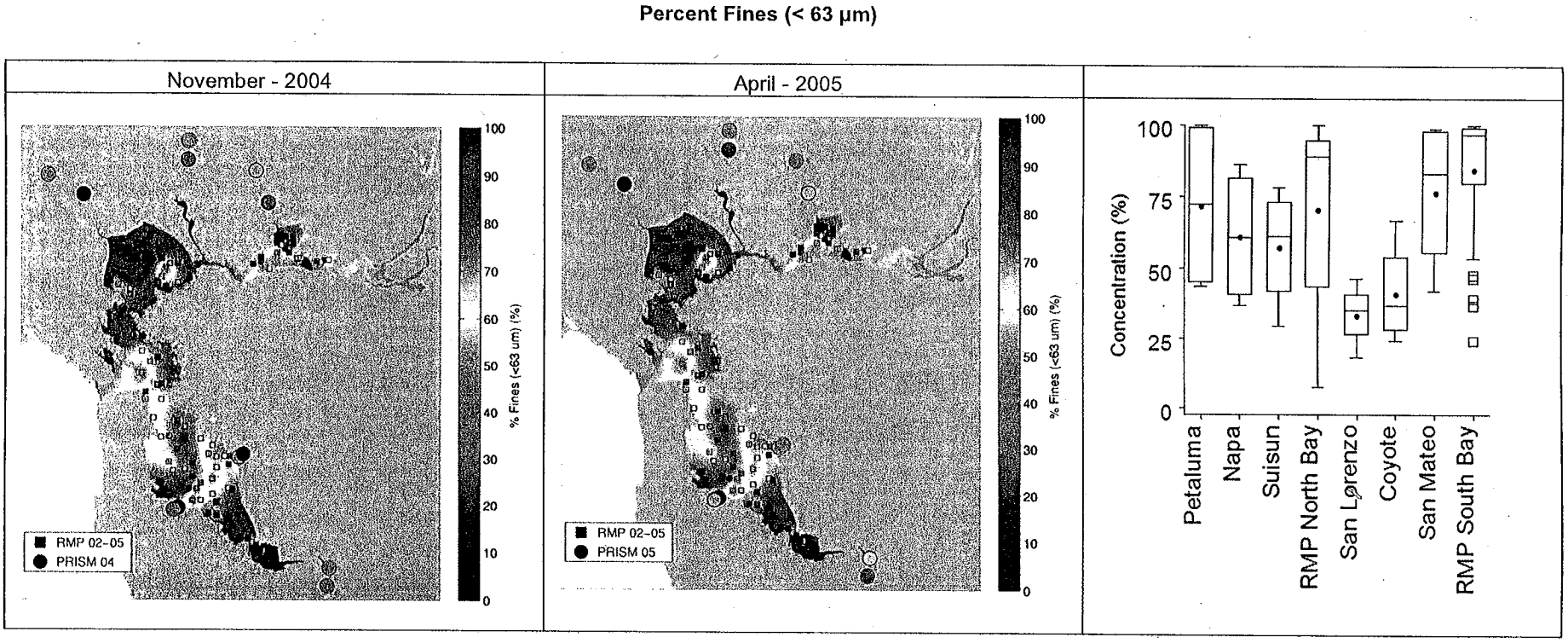


Figure 1.5. Percent Fines measured in the tributaries and in the RMP (2004-2005).

Percent fine-grained sediments (< 63 micron diameter) were measured in all samples during both sampling periods. % Fines concentrations varied widely in samples from each tributary with eleven samples having more than 50% Fines, six samples having 40 to 50% Fines, five samples having 30 to 40% Fines, and two samples having less than 30% Fines. The North Bay tributary average was 64% and the South Bay tributary average was 51%. The San Lorenzo and Coyote Creek stations had low levels of fine-grained sediments (ranging from 18 to 35% and 24 to 67% respectively).

8357147

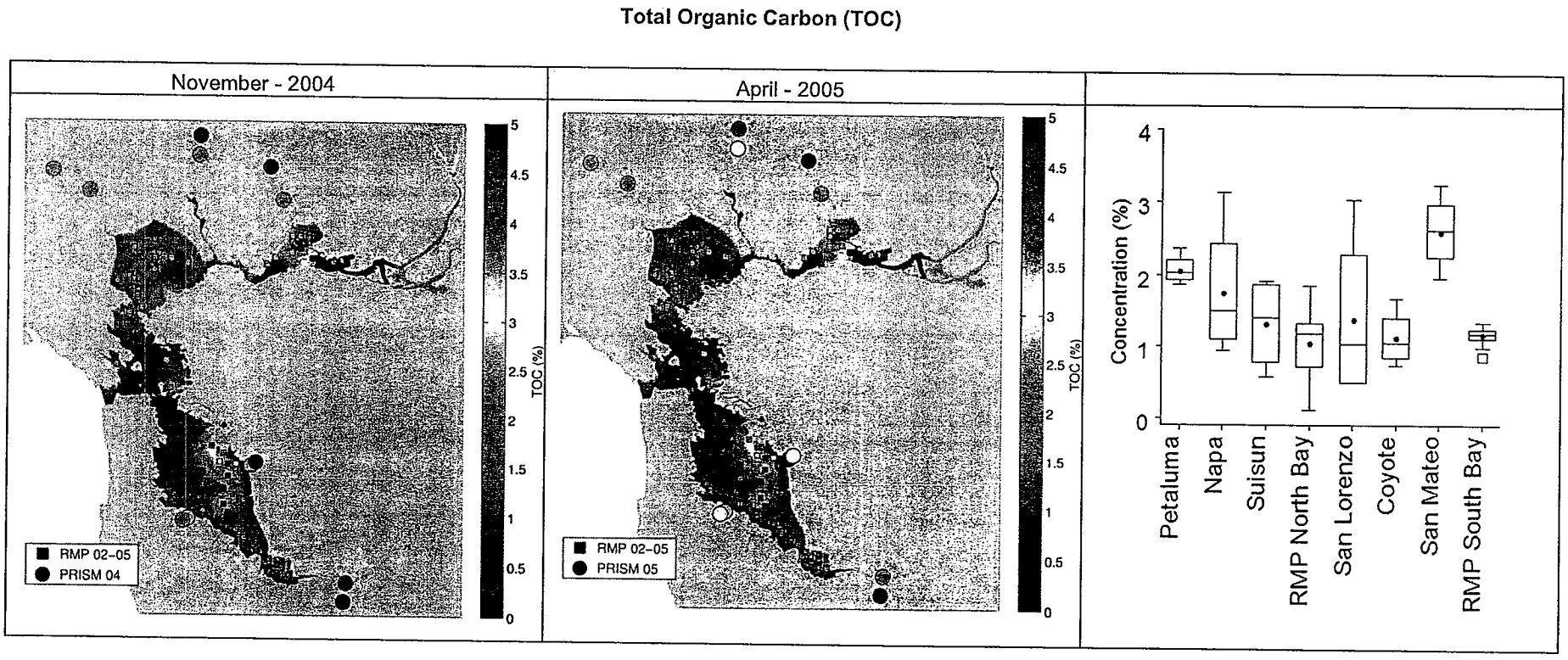


Figure 1.6. Total Organic Carbon measured in the tributaries and in the RMP (2004-2005).

Total Organic Carbon was measured at all stations during both sampling periods. All of the samples showed similar ranges of TOC concentrations as those observed in the RMP North Bay and South Bay samples (2002 – 2005) with the exception of San Mateo Creek. San Mateo Creek samples had significantly higher TOC concentrations (2.0 to 3.3%) than the RMP South Bay samples (2004-2005; average of 1.2%) and Coyote Creek (0.7 – 1.7%), but were not significantly different from concentrations observed in San Lorenzo Creek where the variance was wider (0.5 – 3.0%).

SSSTL01

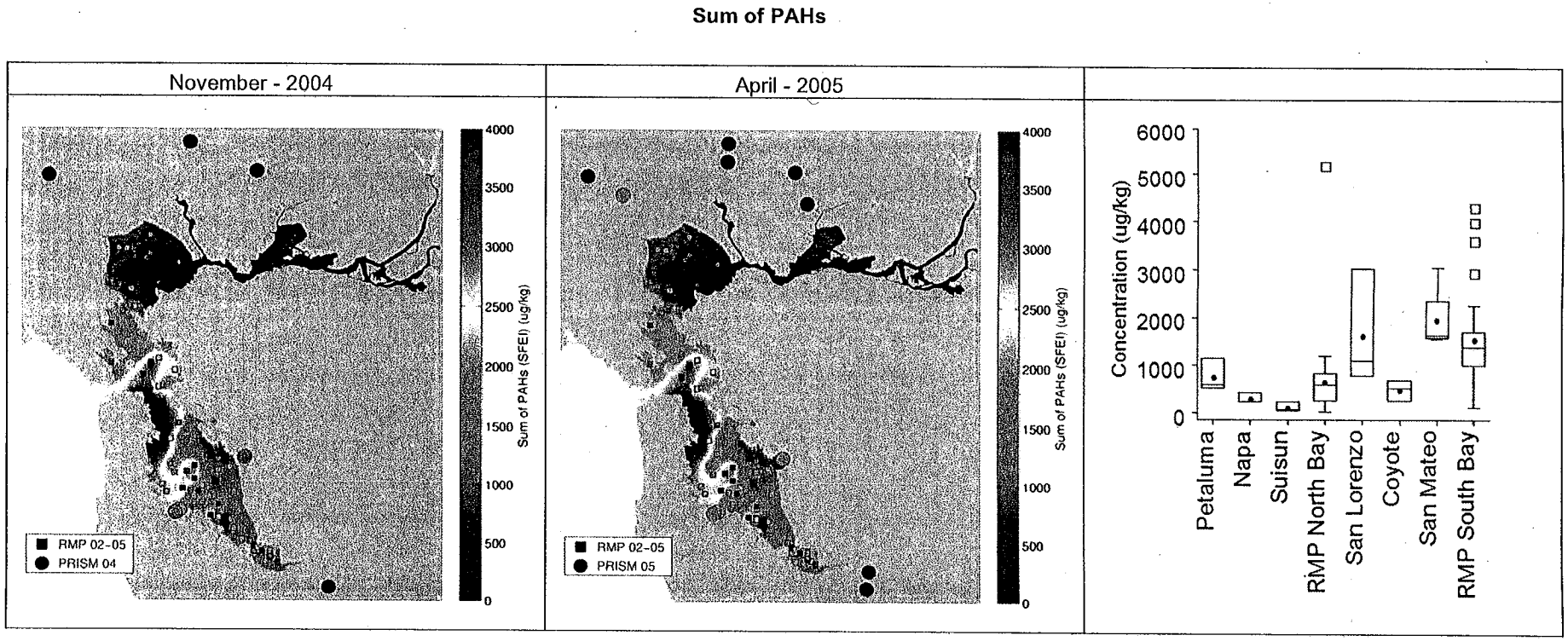


Figure 1.7. Sum of PAHs measured in the tributaries and in the RMP (2004-2005).

Sum of PAHs were detected in all samples from the tributaries and were within similar ranges of concentrations observed in the RMP Status and Trends program in the Northern and Southern Estuary (sampled 2004-2005). Concentrations in the in the three North Bay tributaries were, on average, three times lower than the three South Bay tributaries. San Mateo Creek Upper station had the highest concentration in November (3035 µg/kg), which was almost two times higher than the concentration observed in the San Mateo Creek Lower sample during the same sampling period (1643 µg/kg). The San Lorenzo Creek Upper sample from April was the highest spring concentration (3015 µg/kg), and was close to four times higher than the San Lorenzo Creek Lower sample during the same sampling period (804 µg/kg).

4015ho

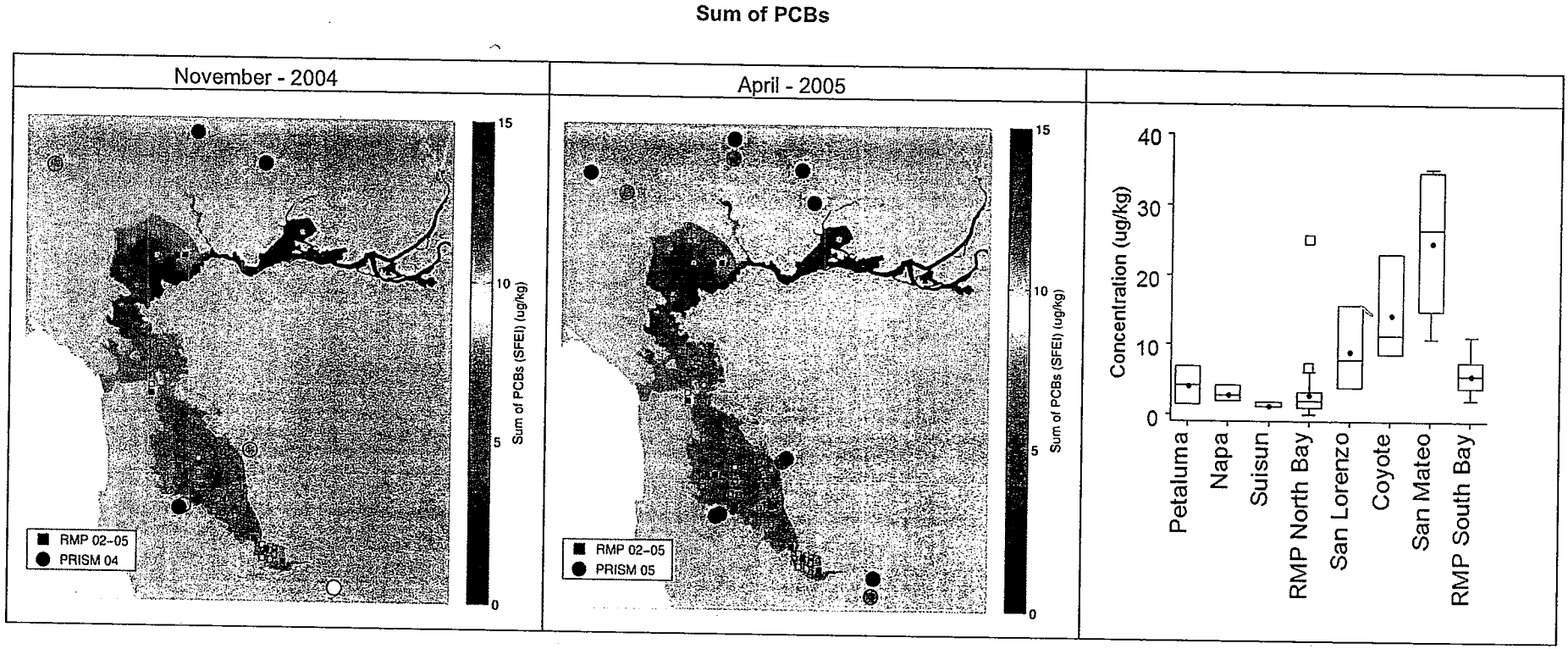


Figure 1.8. Sum of PCBs measured in the tributaries and in the RMP (2004-2005).

Sum of PCBs were detected in all samples from the tributaries and were higher concentrations than those observed in the RMP Status and Trends program in the North and South Bay (sampled 2004-2005). On average, concentrations in the in the three North Bay tributaries were five times lower than the three South Bay tributaries (3 and 17 µg/kg respectively – see Table 1.5b). The three South Bay tributaries had concentrations that were above the scale of these maps: The San Mateo Creek Upper station had the highest concentrations in November and April (35 and 34 µg/kg respectively). The Coyote Creek Lower station had the next highest concentration in April (23 µg/kg), then the San Mateo Creek Lower station in April (19 µg/kg), and San Lorenzo Creek Upper station in April 16 µg/kg). With the exception of the Petaluma River Upper station sample in November (7µg/kg), the North Bay tributaries samples had Sum of PCB concentrations of less than 4 µg/kg.

4015172

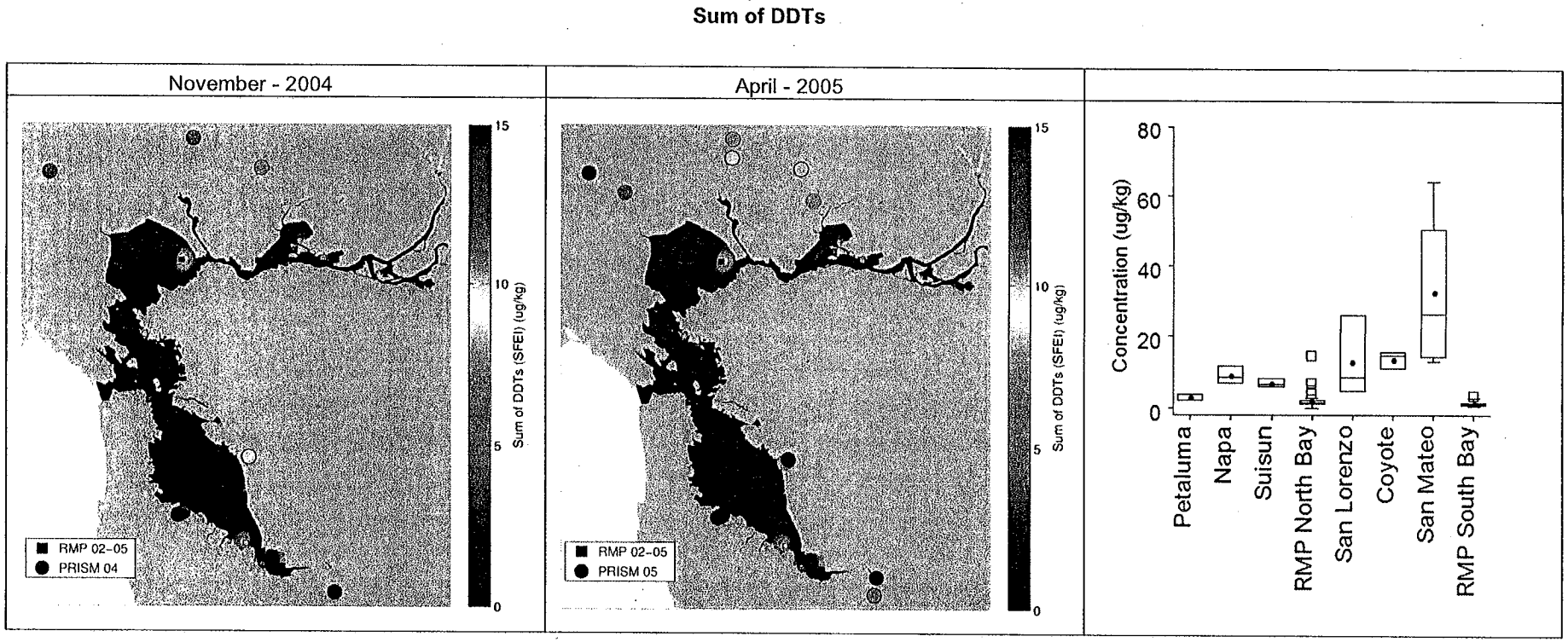


Figure 1.9. Sum of DDTs measured in the tributaries and in the RMP (2004-2005).

Sum of DDTs were detected in all samples from the tributaries and were higher concentrations than those observed in the RMP Status and Trends program in the North and South Bay regions (sampled 2004-2005). On average, concentrations in the in the three North Bay tributaries were three times higher than the average RMP North Bay concentration (7 and 2.2 µg/kg respectively). Average sum of DDT concentrations in the South Bay tributaries were fourteen times the average RMP South Bay concentration (21 and 1.5 µg/kg respectively). With the exception of the Napa River Upper station, in November (12 µg/kg), the North Bay tributary samples ranged from 2 to 4 µg/kg, while the South Bay tributary samples had a much broader range of 4 to 64 µg/kg. Several of the South Bay tributaries had Sum of DDT concentrations that were well above the scale of these maps. The San Mateo Creek Upper station had the highest concentrations of all samples in November and April (64 and 37 µg/kg respectively). The San Lorenzo Creek Upper station had the next highest concentration in April (26 µg/kg), then the San Mateo Creek Upper station and the Coyote Creek Lower station in April each had concentrations of 16 µg/kg.

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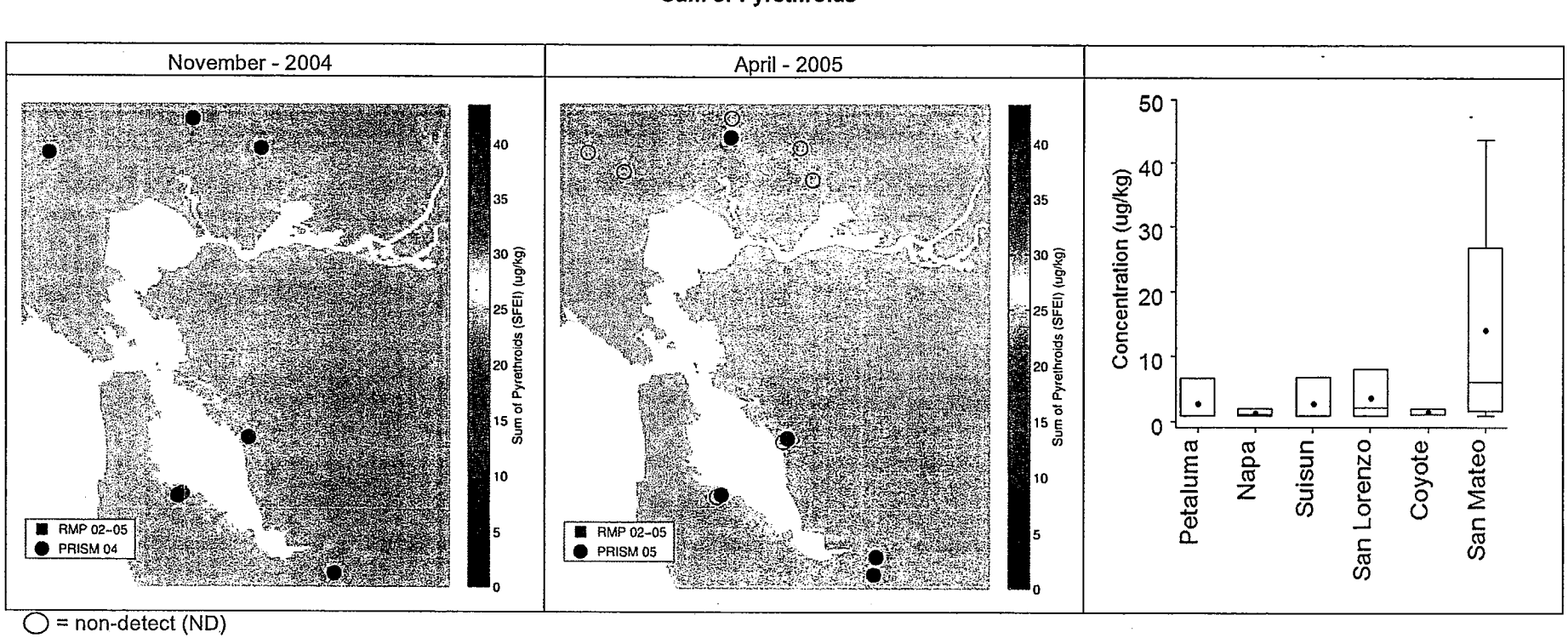
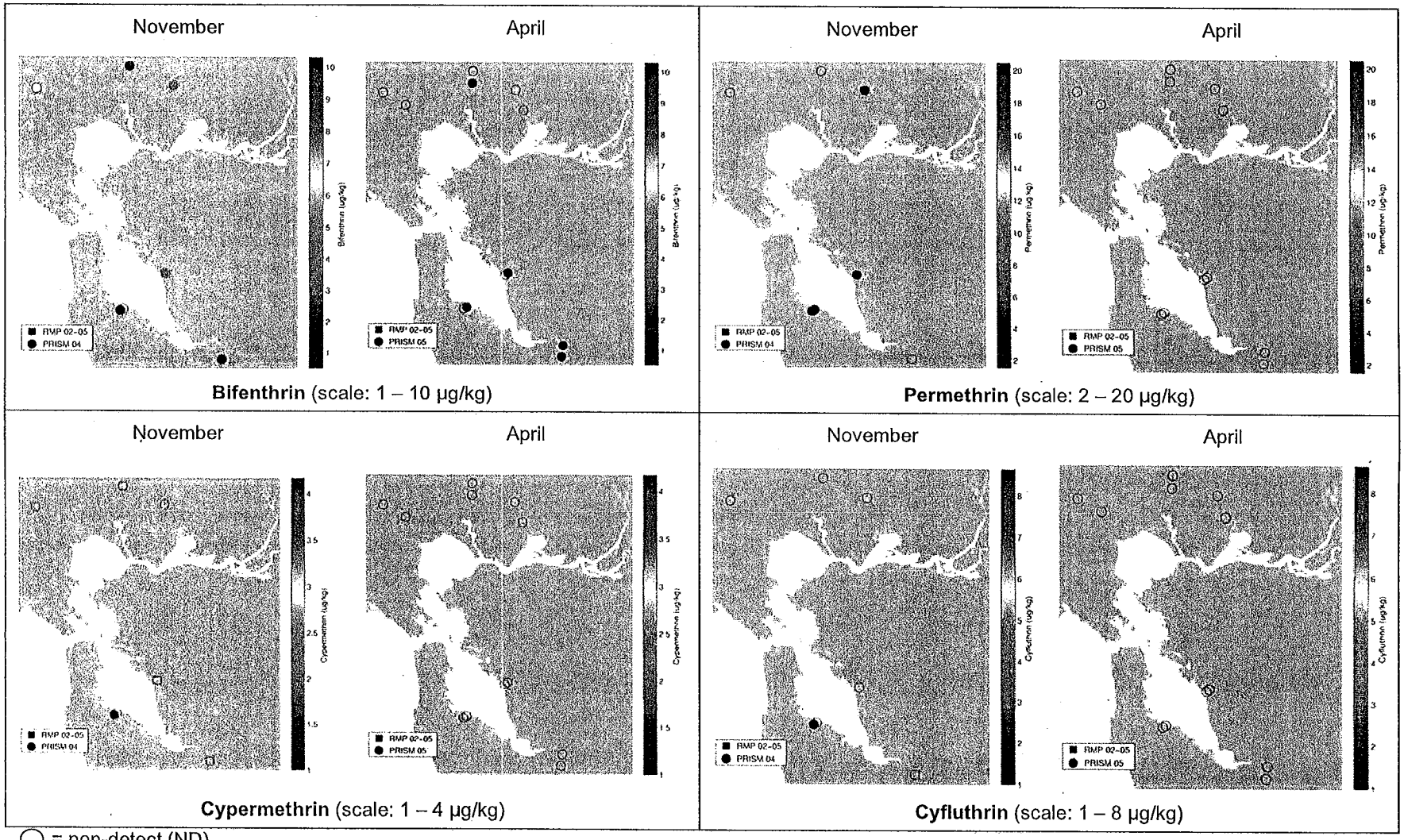


Figure 1.10. Sum of Pyrethroids measured in the tributaries (2004-2005).

Sum of Pyrethroids were detected in all samples from the November sampling period. No pyrethroids were measured in the RMP for comparison to in-Bay concentrations. The San Mateo Creek Upper station was the only location where 4 of the six pyrethroids analyzed were found above detection limits of 1-2 µg/kg. The San Mateo Creek Upper station had the highest concentrations of bifenthrin, and permethrin in November (10.3 and 20.5 µg/kg respectively). Cypermethrin and cyfluthrin were only found in the San Mateo Creek Upper station in November (4.2 and 8.6 µg/kg respectively). Bifenthrin was the only pyrethroid detected in all six tributaries at least once. Detected concentrations ranged from 1.1 to 6.7 µg/kg in the North Bay tributaries, and 1.0 to 10.3 µg/kg in the South Bay tributaries). Permethrin was detected in four samples from three tributaries in the November samples. This finding is consistent with other studies conducted in the region (Weston, 2006). Esfenvalerate and lambda-cyhalothrin were below detection in all samples.



◯ = non-detect (ND)

Figure 1.11. Individual pyrethroid compounds measured in the tributaries (2004-2005).

Four of the six pyrethroids analyzed were found above detection limits of 1-2 µg/kg (esfenvalerate and lambda-cyhalothrin were below detection in all samples and are not presented here). The San Mateo Creek Upper station had the highest concentrations of bifenthrin, and permethrin in November (10.3 and 20.5 µg/kg respectively. Bifenthrin was the only pyrethroid detected in all six tributaries at least once. Detected concentrations ranged from 1.1 to 6.7 µg/kg in the North Bay tributaries, and 1.0 to 10.3 µg/kg in the South Bay tributaries). Permethrin was detected in four samples from three tributaries in the November samples.). Cypermethrin and cyfluthrin were only found in the San Mateo Creek Upper station in November (4.2 and 8.6 µg/kg respectively). These results are consistent with a UC-Berkeley study (Amweg *et al.* 2006) of pyrethroids and toxicity in East Bay tributaries during this same time period.

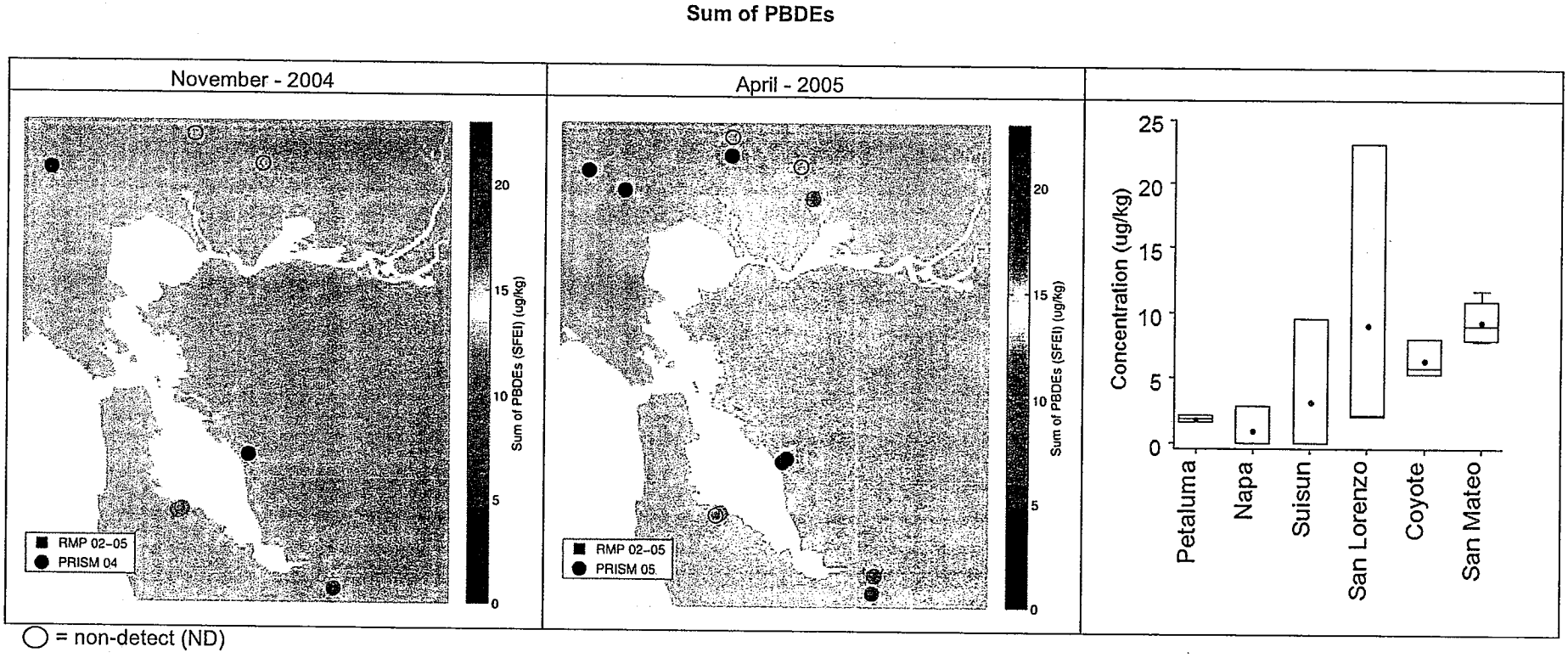


Figure 1.12. Sum of Polybrominated Diphenyl Ether (PBDE) measured in the tributaries (2004-2005).

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BDE 47

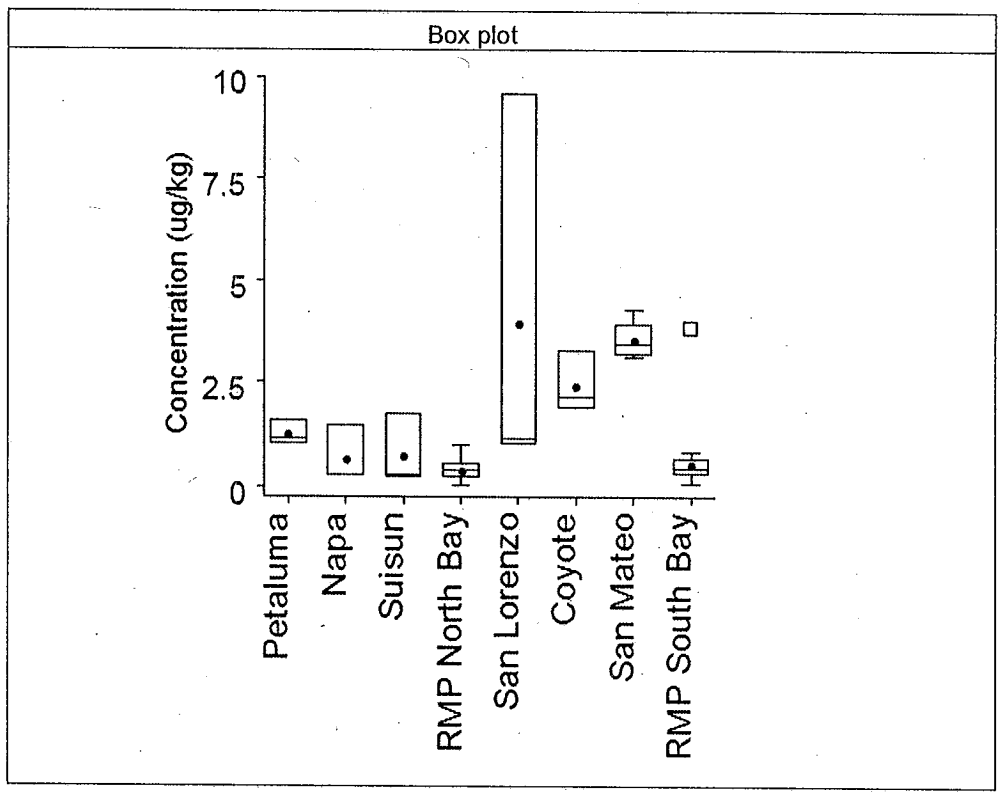

Figure 1.13. Box plot of the Polybrominated Diphenyl Ether 47 (BDE 47) measured in the tributaries and in the RMP (2004-2005).

In 2005 the RMP Status and Trends program only reported BDE 47 as a result of their QA/QC review. Therefore, only that compound was used in this comparison. BDE 47 concentrations observed in the individual tributaries (n= 3 or 4) compared to the RMP Status and Trends 2004-2005 results for the North and South Bays show that the South Bay tributary concentrations were significantly higher than the RMP South Bay concentrations (with the exception of one maximum observation in the RMP South Bay samples). North Bay tributary concentrations were similar to the RMP North Bay concentrations with the exception of Petaluma River, which was higher than the 75th percentile of the RMP North Bay samples.

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Cadmium (Cd)

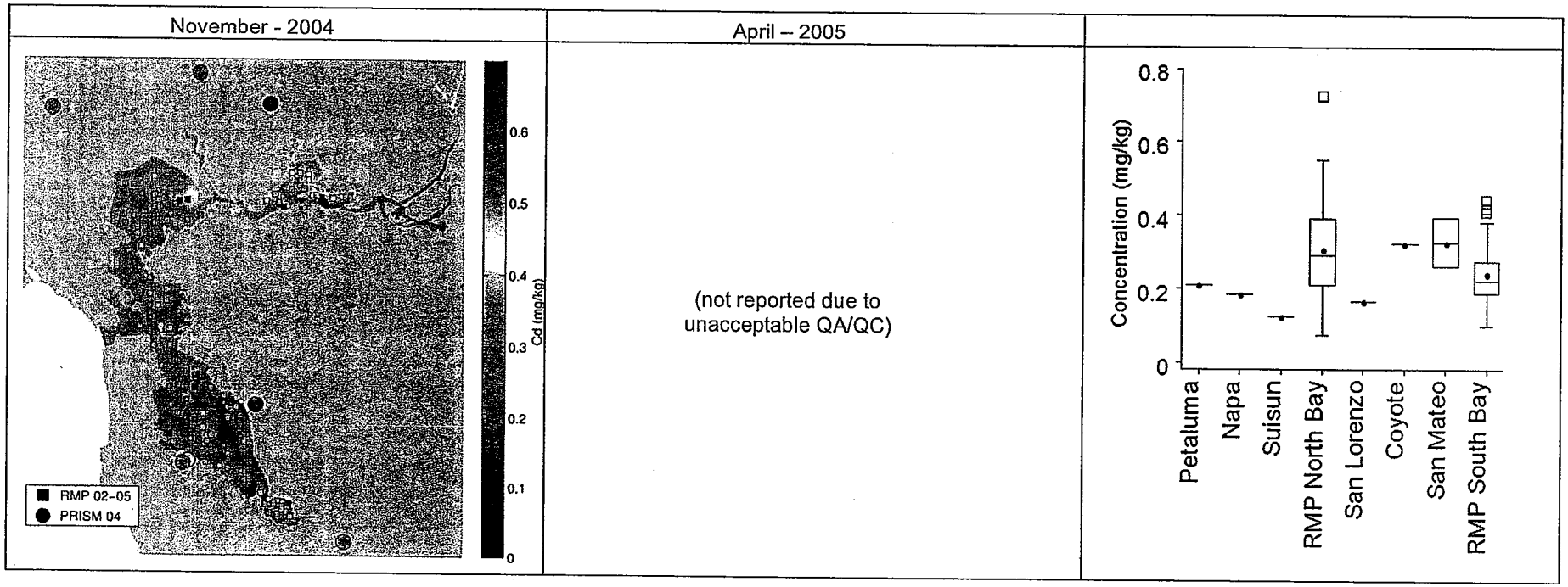

Figure 1.14. Cadmium measured in the tributaries and in the RMP (2004-2005).

Cadmium (Cd) concentrations were detected in all samples from the November sampling period. No results are available for the April sampling period due to poor accuracy outside of acceptable data quality objectives. Note that the box plot represents only one sample from each tributary (except San Mateo Creek which includes the San Mateo Creek Lower station that was toxic to amphipods). The North Bay tributary samples fell within the 25th percentile of the RMP North Bay samples (2004-2005). The South Bay tributary samples were within a similar concentration range as the RMP South Bay samples (2004-2005).

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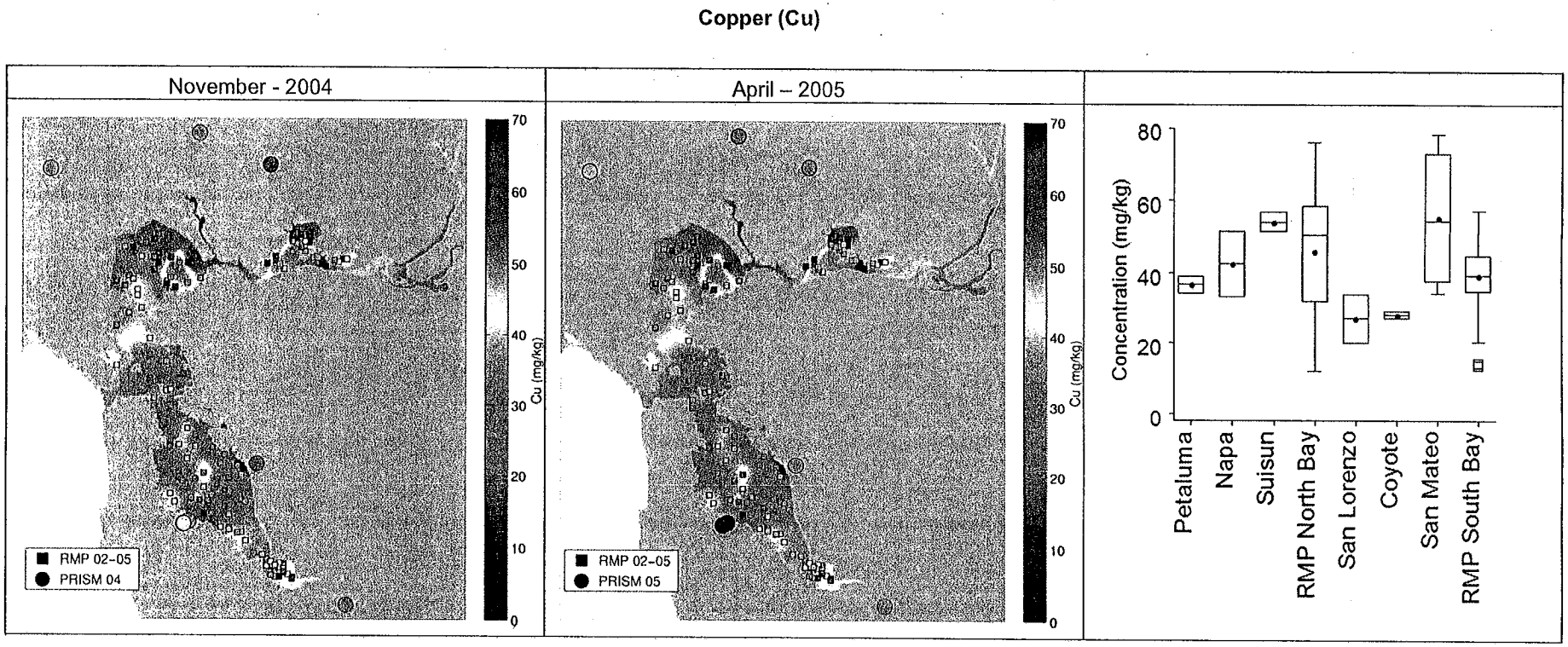

Figure 1.15. Copper measured in the tributaries and in the RMP (2004-2005).

Copper (Cu) concentrations were detected in all samples. North Bay tributary samples were within the range of the RMP North Bay samples (2004-2005). Similarly, the South Bay tributary samples were within the range of the RMP South Bay samples (2004-2005) with the exception that both the San Mateo Creek Upper and Lower stations had copper concentrations above the in-Bay range in April (67 and 78 µg/kg respectively).

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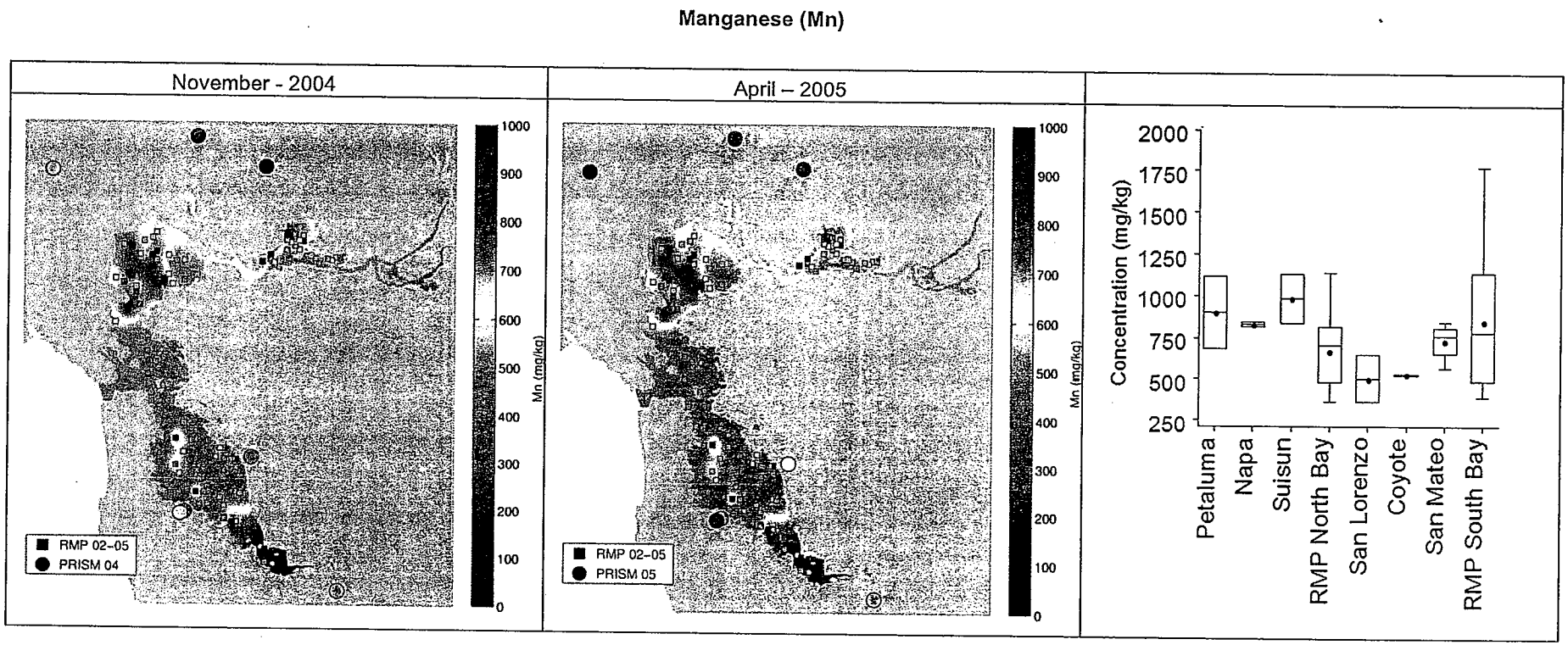

Figure 1.16. Manganese measured in the tributaries and in the RMP (2004-2005).

Manganese (Mn) concentrations were detected in all samples. Suisun Creek and Petaluma River had the highest concentrations and were slightly above the scale of these maps (1134 and 1115 µg/kg respectively). North Bay tributary samples were within the range of the RMP North Bay samples (2004-2005) and were generally above the median North Bay concentration. The South Bay tributary samples were within the range of the RMP South Bay samples (2004-2005) were generally below the median South Bay concentration.

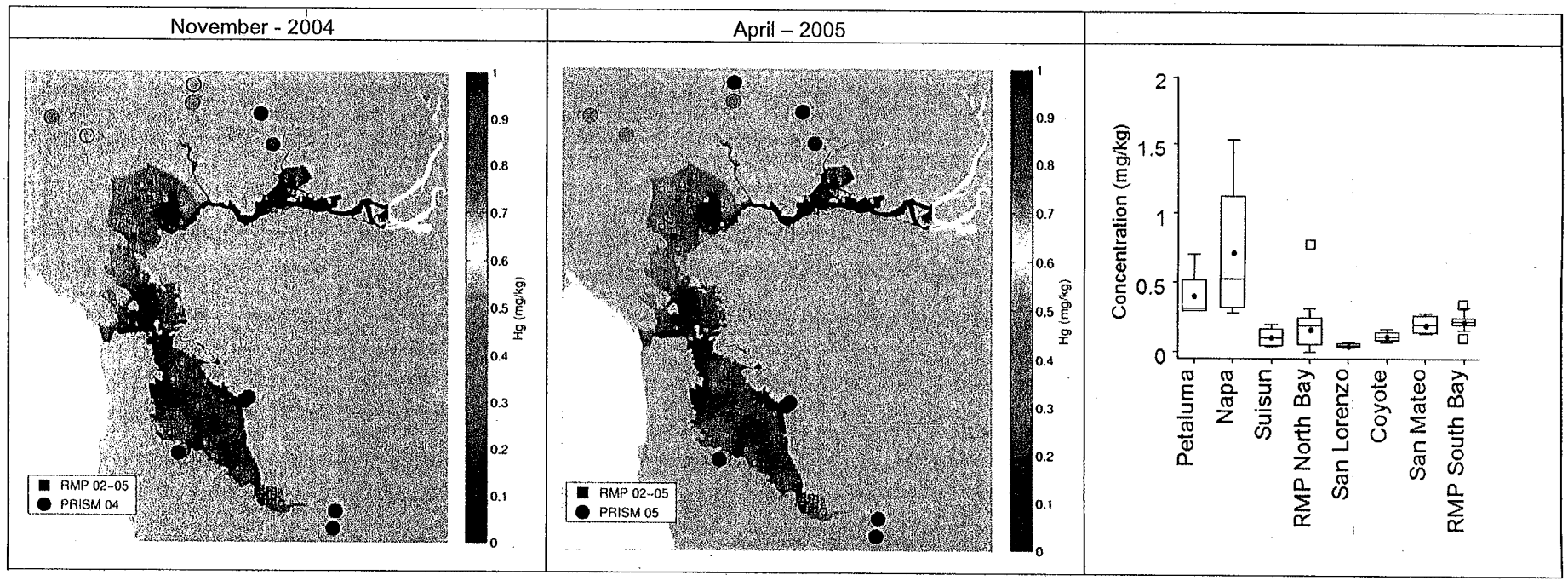

Figure 1.17. Mercury measured in the tributaries and in the RMP (2004-2005).

Total Mercury (Hg) concentrations were detected in all samples, and were analyzed in all the Lower stations for both sampling periods. The highest concentration was measured at the Napa River Upper station in April and was above the scale of these maps (1.53 mg/kg). This concentration was more than two times higher than the next highest value (0.70 mg/kg) observed in both the Napa and Petaluma Rivers in November. Average North Bay tributary mercury concentrations were two times higher than the average RMP North Bay results (2004-2005; 0.41 and 0.18 mg/kg respectively). Average South Bay tributary concentrations were similar to the average RMP South Bay results (2004-2005; 0.29 and 0.24 mg/kg respectively).

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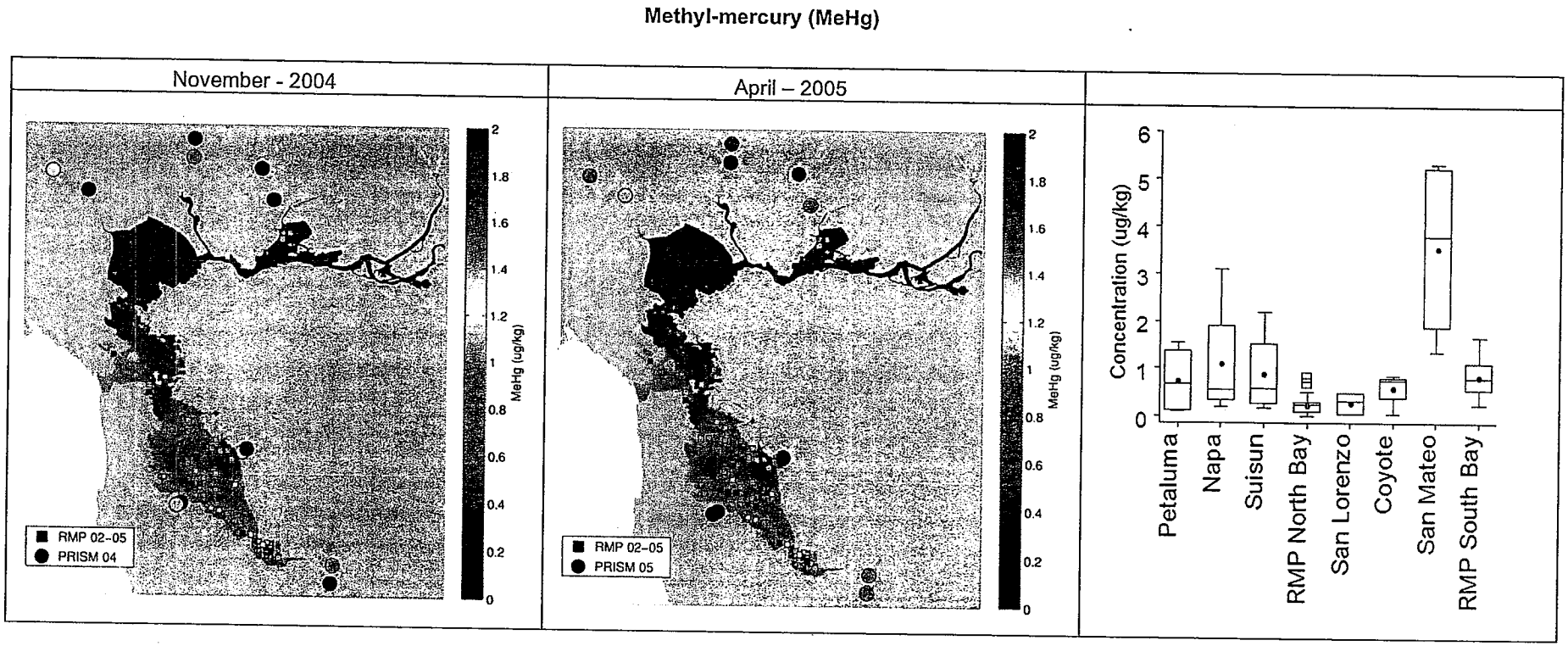

Figure 1.18. Methyl-mercury measured in the tributaries and in the RMP (2004-2005).

Methyl-mercury (MeHg) concentrations were detected in all samples except the Petaluma River Lower station (in April), and were analyzed in all the Lower stations for both sampling periods. Unlike the total mercury concentrations shown in the previous figure, the highest methyl-mercury concentrations were measured in the South Bay at the San Mateo Creek upper and Lower stations and were above the scale of these maps (5.31 and 5.15 µg/kg respectively). The Napa River Lower station (in April) had the next highest concentration (3.10 µg/kg) and the Suisun Creek Lower station had a concentration of 2.19 µg/kg in November). Average North Bay tributary methyl-mercury concentrations were three times higher than the RMP North Bay results (2004-2005; 0.91 and 0.26 µg/kg respectively – see Table 1.5). Average South Bay tributary concentrations were twice the average RMP South Bay results (2004-2005; 1.58 and 0.84 µg/kg respectively).

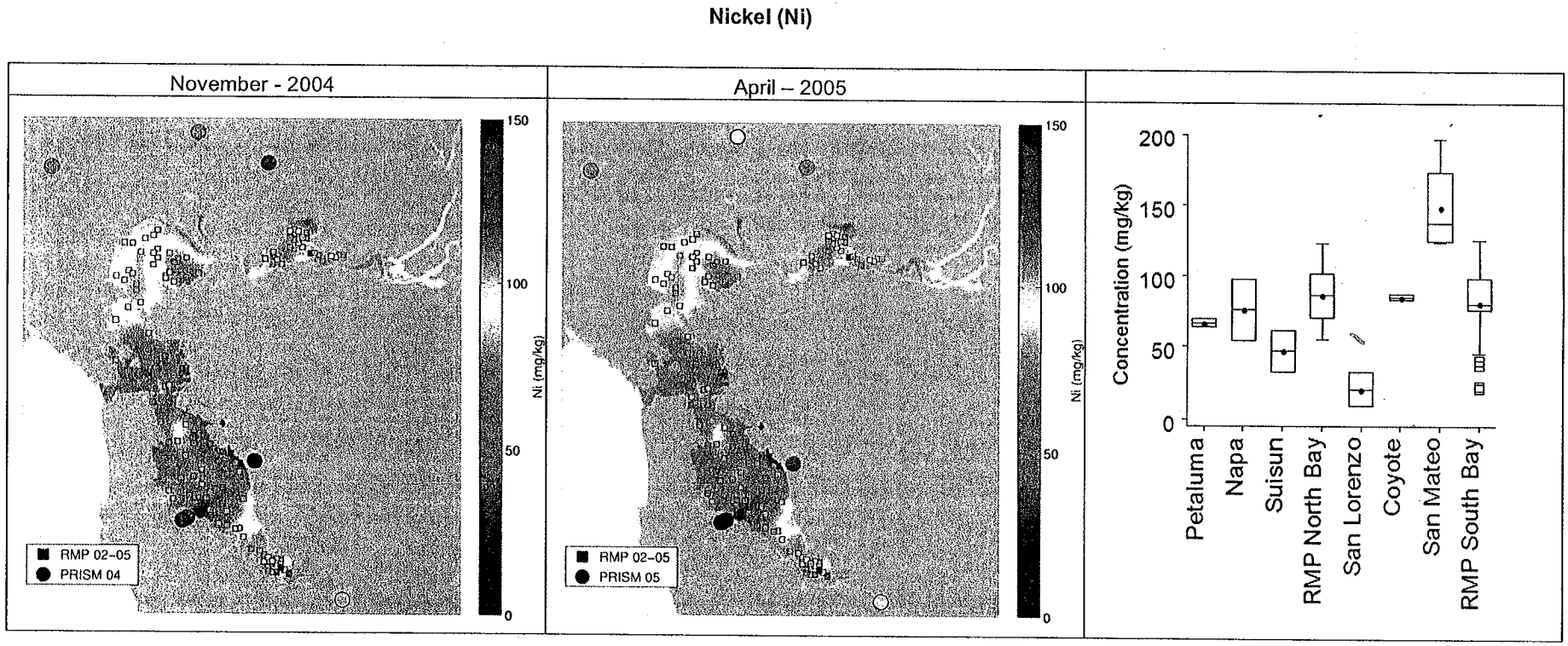

Figure 1.19. Nickel measured in the tributaries and in the RMP (2004-2005).

Nickel (Ni) concentrations were detected in all samples. North Bay tributary samples were generally within the range of the RMP North Bay samples (2004-2005) with the exception that the Suisun Creek concentrations falling below the RMP North Bay 25th percentile. The South Bay tributary samples varied widely with only Coyote Creek concentrations falling within the range of the RMP South Bay samples (2004-2005). San Lorenzo Creek concentrations were well below the in-Bay range, while San Mateo Creek concentrations fell well above the RMP South Bay 75th percentile (2004-2005). In fact San Mateo Creek had the highest nickel concentrations of all the tributaries with concentrations ranging from 124 to 197 mg/kg (the April-Upper sample was above the scale of the map at 197 mg/kg). By comparison, the other tributaries, combined, had sample concentrations ranging from 9 to 98 mg/kg.

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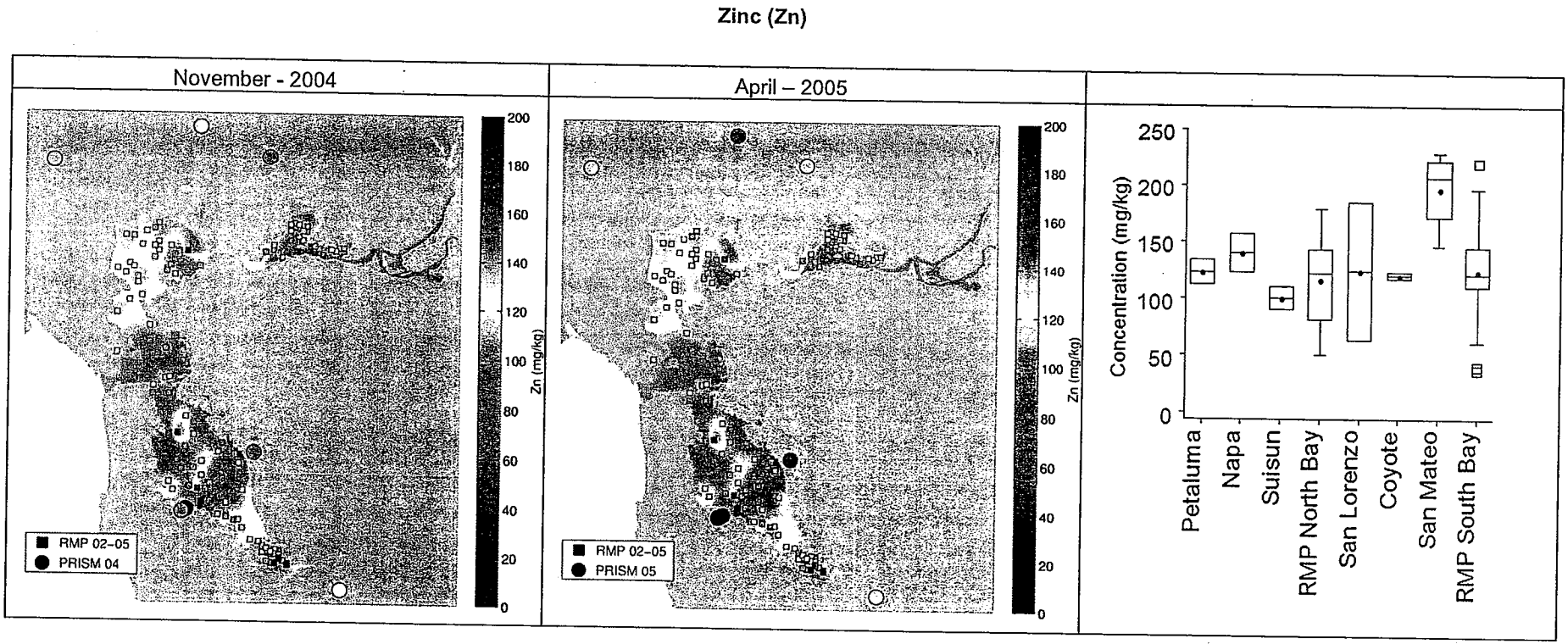

Figure 1.20. Zinc measured in the tributaries and in the RMP (2004-2005).

Zinc (Zn) concentrations were detected in all samples. North Bay tributary samples were within the range of the RMP North Bay samples (2004-2005). The South Bay tributary samples also fell within the range of the RMP South Bay samples (2004-2005). The San Mateo Creek concentrations were the highest of all the tributary samples and fell well above the RMP South Bay 75th percentile (2004-2005).

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CHAPTER 2. RELATIVE SENSITIVITIES OF TOXICITY TEST PROTOCOLS WITH THE AMPHIPODS EOHAUSTORIUS ESTUARIUS AND AMPELISCA ABDITA TO SEDIMENT SPIKED WITH COPPER, CHLORPYRIFOS, FLUORANTHENE, BIFENTHRIN, CYPERMETHRIN, AND PERMETHRIN

Bryn Phillips, UCD-MPSL

This chapter covers work performed under Task 3.20: *Toxicity Assay Testing under this PRISM Grant # 041355520. In addition to the pyrethroid sensitivity study funded by this grant, this report includes results from the RMP Exposure and Effects Pilot Study-2004 which investigated the relative sensitivities of the same estuarine amphipods to three compounds of concern in the San Francisco Estuary: copper, fluoranthene, and chlorpyrifos.*

2.1 ABSTRACT

A series of dose-response experiments were conducted to compare the relative sensitivities of toxicity test protocols using the amphipods *Ampelisca abdita* and *Eohaustorius estuarius*. *A. abdita* is one of the dominant infaunal species in the San Francisco Estuary, and *E. estuarius* is the primary sediment toxicity species used in the Regional Monitoring Program. Experiments were conducted with a formulated sediment spiked with copper, fluoranthene, chlorpyrifos, and the three pyrethroid pesticides permethrin, bifenthrin and cypermethrin, all chemicals of concern in this region. The current results showed that the protocol with *A. abdita* was more sensitive to fluoranthene and much more sensitive to copper, while *E. estuarius* was more sensitive to chlorpyrifos, and much more sensitive to the pyrethroid pesticides.

These results, considered in conjunction with those from previous spiking studies (Weston 1995; and DeWitt *et al.* 1989 and 1997), suggest that, in general, *A. abdita* is more sensitive to metals, *E. estuarius* is more sensitive to pesticides, and the protocols with the two species have roughly comparable sensitivities to hydrocarbons. The preponderance of evidence from previous field studies indicate that *E. estuarius* is considerably more responsive to ambient samples (Bay *et al.* 2005). One reason for this may be that tube-building behavior of *A. abdita* isolates this species from contaminants in pore water, and results from our current experiments generally support this hypothesis. Based on the combined evidence from spiking experiments and side-by-side tests of ambient samples, the results suggest that the protocol with *E. estuarius* demonstrates adequate sensitivity to support continued use in the RMP. *E. estuarius* is also recommended by the State Water Resources Control Board as the primary sediment testing amphipod for use in assessing compliance with newly developed sediment quality objectives. In situations where copper is of concern, use of the embryo-larval development protocol with the mussel *Mytilus galloprovincialis* compensates for the reduced sensitivity of *E. estuarius*. If cadmium contamination is a concern, both of these protocols should be considered less protective than the protocol with *A. abdita*, or the protocol with the copepod *A. tenuiremus*.

2.2 INTRODUCTION

This project was designed to develop dose-response LC50 data for standard EPA sediment toxicity test protocols, in order to evaluate their sensitivities relative to each other and to other

ecologically relevant San Francisco Estuary species. Experiments were conducted using six chemicals: copper, chlorpyrifos, fluoranthene, and the three pyrethroid pesticides, permethrin, bifenthrin, and cypermethrin. The protocols evaluated were the 10 day acute tests with the amphipods *Eohaustorius estuarius* and *Ampelisca abdita*. *Ampelisca abdita* is the dominant resident amphipod species in the Estuary. *Eohaustorius estuarius* is the RMP Status and Trends sediment toxicity test species. Both species are used extensively in sediment toxicity monitoring in estuarine/marine systems. The two amphipods have different behavioral characteristics that may affect their exposure to contaminants: *Eohaustorius* is a free-burrowing detritivore, and *Ampelisca* is a tube-dweller. Previous experiments with contaminated field sediments have shown that these two species respond differently to ambient samples, but interpretation of these results has been confounded by other factors such as sediment grain size, percent clay and total organic carbon (TOC). To avoid these confounding factors, experiments were conducted using a formulated sediment having grain size and TOC distributions within the range tolerated by both amphipod species. The formulated sediment was spiked with single chemicals to avoid the additional complexity imposed by contaminant mixtures.

2.3 METHODS

Ten-day solid-phase dose-response toxicity tests were conducted with copper, chlorpyrifos, and fluoranthene as part of the RMP Exposure and Effects Pilots Study. One range finding test and two definitive tests were conducted with each chemical using both species. Copper was selected as a model metal contaminant because it continues to be of concern in the Estuary, and because there is currently no solid-phase dose-response information on copper toxicity to either *Eohaustorius* or *Ampelisca*. Fluoranthene, a polycyclic aromatic hydrocarbon (PAH), was selected for similar reasons. PAH contamination continues to be of concern in Estuary sediments, and while there is some dose-response data for fluoranthene toxicity to *Eohaustorius*, there is none available for *Ampelisca*. Experiments were also conducted with the organophosphate (OP) pesticide chlorpyrifos. Chlorpyrifos was selected because there is no dose-response information for this compound with either amphipod, it continues to be used in agriculture, and as a less water soluble OP pesticide, it is often found in SF Estuary sediments (Hunt *et al.* , 2001). One additional benefit of using chlorpyrifos in these spiking experiments is that it can be inexpensively analyzed using enzyme-linked immunosorbent assays (ELISAs).

We also investigated the relative sensitivities of these two amphipods to three pyrethroid pesticides, as part of a separate PRISM study awarded to SFEI (project manager Sarah Lowe). The PRISM study was conducted using sediments spiked with cypermethrin, bifenthrin and permethrin. These three pyrethroids are of growing concern to Bay Area water quality agencies because pyrethroids in general are replacing organophosphate pesticides as the primary pesticides used in residential and structural pest control in urban applications.

Formulated Sediment

Formulated sediment was used in all spiking experiments. This sediment was created using equal parts Salinas River, California reference site sediment and clean, kiln-dried sand (#60, RMC Pacific Materials, Monterey, CA, USA). The sediment was amended with 0.75% organic peat moss (Uni-Gro, Chino, CA, USA). One kilogram (dry weight) of formulated sediment was prepared by combining 500g reference sediment, 500g sand, and 7.5g peat with 350 mL water. Granite Canyon seawater adjusted to 20‰ and 28‰ with distilled water was used for tests with *E. estuarius* and *A. abdita*, respectively. Chemical analysis of formulated sediment demonstrated non-detects for 55 organic contaminants. The final measured TOC and grain size

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distribution for the formulated sediment was as follows: TOC = 0.78%; Medium Sand = 13.57%; Fine Sand = 48.17%: Silt and Clay (% fines) = 38.27%.

Spiking Methods

Chlorpyrifos, copper, fluoranthene, permethrin, bifenthrin and cypermethrin were spiked into formulated sediment. Chemical stock solutions, exposure concentrations, and equilibration times are outlined in Table 2.1. Different methods were used to spike the three chemicals. Copper stock solutions were spiked directly into the water used to prepare the formulated sediment. Organic stock solutions were diluted to 50 mL with acetone, poured into jars, and allowed to volatilize (with the jar caps off) on a Wheaton roller apparatus placed under a fume hood (Wheaton Model 348940-48, after Ditsworth *et al.* 1990). After volatilization, dry materials, peat and water were added to the containers and rolled for the first 24 hours of the equilibration time.

2.4 TOXICITY TESTS

Solid-phase exposures

Ampelisca abdita and *Eohaustorius estuarius* exposures followed US EPA protocol (1994), with the following modifications. Five replicate 250 mL beakers containing 50 mL sediment and 200 mL overlying water were used for each chemical concentration. The exposures were conducted under static conditions for 10 days with slow aeration using standard procedures. Each replicate contained five organisms. *A. abdita* were obtained from Brezina and Associates (Dillon Beach, CA) or Aquatic Research Organisms (Hampton, NH). *E. estuarius* were obtained from Northwestern Aquatic Sciences (Newport, OR). Three tests with each chemical were conducted with each species, one rangefinder and two definitive tests. Sediment and interstitial water chemical confirmation samples were collected from spiking jars at the initiation of the second definitive test. Tests with the three pyrethroid pesticides did not include interstitial water analyses. The test protocol for *Eohaustorius estuarius* was conducted at 15 °C using seawater adjusted to 20 ‰. The test protocol for *Ampelisca abdita* was conducted at 15 °C using seawater adjusted to 20 ‰.

Water-only exposures

Information on the responses of *E. estuarius* and *A. abdita* to copper, fluoranthene, and chlorpyrifos were used to compare the relative sensitivities of these amphipods and to help interpret the responses of the amphipods in the solid-phase protocols. When available, water-only LC50s of these species were compiled from the literature. Because water-only data were not available for chlorpyrifos, dose-response experiments in water were conducted with chlorpyrifos using both species. For these exposure, chlorpyrifos stock solutions were prepared as described above using methanol as the solvent. A secondary stock solution was prepared from these, and chlorpyrifos was spiked into seawater using the secondary stock. Methanol concentrations in the secondary stock resulted 0.10% methanol in the highest concentration of chlorpyrifos tested with *E. estuarius*, or 0.3% methanol in the highest concentration of chlorpyrifos tested with *A. abdita*. Because these are lower than the concentrations of methanol typically used in TIEs with these species (1% methanol for *E. estuarius* - Anderson *et al.* 2006; 0.75% methanol for *A. abdita* - Ho *et al.* 2006), no solvent controls were used in these tests. Tests were conducted in 250ml glass beakers, each containing 5 animals. Tests were conducted for 96h with 5 replicate per concentration. Three separate water-only chlorpyrifos tests were conducted with each amphipod species. *E. estuarius* and *A. abdita* were tested at 20 and 28‰ salinity, respectively.

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2.5 RESULTS AND DISCUSSION

The results showed that the protocols using the two amphipod species had variable sensitivities to the six chemicals (Tables 2.2 and 2.3). *E. estuarius* was slightly more sensitive than *A. abdita* to chlorpyrifos-spiked sediment (mean LC50s = 0.103 µg/kg and 0.124 µg/kg, respectively). *A. abdita* was considerably more sensitive to copper than *E. estuarius* (mean LC50s = 61 mg/kg and 534 mg/kg). *A. abdita* was also more sensitive to fluoranthene than *E. estuarius* (mean LC50s =28 µg/kg and 85 µg/kg, respectively). The protocol using *E. estuarius* was considerably more sensitive to all three pyrethroid pesticides. The mean LC50s for *A. abdita* and *E. estuarius*, respectively, were: 0.948 and 0.008 µg/kg for bifenthrin-spiked sediments. 0.469 and 0.011 µg/kg for cypermethrin-spiked sediments, and 8.913 and 0.140 µg/kg for permethrin-spiked sediments.

These results are comparable to those reported by Weston (1995) using sediment spiked with cadmium, DDT, and crude oil. In those experiments *E. estuarius* was more sensitive to the organochlorine pesticide DDT than was *A. abdita* (LC50s = 554 and 769 µg/kg, respectively). *A. abdita* was much more sensitive than *E. estuarius* to cadmium (LC50s = 643 and > 1,000 mg/kg, respectively). The two species demonstrated comparable sensitivities to crude oil (LC50s = 528 and 630 µg/kg, for *A. abdita* and *E. estuarius*, respectively).

Our current results with fluoranthene differ from those reported by DeWitt *et al.* (1989) who found a lower LC50 for *E. estuarius* using fluoranthene-spiked sediment (LC50 = 11.8 mg/kg). DeWitt (1997) also reported *E. estuarius* to be more sensitive than *A. abdita* to sediment spiked with a mixture of 5 PAHs (PAH mixture LC50s = 320 and 120 mg/kg, for *A. abdita* and *E. estuarius*, respectively). The overall trend from current and previous spiked-sediment experiments suggests that *E. estuarius* is more sensitive to pesticides (e.g., DDT, chlorpyrifos, and particularly pyrethroids), and that *A. abdita* is more sensitive to metals (e.g., copper and cadmium). Though the results are variable, both species appear to have roughly comparable sensitivities to hydrocarbons based on results with crude oil, fluoranthene, and PAH mixtures.

The differences in sensitivities between the two protocols using the three pyrethroid pesticides might be partially due to differences in exposure conditions. Pyrethroids are characterized as either Type I or Type II. Type I pyrethroids such as bifenthrin and permethrin do not contain a cyano- group, and have a negative temperature toxicity action. They are therefore characterized as being more toxic at lower temperature. Type II pyrethroids like cypermethrin contain a cyano- group and are characterized as being more toxic at higher temperature. The protocol with *E. estuarius* is conducted at 15°C, using an overlying water salinity of 20‰. The protocol with *A. abdita* is conducted at 20°C, using an overlying water salinity of 28‰. It is possible the differences in temperature between the two protocols influenced the relative responses of the two amphipod species to bifenthrin and permethrin. However, the fact that the protocol with *E. estuarius* was considerably more sensitive to the Type II pyrethroid cypermethrin suggests that temperature differences may not have significantly influenced the results. If temperature affected the relative response of the two amphipods, we would have expected the protocol with *A. abdita* to be more sensitive to cypermethrin, given that the Type II pyrethroids are expected to be more toxic at higher temperatures.

It is also possible that salinity differences between the two protocols could have influenced test results. For example, lower salinities have been shown to influence response of some species to metals. Anderson *et al.* (1995) showed that topsmelt embryos were more sensitive to copper when tested at lower salinities. These authors suggested this could have been due to increased

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cupric ion activity due to dilution of organic ligands in lower salinity tests. In addition, euryhaline species such as *E. estuarius* may be stressed by osmotic challenge at lower salinities. The influence of this on relative response of the two amphipod protocols to organic chemicals is beyond the scope of the current study.

Results with spiked sediments do not suggest a clear trend in the relative sensitivity of the two amphipod species. Despite this, results from most studies using field-collected sediments suggest that there are considerable differences in response between *E. estuarius* and *A. abdita*. In a recent review of side-by-side sediment tests conducted with these two species using field-collected sediments from a variety of monitoring studies along the west coast, Bay *et al.* (2005) reported that most studies indicated *E. estuarius* was much more responsive to field sediments than *A. abdita*. These results corroborate results of recent NOAA/EMAP studies that also suggest *A. abdita* is less sensitive to field-collected sediments (Anderson *et al.* in press). Reasons for the differences in results using laboratory-spiked and field-collected sediments are not clear. It is possible that differences in response between the two amphipods are partly due to greater sensitivity of *E. estuarius* to fine-grained sediments, but a number of studies suggest grain size plays a minimal role in survival of this species in tests using field sediments (DeWitt *et al.* 1989; Bay *et al.* 2005; Anderson *et al.* 1999; Anderson *et al.* in press; Tay *et al.* 1998).

Though grain size may not cause significant mortality in field sediments, observed differences in results using spiked sediments may be related to differences in grain size distributions between sediments. Our current spiking experiments used relatively coarse-grained formulated sediment (38% fines), while most field test sediments are finer–grained (i.e., > 63% fines; Bay *et al.* 2005). It has been hypothesized that *E. estuarius* responds to contaminated field sediments differently than *A. abdita* because *A. abdita* is a tube-builder, and is therefore more isolated from sediment contaminants than free burrowing species such as *Rhepoxynius abronius* or *E. estuarius.* Tube building rates, however, may be affected by the sediment particle size distribution. It is possible that the coarser-grained formulated sediment inhibited the rate of tube building by *A. abdita* in our spiked sediment experiments. If this were the case, *Ampelisca* may have been exposed to the spiked chemicals for longer periods than would occur if finer-grained sediments were used.

Comparison of the ratios of LC50s for *A. abdita* and *E. estuarius* from water-only and spiked sediment dose-response experiments suggests that *A. abdita* is sometimes less sensitive in solid-phase exposures than would be expected based on pore-water concentrations (Table 4). For example, the copper LC50s for *E. estuarius* and *A. abdita* in water-only tests were 33,300 µg/L and 20.5 µg/L, respectively, and the ratio of these LC50s was 1,624. The ratio of solid-phase copper LC50s for *E. estuarius* and *A. abdita* in spiked-sediment tests was much lower at 8.8 (LC50s = 534.3 µg/g and 60.7 µg/g, respectively). The fluoranthene LC50s for *E. estuarius* and *A. abdita* in water-only tests were >70 µg/L and 9.9 µg/L, respectively, and the ratio of these LC50s was >7.07 (Table 2.4). The ratio of fluoranthene solid-phase LC50s for *E. estuarius* and *A. abdita* in spiked-sediment tests was also considerably lower at 3.1 (LC50s = 85.3 µg/g and 27.6 µg/g, respectively). With copper and fluoranthene, therefore, there was a much greater difference in response between these two species in water-only exposures than in spiked-sediment tests. This suggests that some factor associated with the sediment matrix mediates the difference in response between these species. Comparison of the water LC50s to the measured interstitial water concentrations supports this suggestion. The interstitial water copper concentrations measured in treatments that bracketed the solid-phase copper LC50 for *A. abdita* were considerably higher (430 – 2,920 µg/L) than the reported water-only copper LC50 for this species (20.5 µg/L). Similarly, the interstitial water fluoranthene concentrations measured in the treatments that bracketed the solid-phase fluoranthene LC50 for *A. abdita* were

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considerably higher (43.4 – 102 µg/L) than the reported water-only fluoranthene LC50 for this species (9.9 µg/L). This indicates that *A. abdita* survival was higher in sediments than would be expected based on water-only LC50s, and suggests that tube construction may reduce interstitial water contact with this species, despite the fact that these experiments used a formulated sediment with lower fine-grained fractions. This trend did not hold true in the tests with chlorpyrifos. The water-only chlorpyrifos LC50s for *E. estuarius* and *A. abdita* were 0.529 and 0.645 µg/L, respectively, and the ratio to these LC50s was 1.22. The sediment LC50s were 0.103 and 0.124 mg/kg for *E. estuarius* and *A. abdita*, respectively, and the ratio of these was a nearly identical 1.20. Thus, the relative sensitivity of the two protocols was roughly similar in water-only and sediment exposures using chlorpyrifos. The interstitial water concentrations of chlorpyrifos never exceeded the LC50 in the tests with *A. abdita* or *E. estuarius,* but a clear dose-response relationship was observed using both amphipod protocols.

One approach to investigate differences in response to field sediments involves conducting side-by-side amphipod tests using field sediments that have been subjected to toxicity identification evaluations (TIEs). We have used this approach in synoptic tests with sediments from Moss Landing Harbor, California (Anderson *et al.* 1999). These experiments demonstrated that *E. estuarius* was considerably more sensitive to harbor sediments than *A. abdita* and subsequent TIEs with *E. estuarius* showed that toxicity was due to organic chemicals, most likely organochlorine pesticides. This approach of combining side-by-side comparisons of field sediments that are then subjected to TIE procedures can be used to demonstrate whether differences in responses between the two amphipods are due to chemical contaminants rather than non-contaminant factors, such as grain size. Similar experiments should be done with additional field sediments that have been characterized using TIE procedures.

An additional goal of these experiments was to compare the relative sensitivities of *E. estuarius* and *A. abdita* to other infaunal species in the San Francisco Estuary to determine if tests with amphipods are sufficient to protect other sensitive species in the Estuary. Meiobenthic copepods were selected for this comparison. Dose-response data for the copepods *Amphiascus tenuiremus* and *Schizopera knaberi,* were compiled for copper, fluoranthene, and chlorpyrifos (Table 2.5). The results suggest that *E. estuarius* and *A. abdita* have sensitivities comparable to these copepod species. The 96-h chlorpyrifos spiked-sediment LC50 for the copepod *Amphiascus tenuiremus* is 0.066 µg/g, which is within the ranges of the chlorpyrifos LC50s for both amphipod species. Both amphipods were more sensitive to fluoranthene than the copepod *Schizopera knaberi.* The 96-h LC50 for fluoranthene toxicity *S. knaberi* was >2,100 µg/g, considerably greater than the range of sensitivities of both amphipods to this PAH. No spiked sediment data were available for copper using copepods. The 96-h cadmium water-only LC50s for *Amphiascus tenuiremus, E. estuarius,* and *A. abdita* were 240, 9,330, and 330 µg/L, respectively. The 48h LC50 for cadmium toxicity to *M. edulis* embryo development, the other standard protocol used in the RMP is 3,890 µg/L (Phillips *et al.* 2003), also considerably less sensitive to this metal than *A. abdita.* It should be noted that the lower sensitivity of *E. estuarius* to copper relative to *A. abdita* is probably not significant in terms of environmental protection in the Estuary because the 48h LC50 for copper toxicity to *M. galloprovincialis* embryo development is 7 µg/L (Phillips *et al.* 2003), and this test is used in the RMP. However, if cadmium contamination is of concern, the protocols with *E. estuarius* and *M. galloprovincialis* do not offer sufficient protection relative to the protocols for *A. abdita*, or the copepod *A. tenuiremus*.

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2.6 CONCLUSION

Results of the current experiments with *A. abdita* and *E. estuarius* did not conclusively demonstrate that one protocol is more sensitive than the other using sediments spiked with single chemicals. The evidence presented here supports data from Weston (1995) and shows that *A. abdita* is more sensitive to metals, *E. estuarius* is more sensitive to pesticides, and when compared to results of Weston (1995) and DeWitt *et al.* (1989 and 1997), the protocols demonstrate roughly comparable sensitivities to hydrocarbons. While there are chemical-specific differences, published results suggest that the sensitivities of tests with these amphipods are comparable to those with meiobenthic copepods. Our data suggest that tube-building by *A. abdita* may reduce its exposure to contaminants in whole sediment exposures, but additional experiments should be conducted using sediments which demonstrate a range of grain sizes. Regardless of the reason for differences in response, we conclude that the weight-of-evidence from these and other studies shows that tests using *E. estuarius* are more responsive in most cases, particularly in side-by-side comparisons with field sediments, and are therefore appropriate for continued use in the Regional Monitoring Program. This is supported by recent recommendations from the State Water Resources Control Board. The State Board lists *E. estuarius* as the primary amphipod species for use in sediment toxicity tests to assess compliance with newly developed statewide sediment quality objectives.

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Table 2.1. Summary of sediment spiking methods.

Chemical	Amphipod	Stock Solution Concentrations	Stock Solution Matrix	Equilibration Time	Exposure Concentrations (mg/kg) (Rangefinder and Definitive)
Chlorpyrifos	*A. abdita*	0.1-2.5 g/L	Acetone	28 Days	0.032-100 and 0.018-0.18
	E. estuarius	0.1-2.5 g/L	Acetone	28 Days	0.032-100 and 0.032-0.32
Copper	*A. abdita*	20 g/L	Nanopure Water	14 Days	1.8-320 and 18-180
	E. estuarius	20 g/L	Nanopure Water	14 Days	100-1800 and 180-1800
Fluoranthene	*A. abdita*	1.3-7.5 g/L	Acetone	28 Days	5.6-320 and 5.6-56
	E. estuarius	4.0-8.0 g/L	Acetone	28 Days	10-180 and 18-180
Bifenthrin	*A. abdita*	250 mg/L	Acetone	7 Days	0.01–100 and 0.18-10
	E. estuarius	10 mg/L	Acetone	7 Days	0.01-100 and 0.0018-0.1
Cypermethrin	*A. abdita*	200 mg/L	Acetone	7 Days	0.001-10 and 0.032-1.0
	E. estuarius	200 mg/L	Acetone	7 Days	0.001-10 and 0.032-0.56
Permethrin	*A. abdita*	5 g/L	Acetone	7 Days	0.05-500 and 5.6-180
	E. estuarius	100 mg/L	Acetone	7 Days	0.05-500 and 0.056-5.6

Table 2.2. Summary of sediment LC50 values (based on nominal concentrations).

		LC50 (mg/kg)				
Chemical	Amphipod	Rangefinder	Definitive 1	Definitive 2	Mean	SD
Chlorpyrifos	*A. abdita*	0.0433	0.182	0.146	0.124	0.072
	E. estuarius	0.0957	0.122	0.0900	0.103	0.017
Copper	*A. abdita*	66.6	85.5	29.9	60.7	28.3
	E. estuarius	726	355	522	534.3	185.8
Fluoranthene	*A. abdita*	16.1	42.3	24.4	27.6	13.4
	E. estuarius	67	107	82	85.3	20.2
Bifenthrin	*A. abdita*	1.069*	1.373	0.522	0.948**	0.432
	E. estuarius	0.021*	0.009	0.006	0.008**	0.008
Cypermethrin	*A. abdita*	0.190*	0.429	0.509	0.469**	0.166
	E. estuarius	0.022*	0.008	0.014	0.011**	0.007
Permethrin	*A. abdita*	21.594*	7.468	10.358	8.913**	7.463
	E. estuarius	0.388*	0.143	0.137	0.140**	0.143

*Test 1 = range finding test. ** Mean calculated based on the two definitive tests.

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Table 2.3. Measured concentrations of select treatments from amphipod exposures. Eliminate decimal place for % difference.

Chemical	*A. abdita*				*E. estuarius*			
	Nominal (mg/kg)	Measured (mg/kg)	Percent Nominal	Interstitial (ug/L)	Nominal (mg/kg)	Measured (mg/kg)	Percent Nominal	Interstitial (ug/L)
Chlorpyrifos	0.018			0.133	0.032	0.00809	25.3	0.166
	0.032			0.157	0.056			0.216
	0.056	0.0184	32.9	0.172	0.1	0.0835	83.5	0.268
	0.1	0.0909	90.9	0.454	0.18			0.628
	0.18	0.105	58.3	0.377	0.32	0.503	157.2	1.384
Copper	18	35.7	198.3		320	327	102.2	5.30 mg/L
	37			0.43 mg/L	560	590	105.4	
	56	65.1	116.3		1000	978	97.8	13.9 mg/L
	180	200	111.1	2.92 mg/L				
Fluoranthene	5.6	1.8	32.1	9.02	56	33.6	60.0	52
	18	9.6	53.3	43.4	100	67.3	67.3	138
	56	21.5	38.4	102	180	108	60.0	
Bifenthrin	0.32	0.242	75.6	NA	0.0032	0.0023	71.9	NA
	1.00	0.470	47.0		0.010	0.008	80.0	
	3.2	2.190	68.4		0.032	0.020	62.5	
	0.32	0.270	84.4		0.0032	0.0027	84.4	
	1.0	0.705	70.5		0.010	0.008	80.0	
	3.2	2.65	82.8		0.032	0.018	56.3	
Cypermethrin	0.1	0.187	187.0	NA	0.0032	0.0052	163.0	NA
	0.32	0.696	218.0		0.010	0.031	310.0	
	1.0	2.271	227.0		0.032	0.052	163.0	
	0.1	0.166	166.0		0.0032	0.0160	500.0	
	0.32	0.427	146.0		0.010	0.022	220.0	
	1.0	1.719	172.0		0.032	0.062	194.0	
Permethrin	5.6	2.809	50.2	NA	0.056	0.035	62.5	NA
	10.0	3.552	35.5		0.100	0.070	70.0	
	18.0	7.655	42.5		0.560	0.271	48.4	
	5.6	3.480	62.1		0.056	0.037	66.1	
	10.0	5.856	58.6		0.100	0.0592	59.2	
	18.0	7.508	41.7		0.560	0.374	66.8	

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Table 2.4. Relationship between water-only LC50s, measured interstitial water concentrations, and bulk-phase LC50s for experiments conducted with *A. abdita* and *E. estuarius*.

Chemical	*A. abdita*				*E. estuarius*			
	Nominal Conc. (mg/kg)	Sediment LC50 (mg/kg)	Interstitial Measured (ug/L)	Water LC50 (ug/L)	Nominal Conc. (mg/kg)	Sediment LC50 (mg/kg)	Interstitial Measured (ug/L)	Water LC50 (ug/L)
Chlorpyrifos	0.018		0.133		0.032		0.166	
	0.032		0.157		0.056		0.216	
	0.056		0.172		0.1	0.103	0.268	
	0.1	0.124	0.454	0.645 [b]	0.18		0.628	0.529 [b]
	0.18		0.377		0.32		1.384	
Copper	18			20.5 [a]	320		5,300	
	37		430		560	534 [b]		
	56				1000		13,900	
		60.7 [b]						
	180		2,920					33,300 [e]
Fluoranthene	5.6		9.02	9.9 [c]	56		52	
	18		43.4			85.3 [b]		>70.0 [d]
		27.6 [b]	102		100		138	
	56				180			

[a]Berry *et al.* 1996; [b]Current study; [c]Boese *et al.* 1997; [d]Werner and Nagel 1997; [e] Anderson *et al.* 2006.

Table 2.5. Sediment LC50 values for fluoranthene and chlorpyrifos and water LC50 for copper using selected copepod species. Use mg/kg to be consistent with other tables.

Copepod species	**Chemical**	**Sediment LC50 µg/g = mg/kg**	**Water LC50 µg/L**	**Reference**
A. tenuiremus	Chlorpyrifos	0.066		Chandler and Green 2001
S. knaberi	Fluoranthene	>2,100		Lotufo 1997
A. tenuiremus	Cadmium	37.9	240	Green *et al.* 1993
T. furcata	Copper		178	Bechman 1994

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CHAPTER 3. DEVELOPMENT OF TOXICITY IDENTIFICATION EVALUATION (TIE) METHODS FOR PYRETHROID PESTICIDES

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This chapter covers work performed under Task 3.30: *Develop Toxicity Identification Procedures under this PRISM Grant # 041355520.*

3.1 INTRODUCTION

Toxicity Identification Evaluations (TIEs) are laboratory procedures designed to determine the agents responsible for toxicity in a sample. First designed for water, these methods have been adapted for sediments and sediment interstitial water by the U.S. Environmental Protection Agency and others (Ho *et al.* 2006; Anderson *et al.* 2006a). TIEs are designed to proceed in three phases. Phase I manipulations characterize the classes of chemicals causing toxicity and typically differentiate toxicity caused by organic chemicals, metals, or ammonia. Phase II manipulations identify the cause of toxicity, and Phase III TIEs are designed to confirm the chemical(s) identified in Phase II. Ideally, sediment TIEs are conducted using both the aqueous matrix (sediment interstitial water) and the solid-phase matrix (whole sediment). Information from solid-phase and interstitial water TIEs are combined in a weight-of-evidence to determine the cause(s) of toxicity.

Because of their hydrophobicity, pyrethroid pesticides are associated with sediments in the environment. TIEs specific to identifying toxicity caused by these insecticides therefore need to be amenable for use in both solid-phase and interstitial water sediment matrices. Phase I (characterization), II (identification), and III (confirmation) TIE methods found to be useful for characterizing and identifying pyrethroid toxicity are listed in Table 3.1.

Phase I solid-phase TIE methods useful for characterizing toxicity caused by pyrethroid pesticides include addition of carbon sources to reduce pyrethroid bioavailability. Two carbon sources have been used successfully, fined-grain coconut charcoal and the carbonaceous resin Ambersorb 563® (see Ho et. al. 2006, and Anderson *et al.* 2006a). Evidence from a number of studies suggests both carbon sources reduce toxicity due to pyrethroid pesticides. One advantage of using Ambersorb is that it can be recovered from the sediment and eluted with solvent as part of Phase II TIE procedures (discussed below; see also Anderson *et al.* 2006a; Phillips *et al.* 2006). Similar Phase I procedures are used to extract pyrethroid pesticides from interstitial water (IW). Because IW is an aqueous matrix, it can be passed through a solid-phase extraction (SPE) column to remove non-polar organic chemicals such as pyrethroids. The column can then be eluted with solvent, and toxicity of the column eluate can be assessed as part of Phase II TIE procedures. Two additional Phase I TIE procedures that have been shown to be useful in building a weight-of-evidence for characterizing pyrethroid pesticide toxicity include addition of the metabolic inhibitor piperonyl butoxide (PBO), and manipulation of test temperature. PBO is used to inhibit mixed function oxidase enzymes, which metabolize chemicals *in vivo*. It is used as a potent synergist in formulations containing pyrethroids, and is useful as a TIE tool because increase in sample toxicity with the addition of PBO can indicate the presence of pyrethroids.

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Detailed methods for using PBO in solid-phase and IW TIEs are provided in a number of recent publications (Anderson *et al.* 2003; Phillips *et al.* 2006, Anderson *et al.* 2006a and b; Amweg *et al.* 2006). Pyrethroids are characterized as either Type I or Type II. Type I pyrethroids such as bifenthrin and permethrin do not contain a cyano- group, and have a negative temperature-toxicity action. They are therefore characterized as being more toxic at lower temperature. Type II pyrethroids like cypermethrin contain a cyano-group and are characterized as being more toxic at higher temperature. Therefore samples containing Type I pyrethroids might demonstrate greater toxicity when tested at lower temperature (e.g., Anderson *et al.* 2006a; Anderson *et al.* 2006b; Phillips *et al.* 2004; Weston *et al.* 2006).

Phase II TIE procedures build on evidence from the Phase I TIE results and are designed to identify specific chemicals causing toxicity. An example of a Phase II TIE method that can be used to indicate toxicity caused by pyrethroid pesticides is reduction of sample toxicity with addition of a carboxylesterase enzyme. Carboxylesterases are enzymes that hydrolyze ester-containing compounds, such as pyrethroids, to their corresponding nontoxic acid and alcohol detoxification products. Reduction of sample toxicity with the addition of this enzyme has the potential to be a powerful Phase II TIE tool indicating the presence of pyrethroid pesticides (Wheelock *et al.* 2006).

As discussed above, one of the most important steps in Phase II TIEs involving non-polar organic compounds is solvent elution of these compounds from solid-phase extraction media. In this procedure, the solvent eluate is spiked into clean water and toxicity is assessed to confirm that chemicals removed from the extraction media are toxic when returned to water. The eluates are then analyzed to identify specific constituents responsible for toxicity. Examples of two types of extraction media used for this purpose are Ambersorb 563 which is used to remove organics from solid-phase sediment samples, and solid-phase extraction (SPE) columns (C_{18} or OASIS HLB) which are used to extract organics from interstitial water (methods summarized in Ho *et al.* 2006 and Anderson *et al.* 2006a, and references therein).

Phase III TIEs are designed to confirm that chemicals identified in Phase II are the specific chemicals responsible for toxicity. One of the most common methods is the species sensitivity approach. In this approach, chemicals measured in sediment and interstitial water are compared to toxicity thresholds derived from dose-response experiments conducted using spiked sediments or water samples. If chemical concentrations in the original sample exceed known toxicity thresholds, this can be used to confirm results of the Phase I and II TIEs. Confirmation of the cause of toxicity is strengthened if the chemicals measured in the Phase II Ambersorb eluates (solid-phase samples), or in SPE column eluates (IW samples) also exceed known toxicity thresholds. In the case of pyrethroids, sediment and water-only dose response data have been developed for the majority of current-use pesticides, primarily using the freshwater amphipod *Hyalella azteca* (e.g., Maund *et al.* 2002; Amweg *et al.* 2005; Anderson *et al.* 2006c).

The San Francisco Estuary Institute convened two workshops in March 2005 and May 2006. The preliminary workshop was a forum to discuss various issues concerned with pyrethroid pesticides, evaluate what topics were being studied by other researchers, and to guide the focus of the TIE development by UC Davis. The second workshop served as a forum to present recent work and to discuss issues important to both the toxicologists and chemists involved in pyrethroid research locally. The workshops were

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attended by toxicologists and chemists involved in pyrethroid pesticide research, and the primary objectives were to compile TIE methods for identifying toxicity caused by pyrethroid pesticides, describe current projects developing TIE procedures, describe analytical methods for measuring low concentrations of pyrethroids in sediments and water, and identify methods requiring additional research (see Appendix D for meeting agendas and notes).

A number of researchers presented results of recent work involving pyrethroids, and this information was used to amend study plans to ensure that research teams were not duplicating efforts. A workshop summary was produced by SFEI, and this described TIE and chemistry research being pursued by the various researchers. At the time of the 2005 workshop, TIE research at UC Berkeley (PI Don Weston) involved developing methods using PBO and temperature manipulations to create toxicity signatures for specific pyrethroids. TIE research at Aquascience (PI Jeff Miller – PRISM Proposal No. 0032) evaluated the carboxylesterase enzyme for application to water TIEs using *Ceriodaphnia dubia* (Note: this work was conducted under a separate PRISM grant awarded to TDC, and was conducted in conjunction with the current project). Research at UC Davis emphasized the following TIE procedures for the current PRISM project: 1) efficacy of the carboxylesterase enzyme for use in sediment TIEs with the amphipod *Hyalella azteca*; 2) evaluation of Phase II procedures for extracting pyrethroids from sediment interstitial water using solid-phase extraction columns; 3) evaluation of solvent elution procedures for single pyrethroids and pesticide mixtures using solid-phase extraction columns.

3.2 CARBOXYLESTERASE EXPERIMENTS

Methods

The utility of the caboxylesterase for use in TIEs with pyrethroid pesticides is described above, and is summarized in Wheelock *et al.* (2006). In order to use this enzyme in TIEs with the amphipod *Hyalella azteca*, basic information regarding the efficacy of the enzyme to reduce toxicity of pyrethroid pesticides was required. This research was conducted by spiking laboratory well water and sediment interstitial water with known concentrations of bifenthrin and permethrin and assessing toxicity of these solutions after carboxylesterase additions.

The following is a brief summary of the methods, more detailed descriptions are provided in Wheelock et. al. (2006). Laboratory control water and interstitial water were spiked with bifenthrin and permethrin prepared from secondary stock solutions prepared in methanol (described below). Bifenthrin was spiked at 0, 20, 60, and 100 ng/L, and permethrin was spiked at 100, 150, and 200 ng/L. These concentrations corresponded roughly to 2, 6, and 10 toxic units of bifenthrin, and 5, 7.5, and 10 toxic units of permethrin (Anderson *et al.* 2006c). Increasing strengths of carboxylesterase esterase enzyme derived from porcine liver (Aldrich Chemical, St. Louis, MO, USA) were added to increasing concentrations of bifenthrin and permethrin to determine the reductions in toxicity via esterase-mediated hydrolysis of the pyrethroids.

Initial experiments used a liquid preparation of enzyme (activity = 184 units/mL) that was diluted to 10.03 units/mL. Based on $X = 2.5 \times 10^{-3}$ enzyme activity units/mL, enzyme exposures were conducted at 0, 100, 500, 1000, and 5000X. Subsequent experiments used a lyophilized powder enzyme preparation (activity = 20 units/mg, Sigma-Aldrich, Inc., St. Louis, MO) that was used to create a stock solution of 1 mg/mL. Lyophilized

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enzyme exposures were conducted at 0, 10, 50, 100, and 500X, and then at 0, 100, 500, 1000, and 5000X.

Results and Summary of Carboxylesterase Experiments

The complete methods and results of these experiments are summarized in Wheelock *et al.* (2006), and a brief summary of the results are provided here. The original liquid preparation of the enzyme introduced high concentrations of ammonia into the spiked water samples and confounded the toxicity results. Subsequent experiments therefore emphasized use of the lyophilized powder form of the enzyme. These did not result in the production of unionized ammonia and allowed better evaluation of the esterase enzyme.

H. azteca could be exposed to enzyme concentrations up to a strength of 500x without causing amphipod mortality (Table 3.2). At the highest strength, the enzyme removed approximately 2 TUs of bifenthrin toxicity (20 ng/L) in laboratory water, and approximately 6 TUs of bifenthrin toxicity (60 ng/L) in the Salinas River reference site interstitial water. The enzyme removed up to 10 TUs of permethrin toxicity (200 ng/L) in both laboratory and interstitial water.

These results suggest that the esterase enzyme provides a useful tool to help characterize toxicity due to pyrethroid pesticides. Results presented in Wheelock *et al.* (2006) show that the enzyme successfully mitigated toxicity of pyrethroids spiked into laboratory well water and sediment interstitial water. Since the majority of ambient samples contain pyrethroid concentrations considerably lower than those used in the spiking experiment, the enzyme is expected to produce greater reductions in toxicity in most samples. In samples where concentrations of pyrethroid concentrations may exceed the capacity of the enzyme, a dilution series of the original sample may be used to increase its effectiveness. In addition to its use with interstitial waters, methods to treat sediment overlying water with the enzyme have also been developed. The utility of the enzyme in characterizing toxicity caused by pyrethroids has been confirmed in several recent ambient sample solid-phase and interstitial water TIEs (Anderson *et al.* 2006a; Anderson *et al.* 2006b, Phillips *et al.* 2006), and in the TIEs of San Mateo Creek sediment presented in this report.

3.3 SOLID-PHASE EXTRACTION COLUMN EXPERIMENTS

As discussed above, a key step in Phase II TIEs involves solvent elution of chemicals from solid-phase extraction (SPE) columns used to remove organic chemicals from sediment interstitial water. After elution, the solvent is then spiked into clean water and toxicity of this solvent eluate spike is assessed to verify that toxic concentrations of chemicals were recovered from the interstitial water. Organic chemicals are then measured in the (toxic) eluate, and specific chemicals that exceed their respective toxicity thresholds are identified. This information is then combined with other Phase I, II and III TIE results to provide a weight-of- evidence of chemicals responsible for toxicity.

A series of experiments were conducted to investigate the ability of SPEs to remove pyrethroids from interstitial water spiked with single pyrethroids, pyrethroid mixtures, and a mixture of pyrethroid and organophosphate pesticides. These experiments also investigated effectiveness of solvent elution of chemicals from SPEs.

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Methods

Four batches of Salinas River reference site interstitial water were spiked separately with bifenthrin, permethrin, bifenthrin and permethrin in combination, and permethrin and chlorpyrifos in combination. Pesticide concentrations were prepared from 100 mg/L stock solutions. Bifenthrin and permethrin stocks were purchased (Accustandard, New Haven, CT), while the chlorpyrifos stock was prepared in the laboratory (10 mg chlorpyrifos in 100 mL acetone, Chem Service, West Chester, PA). Superstock solutions were diluted to 100 µg/L secondary stock solutions in methanol, and then further diluted to test concentrations using interstitial water extracted via centrifugation (2500g) from sediment collected from a reference site on the Salinas River, California (Hunt *et al.* 2003). Bifenthrin was spiked at 100 ng/L for the initial test, and 50 ng/L for subsequent tests, permethrin was spiked at 200 ng/L, and chlorpyrifos was spiked at 400 ng/L. Three solid-phase extraction (SPE) column experiments were conducted on each batch of spiked interstitial water. These experiments assessed the ability of the column to remove chemicals from the interstitial water, and to assess solvent elution of chemicals from the columns.

Oasis® HLB columns were used for all treatments (HLB = Hydrophilic-Lipophilic Balance®, 6 mL, 500 mg, Waters Corporation, Milford, MA, USA). All column treatments followed the manufacturer's suggested generic method for conditioning and loading the column. Three separate column elution methods were tested: generic method with methanol, generic method with acetone, and a serial extraction method using the standard EPA Phase II TIE suite of methanol fractions (US EPA 1991).

The column and pump apparatus was constructed by placing a column in a ring stand clamp, attaching tubing to the outlet of the column, and then passing the tubing through a peristaltic pump. Prior to attachment to the column, the tubing was cleaned by passing 10 mL 1N HCl, 25 mL Nanopure®, 25 mL methanol, and 25 mL Nanopure. After attaching tubing to the columns, they were conditioned by passing 3 mL methanol followed by 5 mL Nanopure. A separatory funnel was clamped above the column and filled with 100 mL control water. The control water was dripped into the column and pumped through at a rate of 1 mL per minute. After control water had passed through the column, 100 mL of spiked interstitial water was pumped through. Post column test concentrations were prepared by combining control and sample rinsates (rinsate = post column water). Post–column test concentrations were 0 (control), 10, 25, 50, and 100% rinsate. Columns were eluted by first washing them with 4 mL Nanopure water, followed by 4 mL solvent (methanol or acetone).

For the serial elution experiment, the column was eluted with 4 mL aliquots of methanol at the following concentrations: 25, 50, 75, 80, 85, 90, 95, and 100%. The serial elution experiments were designed to assess whether the three pesticides could be eluted from the columns in specific methanol fractions, and follows standard U.S. EPA Phase II procedures (U.S. EPA 1993).

After elution, the eluate fractions were evaporated to 1 mL using nitrogen gas under a fume hood, then the concentrated solvent was reconstituted in 100 mL control water. This reconstituted eluate was then tested with the amphipod *Hyalella azteca* in a water-only exposure. Toxicity test solvent blanks were prepared by spiking control water with highest concentrations of methanol or acetone.

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Hyalella azteca were obtained from Chesapeake Cultures (Hayes, VA) 48 hours prior to test initiation. The culture was maintained at 23°C and fed YCT (US EPA 2002). Amphipods were 7-14 days old at test initiation. *H. azteca* exposures were conducted in 20 mL glass scintillation vials (3 replicates) containing 10 mL treated sample and five amphipods. Exposures were conducted for 96 hours at 23°C, following procedures described in US EPA (2002). Water quality parameters of dissolved oxygen, pH and conductivity were measured using a Hach SensION© selective ion meter with appropriate electrodes at test initiation, and temperature was measured using a continuously recording thermograph and thermometer.

Chemical analyses

Concentrations of bifenthrin and permethrin were measured in the spiked (baseline) samples and in selected treatments. Pyrethroid pesticides were measured using Gas Chromatography-Mass Spectroscopy (GC-MS; US EPA method 1660 (1993)) ECD-MS detector following methods developed by the California Department of Fish and Game Water Pollution Control Laboratory (reporting limits for bifenthrin and permethrin = 10 ng/L and 20 ng/L, respectively). Concentrations of chlorpyrifos were measured in all treatment concentrations using enzyme-linked immunosorbent assays (ELISA, Sullivan and Goh, 2000). The reporting limit for chlorpyrifos was 100 ng/L. Chemical analysis was conducted on spiked interstitial water, post-column rinsate, and eluate fractions reconstituted in clean dilution water.

Results

Results are presented as the mean survival of *H. azteca* in each TIE treatment and interstitial water concentration (Tables 3.3 to 3.9). A median lethal concentration (LC50) was calculated for each set of dose-response data, and toxic units (TU) were calculated by dividing 100 by the LC50. All column rinsate treatments are identical, but elution treatments are specific to the solvent being used to elute the column and rinsate fractions. Toxic unit results from each solid-phase extraction column test are compared and summarized in Table 3.10.

The first column experiment was conducted with interstitial water that was spiked with 100 ng/L bifenthrin. There were 13.5 TUs in the baseline treatment (Table 3.3). The columns reduced the toxicity to 6.3, 5.3 and 8.4 TUs, an approximate average reduction of 50%. Although there was incomplete removal of toxicity by the columns, the toxicity of the methanol and acetone eluates was greater than the original signal. The reason for these strong signals was most likely due to reduced survival in the eluate blanks. The serial methanol extraction returned approximately half of the toxicity in a combination of the 85 and 100% methanol fractions.

The bifenthrin experiment was repeated with a 50 ng/L spike in order to attempt complete removal of the bifenthrin. The acetone elution treatment was dropped from this experiment because it had performed as well as the methanol treatment in the previous bifenthrin experiment. The baseline sample contained 7.4 TUs (Table 3.4), and although the columns still only removed approximately half of the bifenthrin toxicity, a strong signal was returned when the methanol eluate was spiked into clean water. The serial methanol extractions demonstrated a return of toxicity in the 80, 95, and 100% fractions. These results were somewhat different from the first bifenthrin experiment (toxicity in 85 and 100% methanol fractions).

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Interstitial water in both permethrin experiments was spiked with 200 ng/L. The baseline TUs for the first and second permethrin experiments were 2.5 and 2.3, respectively (Tables 3.5 and 3.6). The first HLB column in the first experiment reduced toxicity to 1.4 TU, and the methanol eluate returned 1.1 TU. The second column completely removed toxicity and the acetone eluate returned 100% of the toxicity. The third HLB column also completely removed toxicity, but the serial methanol extraction of the column only returned toxicity in the 100% fraction. Similar removal of toxicity was observed in the second permethrin experiment, but the methanol rinsate did not return toxicity and the 100% methanol fraction only returned 70% of the toxicity.

Two experiments were conducted with interstitial water spiked with a mixture of 50 ng/L bifenthrin and 200 ng/L permethrin. As before, the mixtures were extracted with three separate HLB columns, and these were subjected to either acetone or methanol elution, or to a serial extraction using increasing concentrations of methanol. Baseline interstitial water in both tests contained an average of 6.2 TU (Tables 3.7 and 3.8). There was variable reduction of toxicity by the HLB columns in these experiments. In the first mixture experiment, the three HLB columns reduced toxicity an average of 46%, whereas the columns in the second experiment only reduced toxicity by an average of 14%. Variable levels of toxicity were observed in the three solvent eluate treatments. Inconsistent results were observed when these experiments were repeated. Approximately half the toxicity was returned in the single fraction methanol or acetone eluates in the first experiment. No toxicity was observed in the methanol eluate in the second experiment. The two methanol serial elution experiments also produced variable results, and showed toxic elutions in several of the methanol fractions (Table 3.7 and 3.8).

A final experiment was conducted to assess TIE methods to separate organophosphate and pyrethroid pesticides in sediment interstitial water. For this experiment, interstitial water was spiked with 200 ng/L permethrin and 400 ng/L chlorpyrifos. This experiment used methanol to elute the HLB column, but did not include an acetone extraction of the column. Toxicity in the baseline was 3.4 TUs, and the two HLB columns reduced the toxicity to 1.9 and 2.7 TUs (Table 3.9). The methanol eluate did not return toxicity to clean dilution water, and the serial elution fractions did not return toxicity until 100% methanol was passed through the column. Chlorpyrifos concentrations were measured in the 100% concentration of every treatment. The baseline contained 451 ng/L chlorpyrifos, which was removed to below detection limits by each HLB column. The 100% methanol eluate returned 141 ng/L to clean dilution water, and the 95% methanol fraction returned 178 ng/L to clean dilution water. Although the concentrations returned in these eluate treatments were above the LC50 for *H. azteca* (86 ng/L, Phipps *et al.* 1995), significant toxicity was not observed. Previous researchers have shown that chlorpyrifos is returned in the 80 and 85% methanol fractions using a C_{18} column (Bailey *et al.* 1996). These results suggest that resins used in the HLB column react differently than those used in the C_{18} and this required a higher methanol concentration to elute chlorpyrifos.

Bifenthrin and permethrin toxicity was never completely removed by the HLB columns in these experiments. Regardless of the interstitial water spiking concentration, the proportion of pyrethroid toxicity removed by the HLB columns consistently fell within the range of 50 to 60%. Extraction of pyrethroids from interstitial water in the second pyrethroid mixture experiment was even lower (14%). Incomplete pesticide extraction (and therefore incomplete toxicity reduction) could be attributed to column breakthrough

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due to pesticides overwhelming the sorptive capacity of the column. Breakthrough could also be attributed to incomplete pesticide sorption due to the presence of dissolved organic material (DOM) in the interstitial water (personal communication, M. Hladic, USGS). Pyrethroids preferentially associate with DOM in water, and may in this situation not be susceptible to binding by the sorbent material in the HLB column. This would result in column breakthrough and rinsate toxicity. The concentration of DOM in the interstitial water was not measured in these experiments; therefore their role can not be defined.

An additional experiment was conducted to compare the standard 200 mg HLB columns used in the experiments described above to higher capacity 1000 mg HLB columns. This experiment was conducted to determine if increased sorbent material would increase the efficiency of pyrethroid extraction from the interstitial water. The methods for conditioning, loading and eluting the 200 mg column are described above, except that after the spiked interstitial water was loaded to the column, the column was washed with 4 mL of 5% methanol, and was then eluted by passing 4 mL 100% methanol through the column three times. The 1000 mg column was conditioned with 10 mL methanol followed by 10 mL Nanopure water. After loading with spiked interstitial water, the 1000 mg column was washed with 10 mL 5% methanol and eluted by passing 10 mL pure methanol through the column three times. Bifenthrin and permethrin were spiked individually at 50 ng/L and 200 ng/L as described above.

Baseline toxicity in the bifenthrin experiment was 16.4 TUs (Table 3.10). The 200 mg HLB column reduced toxicity to 5.5 TUs and returned 6.5 TUs, while the 1000 mg HLB column reduced toxicity to 3.4 TUs and returned 2.6 TUs. These results demonstrated that larger column was more efficient at removing toxicity, but the smaller column had better elution efficiency. The baseline toxicity in the permethrin treatment was 1.5 TUs. Both columns removed the toxicity, but the eluates failed to return toxicity. Although a larger column was used, bifenthrin still passed through the sorbent material, possibly because it was associated with DOM. Additional studies with slower pumping rates or multiple columns are necessary to determine if increased residence time with the sorbent can better extract pyrethroids from interstitial water.

Toxicity of water spiked with the HLB column solvent eluate samples was variable in these experiments. This was apparently due to incomplete elution of pyrethroids using methanol. Bifenthrin eluated from the HLB columns with 100% methanol returned toxicity greater than those of the baseline treatments, while inconsistent toxicity was observed in water spiked with the serial methanol fractions. Permethrin methanol eluations were more successful, but also demonstrated some variability. All of the permethrin toxicity that was removed by HLB columns in the first experiment was accounted for in the respective HLB column eluates. In the second permethrin experiment, approximately half of the toxicity removed by the HLB column was recovered in the methanol eluates. No permethrin toxicity was returned in water spiked with the methanol serial fractions (Table 3.10).

Methanol elution of HLB columns used to extract interstitial waters spiked with pyrethroid mixtures also resulted in incomplete recovery of pesticides. This resulted in inconsistent toxicity of water spiked with these eluates. Approximately half the toxicity was returned in the 100% solvent eluates in the first pyrethroid mixture experiment, but excessive toxicity (greater than baseline) was observed in several fractions of methanol in the serial extraction treatment. The results of the second experiment differed from the first.

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No toxicity was observed in the 100% methanol fraction, and minimal toxicity was observed in the 85% fraction (Table 3.11).

Bifenthrin and permethrin were measured in selected treatments from the solid-phase extraction experiments. No permethrin was detected in any of the samples, and inconsistent concentrations of bifenthrin were detected in approximately half of the samples (Table 3.12). The lack of detectable concentrations can be attributed to small sample volume, and in the case of bifenthrin, low initial dosing concentration. In these experiments, 100 mL of interstitial water was spiked with bifenthrin, permethrin or mixtures of both, using methods that duplicated those used in the TIEs. Based on conversations with the chemistry laboratory, we concluded this would provide sufficient method detection limits for these experiments. Use of the 100 ml sample did not provide sufficient volumes to detect low concentrations of pyrethroids in these experiments, even in samples where toxicity was observed.

These results demonstrate that methanol and acetone are not appropriate solvents for eluting pyrethroid pesticides from solid-phase extraction columns. These solvents were selected for the interstitial water TIEs because of their relatively low toxicity to *Hyalella azteca* and their miscibility with water. Methanol is the solvent of choice in US EPA TIE methods, but may not be appropriate for extremely hydrophobic chemicals such as pyrethroids (Ankley *et al.* 1991; Anderson *et al.* 2006). Experiments conducted by the United State Geological Survey (USGS) also found variable elution of pyrethroids from HLB solid-phase extraction columns using methanol (personal communication, M. Hladick, USGS, Menlo Park). Their results suggested that the ethyl acetate is more appropriate for eluting pyrethroids from the HLB column, because this solvent is less polar than methanol, and therefore more efficiently solubilizes hydrophobic chemicals. Further studies are necessary to determine if ethyl acetate can be used in the TIE process. Additional studies are also needed to determine the role of DOM in column breakthrough of pyrethroids. Currently, either multiple columns or larger columns might be necessary to extract pyrethroids from interstitial water containing high concentrations of dissolved organic matter.

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Table 3.1. Toxicity Identification Evaluation (TIE) methods used to identify toxicity caused by pyrethroid pesticides in solid-phase and interstitial water.

Solid-Phase	Interstitial Water
Phase I TIE = Characterization	***Phase I TIE = Characterization***
Coconut Charcoal – Bioavailability	Solid-Phase Extraction (SPE) – Bioavailability
Ambersorb #563 – Bioavailability	PBO – Inhibition or synergism
PBO – Inhibition or synergism	PBO/Carboxylesterase combo - mixtures
PBO/Carboxylesterase combo - mixtures	
Phase II TIE = Identification	***Phase II TIE = Identification***
Carboxylesterase enzyme- metabolism	Carboxylesterase enzyme - metabolism
Ambersorb elution + toxicity and chemistry	SPE column elution + toxicity and chemistry
HPLC Fractionation – toxicity + chemistry	HPLC or SPE Column Fractionation – toxicity + chemistry
Phase III TIE = Confirmation	***Phase III TIE = Confirmation***
Species sensitivity	Species sensitivity

Table 3.2. Mean survival (± standard deviation) of amphipods (*Hyalella azteca*) in interstitial water spiked with the pyrethroid pesticides bifenthrin or permethrin and treated with increasing concentrations of carboxylesterase enzyme.

Enzyme concentrations are expressed as activity units 10x – 500x (after Wheelock *et al.* 2006).

	Percent Survival per Enzyme Concentration									
	0x		10x		50x		100x		500x	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Bifenthrin (ng/L) Lab Water										
0	100	0	93	12	93	12	73	31	100	0
20	15	13	60	20	100	0	87	12	87	23
60	0	0	0	0	13	23	7	12	7	12
100	0	0	0	0	7	12	0	0	0	0
Interstitial Water										
0	100	0	87	12	93	12	93	12	100	0
20	80	0	7	12	77	9	93	12	87	12
60	0	0	0	0	0	0	13	12	87	12
100	0	0	0	0	0	0	0	0	33	12
Permethrin (ng/L) Lab Water										
0	100	0	93	12	93	12	73	31	100	0
100	27	23	93	12	93	12	100	0	100	0
150	7	12	100	0	100	0	93	12	93	12
200	0	0	100	0	100	0	93	12	100	0
Interstitial Water										
0	100	0	87	12	93	12	93	12	100	0
100	7	12	67	23	100	0	100	0	100	0
150	0	0	20	20	100	0	100	0	93	12
200	0	0	7	12	100	0	100	0	87	23

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Table 3.3. Mean survival of amphipods (*Hyalella azteca*) in interstitial waters spiked with bifenthrin and subjected to solid-phase extraction using HLB SPE column. Experiment #1 = bifenthrin spiked at 100 ng/L.

Results show amphipod survival after 96h in 4 different interstitial water concentrations: 10, 25, 50, and 100% IW.

	Percent Sample										
	0		10		25		50		100		Toxic
Treatment	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Units
Baseline	81	20	27	23	0	0	0	0	0	0	13.5
Methanol											
Rinsate	87	12	80	20	7	12	0	0	0	0	6.3
Eluate	57	21	0	0	0	0	0	0	0	0	20
Acetone											
Rinsate	80	0	67	12	27	12	7	12	0	0	5.3
Eluate	33	12	7	12	0	0	0	0	0	0	15.9
Serial Methanol											
Rinsate	100	00	60	35	7	12	0	0	0	0	8.4
Fraction 25	7	12	100	0	93	12	93	12	100	0	<1
Fraction 50	73	31	93	12	100	0	93	12	94	10	<1
Fraction 75	100	0	100	0	93	12	100	0	60	53	<1
Fraction 80	93	12	87	12	100	0	100	0	93	12	<1
Fraction 85	100	0	100	0	53	23	0	0	0	0	4.1
Fraction 90	100	0	73	46	100	0	93	12	100	0	<1
Fraction 95	87	12	93	12	93	12	93	12	47	12	<1
Fraction 100	87	12	100	0	100	0	93	12	40	35	1.1

SD = Standard Deviation

Table 3.4. Survival of amphipods (*Hyalella azteca*) in interstitial waters spiked with bifenthrin and subjected to solid-phase extraction using HLB SPE column. Experiment #2 = bifenthrin spiked at 50 ng/L.

Results show amphipod survival after 10d in 4 different interstitial water concentrations: 10, 25, 50, and 100% IW.

	Percent Sample										
	0		10		25		50		100		Toxic
Treatment	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Units
Baseline	74	13	47	23	20	20	0	0	0	0	7.4
Methanol											
Rinsate	87	12	0	0	62	4	13	23	0	0	3.0
Eluate	80	20	47	23	20	20	7	12	0	0	7.9
Serial Methanol											
Rinsate	87	12	67	12	67	12	13	23	0	0	2.9
Fraction 25	80	0	87	12	100	0	0	0	80	0	<1
Fraction 50	80	0	80	20	93	12	67	12	100	0	<1
Fraction 75	80	20	73	31	81	2	93	12	73	31	<1
Fraction 80	60	20	80	20	60	20	0	0	60	20	2.2
Fraction 85	80	20	81	2	34	44	60	20	47	31	<1
Fraction 90	81	2	87	23	74	13	47	42	67	12	<1
Fraction 95	93	12	73	12	47	23	40	0	0	0	3.5
Fraction 100	87	12	20	20	67	12	7	12	0	0	3.1

SD = Standard Deviation

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Table 3.5. Survival of amphipods (*Hyalella azteca*) in interstitial waters spiked with permethrin and subjected to solid-phase extraction using HLB SPE column. Permethrin experiment #1 = permethrin spiked at 200 ng/L.

Results show amphipod survival after 7d in 4 different interstitial water concentrations: 10, 25, 50, and 100% IW.

7 Day Treatment	Percent Sample										Toxic Units
	0		10		25		50		100		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Baseline	93	12	100	0	87	12	27	12	0	0	2.5
Methanol											
Rinsate	87	12	93	12	100	0	0	0	33	12	1.4
Eluate	87	12	93	12	87	12	88	11	40	0	1.1
Acetone											
Rinsate	100	0	67	12	67	12	93	12	60	20	<1
Eluate	94	10	71	34	80	0	33	23	7	12	2.5
Serial Methanol											
Rinsate	87	12	100	0	87	12	80	20	60	20	<1
Fraction 25	87	12	100	0	100	0	100	0	93	12	<1
Fraction 50	87	12	93	12	60	40	80	20	93	12	<1
Fraction 75	87	12	100	0	100	0	100	0	93	12	<1
Fraction 80	93	12	87	12	80	0	100	0	87	12	<1
Fraction 85	87	12	94	10	93	12	93	12	87	12	<1
Fraction 90	87	23	94	10	100	0	93	12	93	12	<1
Fraction 95	80	20	100	0	94	10	100	0	93	12	<1
Fraction 100	100	0	87	12	87	12	20	20	0	0	2.7

SD = Standard Deviation

A011579

Table 3.6. Survival of amphipods (*Hyalella azteca*) in interstitial waters spiked with permethrin and subjected to solid-phase extraction using HLB SPE column. Permethrin experiment #2 = permethrin spiked at 200 ng/L.

Results show amphipod survival after 7d in 4 different interstitial water concentrations: 10, 25, 50, and 100% IW.

7 Day Treatment	Percent Sample										Toxic Units
	0		10		25		50		100		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Baseline	100	0	93	12	87	23	33	23	12	11	2.3
Methanol											
Rinsate	100	0	100	0	60	20	100	0	60	0	<1
Eluate	100	0	93	12	93	12	100	0	67	31	<1
Serial Methanol											
Rinsate	93	12	93	12	93	12	94	10	87	12	<1
Fraction 25	100	0	100	0	100	0	100	0	93	12	<1
Fraction 50	93	12	100	0	93	12	80	20	100	0	<1
Fraction 75	93	12	93	12	100	0	13	23	87	12	<1
Fraction 80	87	12	100	0	93	12	93	12	93	12	<1
Fraction 85	100	0	100	0	100	0	93	13	100	0	<1
Fraction 90	100	0	100	0	67	31	93	12	100	0	<1
Fraction 95	93	12	100	0	100	0	0	0	87	12	<1
Fraction 100	93	12	80	35	87	23	73	12	7	12	1.6

SD = Standard Deviation

A011580

Table 3.7. Survival of amphipods (*Hyalella azteca*) in interstitial waters spiked with a mixture of bifenthrin and permethrin and subjected to solid-phase extraction using HLB SPE column. Mixture experiment #1 = bifenthrin spiked at 50 ng/L and permethrin spiked at 200 ng/L.

Results show amphipod survival after 7d in 4 different interstitial water concentrations: 10, 25, 50, and 100% IW.

7 Day Treatment	Percent Sample 0 Mean	SD	10 Mean	SD	25 Mean	SD	50 Mean	SD	100 Mean	SD	Toxic Units
Baseline	100	00	87	12	20	35	00	00	00	00	6.1
Methanol											
Rinsate	100	00	93	12	73	31	07	12	00	00	3.5
Eluate	100	00	100	00	81	02	60	00	00	00	2.2
Acetone											
Rinsate	93	12	73	46	73	12	33	12	00	00	2.5
Eluate	87	12	87	23	67	31	33	31	00	00	2.6
Serial Methanol											
Rinsate	100	00	93	12	73	12	47	12	00	00	2.5
Fraction 25	87	23	100	00	93	12	100	00	100	00	<1
Fraction 50	100	00	100	00	87	12	93	12	80	20	<1
Fraction 75	93	12	87	23	93	12	87	12	40	20	1.1
Fraction 80	100	00	100	00	87	12	93	12	60	20	<1
Fraction 85	100	00	93	12	93	12	73	12	20	20	1.5
Fraction 90	100	00	100	00	93	12	73	12	27	12	1.4
Fraction 95	100	00	100	00	100	00	73	12	27	23	1.4
Fraction 100	100	00	33	23	00	00	00	00	00	00	13.3

SD = Standard Deviation

A011581

Table 3.8. Survival of amphipods (*Hyalella azteca*) in interstitial waters spiked with a mixture of bifenthrin and permethrin and subjected to solid-phase extraction using HLB SPE column. Mixture experiment #2 = bifenthrin spiked at 50 ng/L and permethrin spiked at 200 ng/L.

Results show amphipod survival after 10d in 4 different interstitial water concentrations: 10, 25, 50, and 100% IW.

	Percent Sample										
	0		10		25		50		100		
10 Day Treatment	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Toxic Units
Baseline	100	00	100	00	00	00	00	00	00	00	6.3
Methanol											
Rinsate	80	00	100	00	30	26	00	00	00	00	4.8
Eluate	87	23	93	12	93	12	93	12	47	12	<1
Serial Methanol											
Rinsate	100	00	87	12	20	00	00	00	00	00	6.0
Fraction 25	93	12	100	00	93	12	93	12	47	31	1.0
Fraction 50	88	11	93	12	100	00	100	00	100	00	<1
Fraction 75	80	20	53	31	53	46	93	12	100	00	<1
Fraction 80	27	31	27	31	87	12	80	35	94	10	<1
Fraction 85	100	00	100	00	93	12	60	40	00	00	2.0
Fraction 90	87	12	100	00	93	12	100	00	93	12	<1
Fraction 95	100	00	87	12	100	00	87	23	100	00	<1
Fraction 100	67	23	87	23	53	12	62	04	47	12	<1

SD = Standard Deviation

Table 3.9. Survival of amphipods (*Hyalella azteca*) in interstitial waters spiked with a mixture of bifenthrin and permethrin and subjected to solid-phase extraction using HLB SPE column. Permethrin-Chlorpyrifos mixture experiment #1 = permethrin spiked at 200 ng/L and chlorpyrifos spiked at 400 ng/L.

Results show amphipod survival after 10d in 4 different interstitial water concentrations: 10, 25, 50, and 100% IW.

	Percent Sample											
	0		10		25		50		100		Toxic	Chlorpyrifos
10 Day	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Units	ng/L
Baseline	80	20	93	12	67	31	00	00	00	00	3.4	451
Methanol												
Rinsate	93	12	93	12	87	23	60	20	00	00	1.9	ND
Eluate	93	12	80	00	94	10	73	12	73	12	<1	141
Serial Methanol												
Rinsate	93	12	89	19	60	20	47	12	00	00	2.7	ND
Fraction 25	80	20	93	12	100	00	93	12	87	12	<1	ND
Fraction 50	80	20	80	20	80	00	87	12	60	40	<1	ND
Fraction 75	87	12	87	12	100	00	93	12	82	17	<1	ND
Fraction 80	80	20	80	00	100	00	93	12	82	17	<1	ND
Fraction 85	87	12	100	00	87	12	87	12	60	00	<1	ND
Fraction 90	93	12	93	12	89	19	80	00	61	22	<1	ND
Fraction 95	67	23	100	00	93	12	93	12	73	12	<1	178
Fraction 100	93	12	93	12	87	23	47	42	40	35	1.7	ND

SD = Standard Deviation

A011582

Table 3.10. Mean (± SD) survival of amphipods (*Hyalella azteca*) in interstitial water spiked with bifenthrin or permethrin and subjected to solid-phase extraction with either 200 mg or 1000mg HLB SPE columns.

Treatment	Percent Sample										Toxic Units
	0		10		25		50		100		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Bifenthrin											
Baseline	73	23	13	23	6	10	0	0	0	0	16.4
200 Rinsate	80	20	73	12	10	35	0	0	0	0	5.5
200 Eluate	87	23	80	35	0	0	0	0	0	0	6.5
1000 Rinsate	87	12	73	12	62	4	6	10	0	0	3.4
1000 Eluate	93	12	87	23	80	20	27	12	0	0	2.6
Permethrin											
Baseline	87	12	94	10	93	12	67	31	20	0	1.5
200 Rinsate	88	11	93	12	87	12	100	0	93	12	<1
200 Eluate	93	12	87	12	87	12	93	12	73	23	<1
1000 Rinsate	87	12	100	0	93	12	87	12	64	34	<1
1000 Eluate	93	12	93	12	100	0	67	31	80	20	<1

Table 3.11. Toxic Unit calculations from single pyrethroid, pyrethroid mixtures, and pyrethroid-organophosphate pesticide mixture experiments.

See text for details (Results section).

Test	Bifenthrin 1	Bifenthrin 2	Permethrin 1	Permethrin 2	Bifenthrin-Permethrin 1	Bifenthrin-Permethrin 1	Permethrin-Chlorpyrifos 1
Spike	100 ng/L	50 ng/L	200 ng/L	200 ng/L	50 & 200 ng/L	50 & 200 ng/L	200 & 400 ng/L
Baseline	13.5	7.4	2.5	2.3	6.1	6.3	3.4
Methanol							
Rinsate	6.3	3.0	1.4	<1	3.5	4.8	1.9
Eluate	20	7.9	1.1	<1	2.2	<1	<1
Acetone							
Rinsate	5.3		<1		2.5		
Eluate	15.9		2.5		2.6		
Serial Methanol							
Rinsate	8.4	2.9	<1	<1	2.5	6.0	2.7
Fraction 25	<1	<1	<1	<1	<1	1.0	<1
Fraction 50	<1	<1	<1	<1	<1	<1	<1
Fraction 75	<1	<1	<1	<1	1.1	<1	<1
Fraction 80	<1	2.2	<1	<1	<1	<1	<1
Fraction 85	4.1	<1	<1	<1	1.5	2.0	<1
Fraction 90	<1	<1	<1	<1	1.4	<1	<1
Fraction 95	<1	3.5	<1	<1	1.4	<1	<1
Fraction 100	1.1	3.1	2.7	1.6	13.3	<1	1.7

A011583

Table 3.12. Nominal and measured concentrations of bifenthrin, chlorpyrifos, and permethrin in TIE experiments.

All concentrations are in ng/L. ND = not detected; NA = not analyzed.

	Bifenthrin Spike	Bifenthrin Measured	Chlorpyrifos Spike	Chlorpyrifos Measured	Permethrin Spike	Permethrin Measured	Survival (%)
BIF 2 - Baseline	50	ND					0
BIF 2 - Rinsate	50	ND					0
BIF 2 - Eluate	50	32					0
PER 2 - Baseline					200	ND	12
PER 2 - Rinsate					200	ND	53
PER 2 - Fraction 100					200	ND	0
BIF/PER 2 - Baseline	50	32			200	ND	0
BIF/PER 2 - Rinsate	50	30			200	ND	0
BIF/PER 2 - Fraction 85	50	ND			200	ND	0
BIF/PER 2 - Fraction 100	50	ND			200	ND	47
CHL/PER 1 - Baseline			400	451	200	ND	0
CHL/PER 1 - Rinsate			400	ND	200	ND	0
CHL/PER 1 - Fraction 95			400	178	200	NA	73
CHL/PER 1 - Fraction 100			400	ND	200	ND	40

A011584

A011585

APPENDIX A. FIELD SAMPLING EVENT PHOTOS (SEE CHAPTER 1)

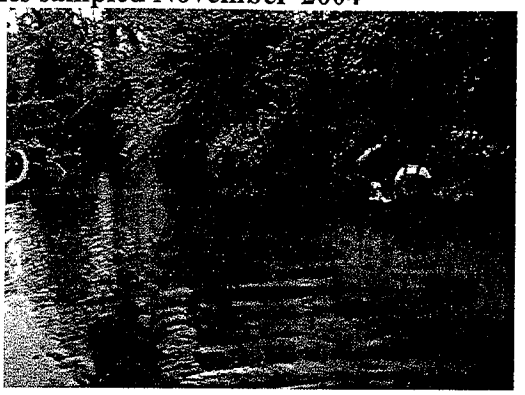
A011586

Sample Event Photos from Ambient Sediment Sampling (RMP Episodic Toxicity / PRISM Grant)

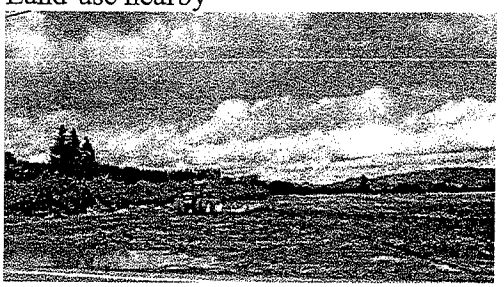
Six tributaries in the local watersheds of the San Francisco Estuary were sampled. Two stations were sampled in each tributary (an Upper-freshwater and Lower-tidal station) for two sampling events November-2004 and April-2005.

Figure A1. North San Francisco Bay tributaries sampled November-2004

Suisun Creek Upper: (freshwater)
Rockville Rd and Willotta Dr.,
Suisun City, CA
Sampled the quieter, upstream portion of the Creek 11/3/04.

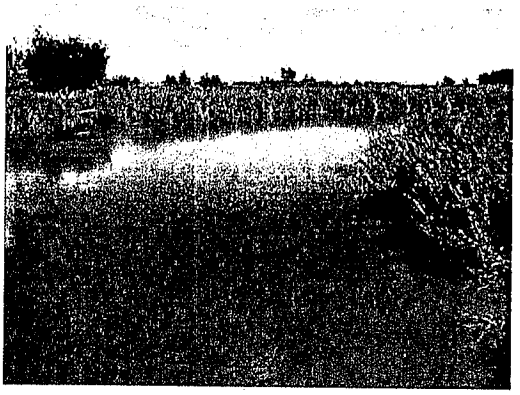


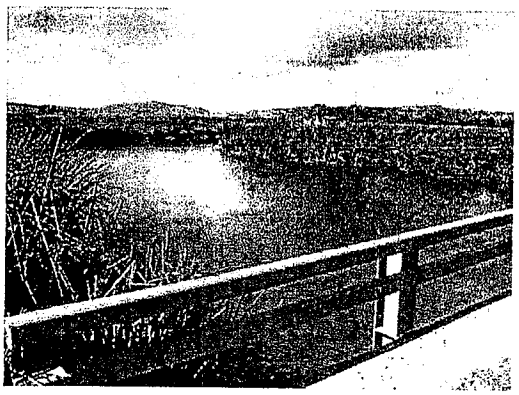
Land-use nearby



A011587

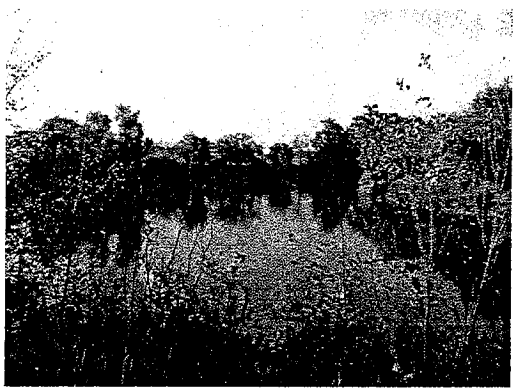
Suisun Creek Lower: (tidal)
Chadbourne Rd. past Jacksnipe Rd.,
Suisun City, CA
Sampled the downstream side of the
overpass 11/3/04.

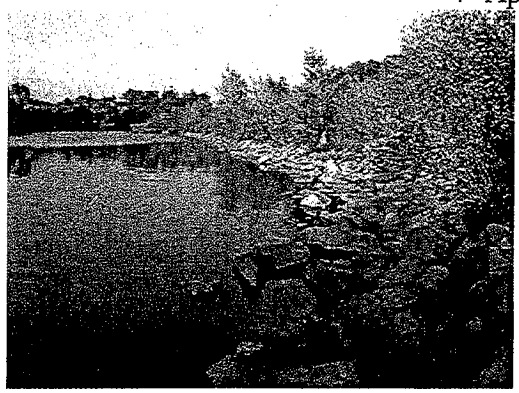




A011588

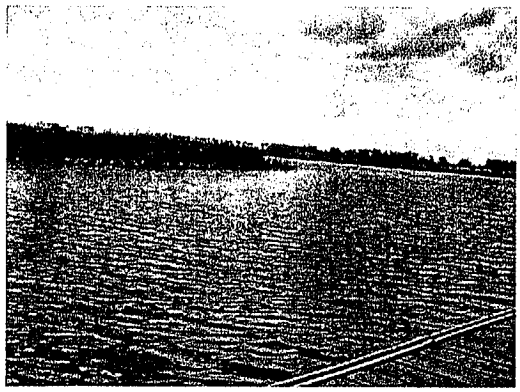
Napa River Upper: (freshwater)
1st Street at Copia, Napa, CA
Sampled River below the Northwest corner of parking lot 11/2/04.

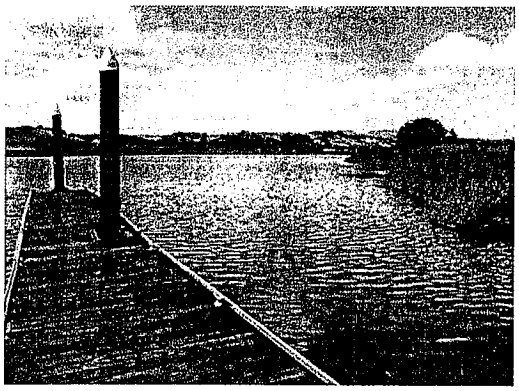




A011589

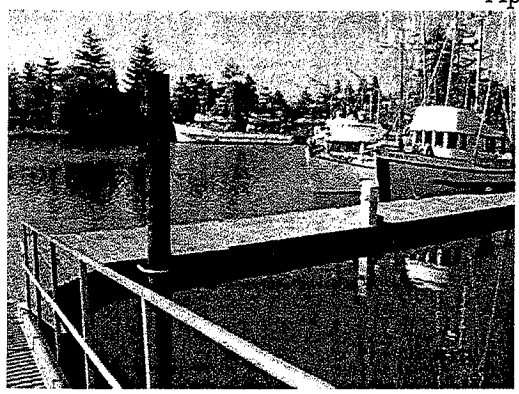
Napa River Lower: (tidal)
John F. Kennedy Park downstream of town, Napa, CA
Sampled off of wharf using the Eckman grab 11/2/04.

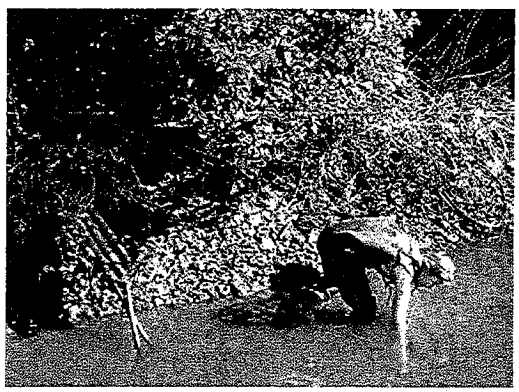




A011590

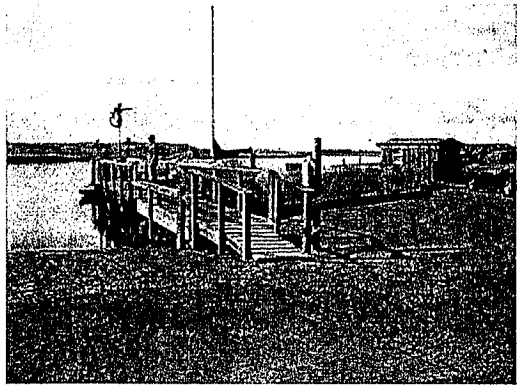
Petaluma River Upper: (freshwater/tidal)
East Washington St. & Weller, Petaluma, CA
Sampled near bank off of wharf 11/2/04.
(Salinity was ~ 15psu)

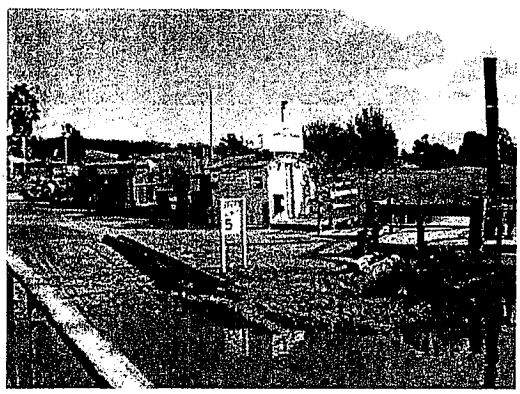




A011591

Petaluma River Lower: (tidal)
Gilardi's Lakeville Marina, Lakeville, CA
Sampled to the side of the launch ramp
11/2/04.

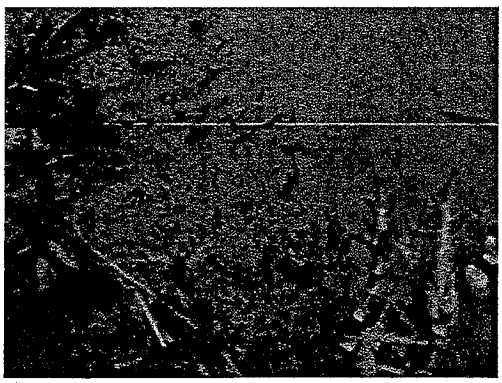




A011592

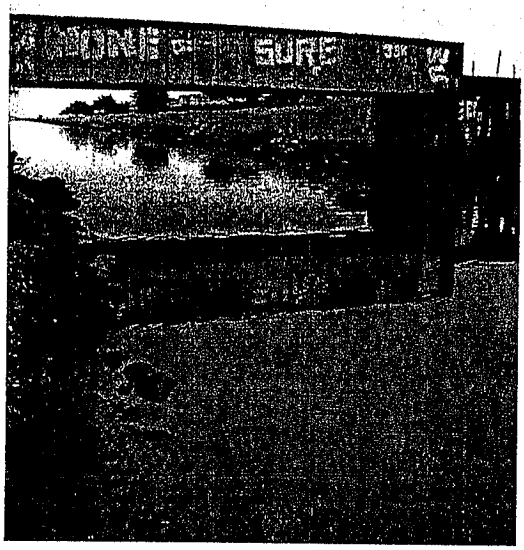
Figure A2. South San Francisco Bay tributaries sampled November-2004

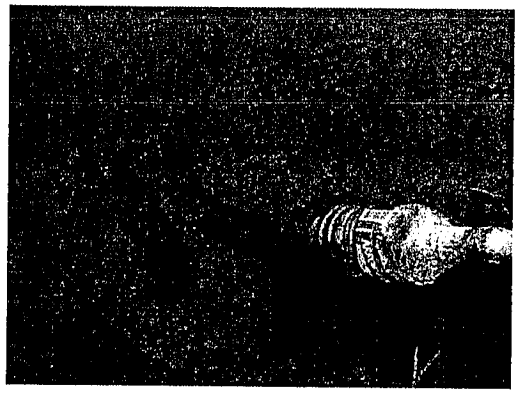
San Lorenzo Creek Upper: (freshwater)
Via Bregani and Madeline, San Lorenzo, CA.
Sampled 11/3/04.



A011593

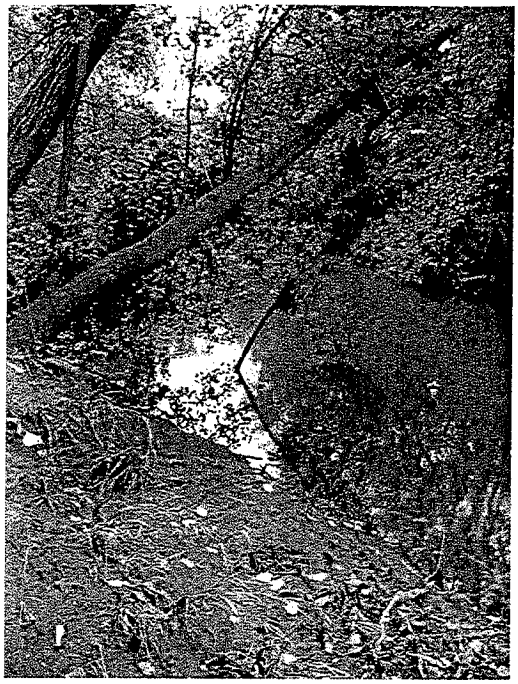
San Lorenzo Creek Lower: (tidal)
Via Murieta and Via Sorrento, San Lorenzo, CA.
Sampled 11/3/04.

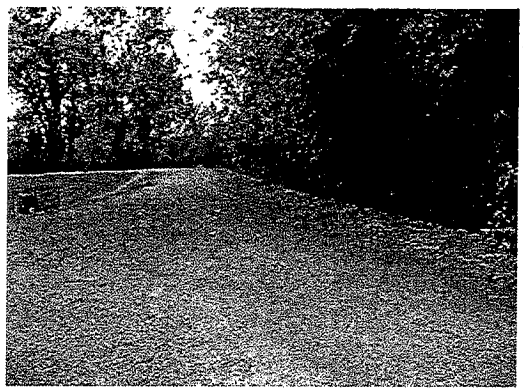




A011594

Coyote Creek Upper: (freshwater)
Murphy Ranch Rd. and Technology Dr., Milpitas, CA.
Sampled 11/3/04. USGS gauge is a few 100 meters downstream.

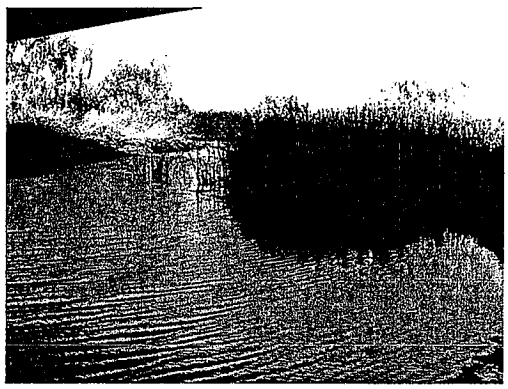




A011595

Coyote Creek Lower: (tidal)
RMP station BW10, N. McCarthy Blvd./
just over the overpass heading south from
Dixon Landing Rd., Milpitas, CA
Sampled 11/1/04.

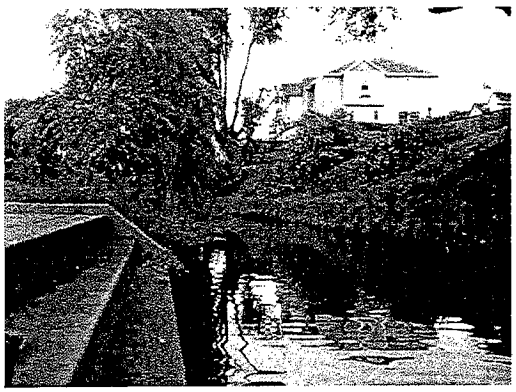
note: Paul Salop says the vegetation along the bank has changed drastically since the Estuary Interface Pilot Study. We had to sample under the bridge to get access to the sediment along the bank.

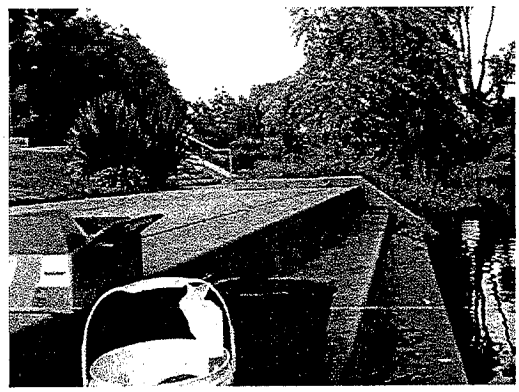


A011596

San Mateo Creek Upper: (freshwater)
in Gateway Park, 3rd Ave, San Mateo, CA.
Sampled 11/4/04.

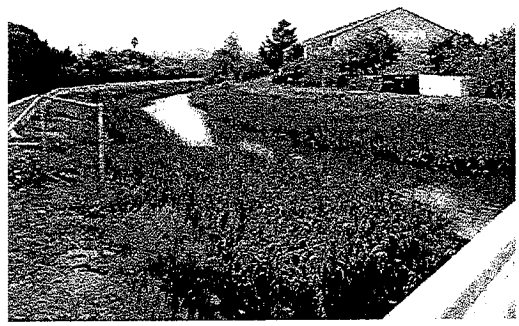
This is also a SWAMP station.
Sampled mud off the step since sediments in the creek were sand/gravel. A city maintenance worker told us that the creek had recently risen above the steps.





San Mateo Creek Lower: (tidal)
3rd Ave. and J. Hart Clinton Drive, San Mateo, CA
Sampled 11/4/04.

Sampled under the overpass on the upstream side of the road.

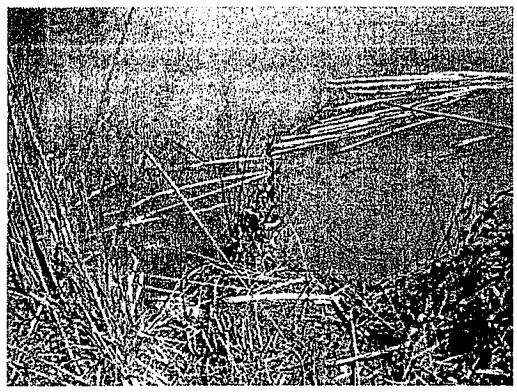


A011597

Figure A3. North San Francisco Bay tributaries sampled April-2005

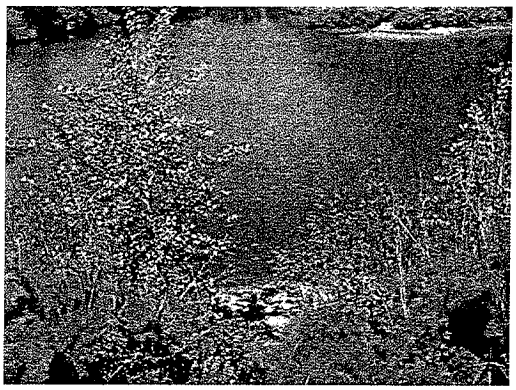
Suisun Creek Upper: (freshwater)
Rockville Rd and Willotta Dr.,
Suisun City, CA
Sampled the quieter, upstream portion of the Creek.

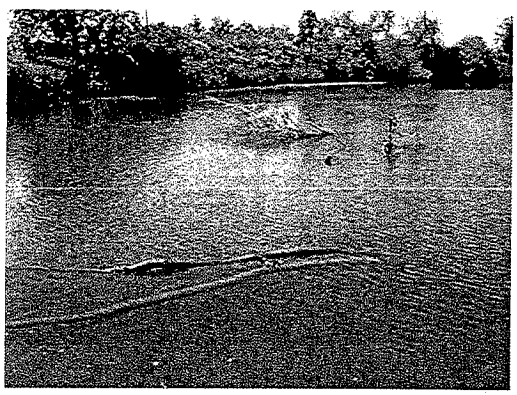
Suisun Creek Lower: (tidal)
Chadbourne Rd. past Jacksnipe Rd.
Sampled the downstream side of the overpass.



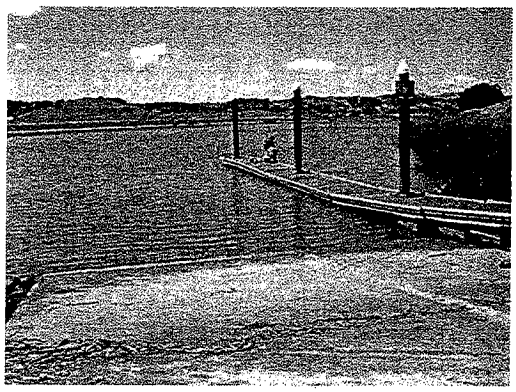
A011598

Napa River Upper: (freshwater)
1st Street at Copia. Sampled River below the Northwest corner of parking lot.



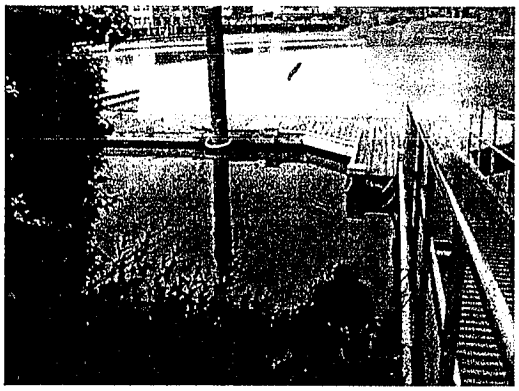


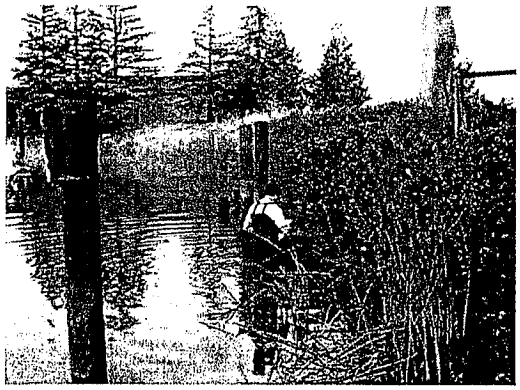
Napa River Lower: (tidal)
John F. Kennedy Park downstream of town. Sampled off of wharf.



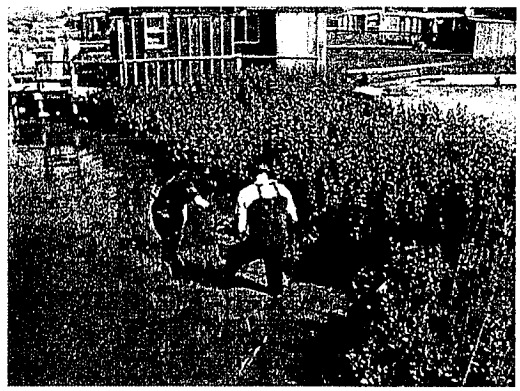
A011599

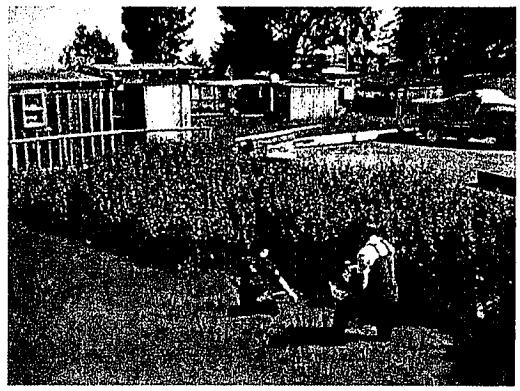
Petaluma River Upper: (fresh/tidal)
East Washington St. & Weller





Petaluma River Lower: (tidal)
Gilardi's Lakeville Marina

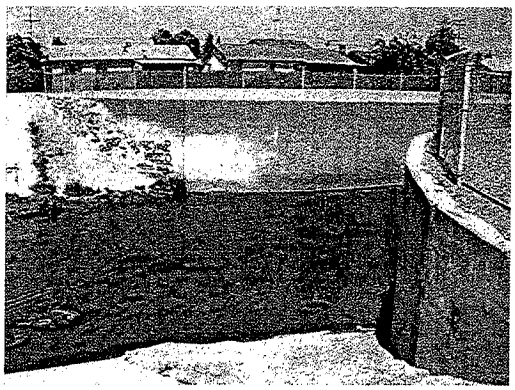




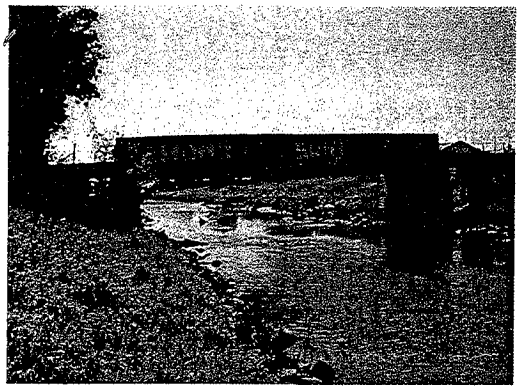
AR11600

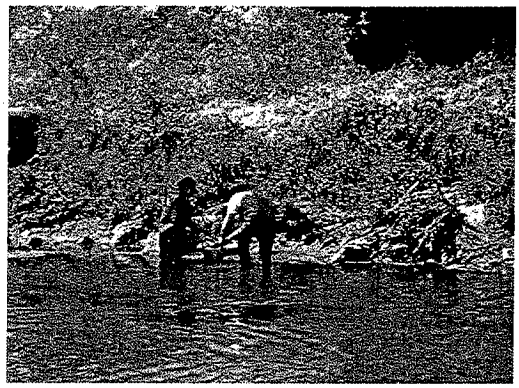
Figure A4. South San Francisco Bay tributaries sampled April-2005

San Lorenzo Creek Upper: (fresh)
(Via Bregani / Madeline)



San Lorenzo Creek Lower: (tidal)
(Via Murieta / Via Sorrento)





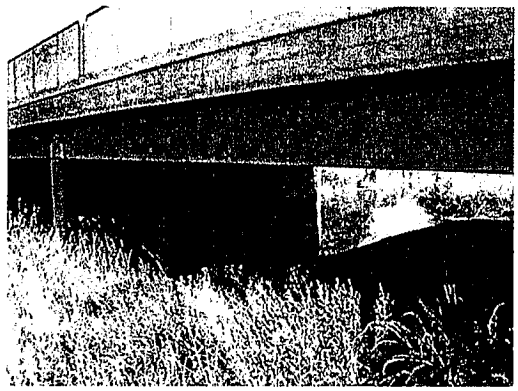
A011601

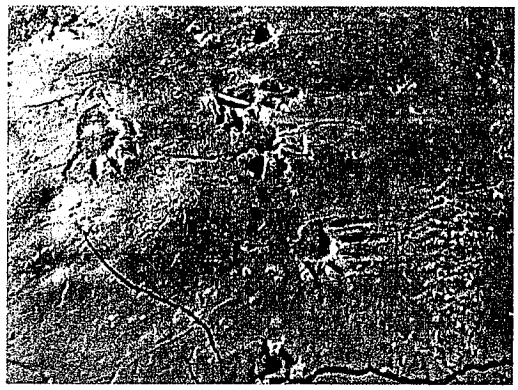
Coyote Creek Upper: (freshwater)
(Murphy Ranch Rd./ Technology Dr. Milpitas, CA)

Sampled several locations along creek bank.

Coyote Creek Lower: (tidal)
(RMP station BW10, N. McCarthy Blvd./ just over the overpass heading south from Dixon Landing Rd., Milpitas, CA)

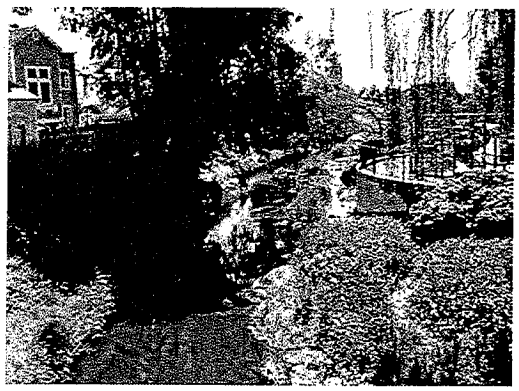
Sampled under the overpass





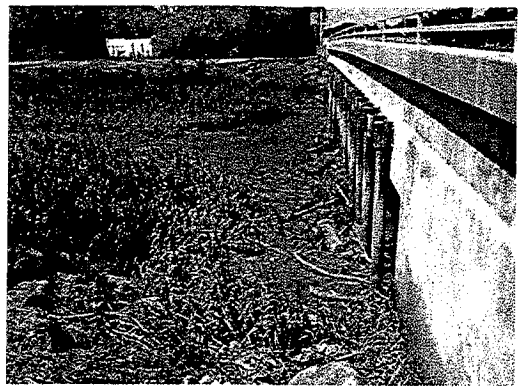
A011602

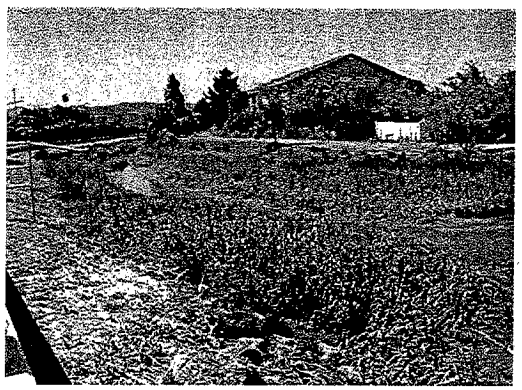
San Mateo Creek Upper: (freshwater)
(Gateway Park, 3rd Ave)



San Mateo Creek Lower: (tidal)
(3rd Ave. and J Hart Clinton Drive)

Sampled submerged sediments right next to the creek overpass.





A011603

APPENDIX B. FIELD SAMPLE SEDIMENT CHEMISTRY - QA REVIEW (SEE CHAPTER 1)

A011604

PRISM 2004-2005 Sediment Chemistry - QA Review

Data quality was evaluated by reviewing laboratory data submissions against the data quality objectives outlined by the project's QAPP. Five QA/QC elements were evaluated: Completeness, Sensitivity, Blank contamination, Accuracy, and Precision. These elements were evaluated for all QA samples provided by each laboratory for each sampling event (November – 2004 or April – 2005), except for the Blank contamination review, which was evaluated for each reported laboratory batch. This project's Data Quality Objectives (DQOs) follow the PRISM QAPP guidelines and are at least as conservative as SWAMP's DQOs. All data that were qualified with a QACode that contained "VRxxx" were considered to be outside acceptable QA standards and were dropped from any subsequent data analysis.

Sensitivity (Method Detection Limits)

Sensitivity evaluates if the analytical methods used were sensitive enough to measure targeted contaminants at levels found in the environment sampled. Analytical sensitivity was evaluated for each parameter group (RGROUP) by calculating the average percentage of field samples (and lab replicates) that were reported to be below the method detection limits (results that were qualified as non-detect (ND)).

The average percentage of samples with non-detect results for each sampling event are listed below and show that method sensitivity was similar between events, or improved in the later event. Avg of xMDL =Average(Result/MDL) and provides a sense of how much higher the field sample results were than the detection limit for each parameter group.

Parameter groups that had more than 70 percent of the results reported as non-detects include PBDEs, HCHs, Cyclopentadienes, 04OTHER (Endosulfans), 05OTHER (Diazinon, Chlorpyrifos, Hexachlorobenzene, and Mirex), and Pyrethroids.

Paramter Group	Type	RGROUP	Cruise Number	Number Of Analytes in RGROUP	Avg percent of samples reporting ND results	Avg Of xMDL[2] all analytes in RGROUP
ORG	PAH	1LPAH	2004-11	16	23.21	12.61
ORG	PAH	1LPAH	2005-04	16	26.28	6.88
ORG	PAH	2HPAH	2004-11	13	12.50	81.38
ORG	PAH	2HPAH	2005-04	13	7.69	52.27
ORG	PBDE	PBDE	2004-11	12	82.29	0.47
ORG	PBDE	PBDE	2005-04	12	78.85	0.73
ORG	PCB	PCB	2004-11	51	63.72	1.67
ORG	PCB	PCB	2005-04	51	62.69	1.73
ORG	PEST	1DDT	2004-11	6	62.50	2.99
ORG	PEST	1DDT	2005-04	6	66.15	1.76
ORG	PEST	2CHLR	2004-11	7	53.57	2.29
ORG	PEST	2CHLR	2005-04	7	62.64	1.45
ORG	PEST	3HCH	2004-11	4	100.00	0.00
ORG	PEST	3HCH	2005-04	4	100.00	0.00
ORG	PEST	4CYCPENT	2004-11	3	75.00	0.81
ORG	PEST	4CYCPENT	2005-04	3	84.62	0.29
ORG	PEST	4Other	2004-11	3	100.00	0.00
ORG	PEST	4Other	2005-04	3	100.00	0.00

[2] Avg Of xMDL = average of (field sample result/MDL value for each analyte reported for all samples within a targeted RGROUP). This indicates, on average, how many times greater the field sample results were than the reported method detection limits for a given parameter group.

A011605

Paramter Group	Type	RGROUP	Cruise Number	Number Of Analytes in RGROUP	Avg percent of samples reporting ND results	Avg Of xMDL[2] all analytes in RGROUP
ORG	PEST	5Other	2004-11	8	71.88	0.89
ORG	PEST	5Other	2005-04	7	91.12	0.54
ORG	PEST	6PYRETH	2004-11	15	91.96	0.45
ORG	PEST	6PYRETH	2005-04	15	97.44	0.05
ORG1	PAH ALKYLATED		2004-11	18	12.50	33.48
ORG1	PAH ALKYLATED		2005-04	18	10.77	17.55
TE	TE	TE	2004-11	14	0	na
TE	TE	TE	2005-04	13	6.25	na

Blank Contamination (laboratory blank evaluation)

Blank contamination (BC) review was performed on laboratory blanks within each laboratory batch. If the field sample results were not blank corrected then the average Blank results were evaluated against the average reported Blank MDLs. If the field sample results were Blank corrected (average Blank concentration subtracted from the field sample result) then the average standard deviation of the blanks were evaluated against the average reported Blank MDLs.

Results indicated that the following laboratory batches exhibited some contamination in the Blank samples. Field samples (FS), and associated QA samples (with the exception of blank samples), were qualified with the following blank contamination qualifiers: VIP (if Result>AveBlank) or VRIP (if Result>3*AveBlank).

TYPE	RGROUP	Analyte	Lab Batch	Cruise Number	NumOf SFEI result	Were FS Blank Corrected?
ORG	2HPAH	Benzo(ghi)perylene	WPCL_L-211-05_S_PAH	2005-04	13	No
ORG	PCB	Aroclor 1260	WPCL_L-211-05_BS375_KR_S_PCB	2005-04	12	No
ORG	PCB	PCB 018	WPCL_L-211-05_BS375_KR_S_PCB	2005-04	12	No
ORG	PCB	PCB 028	WPCL_L-192-05_BS373_KR_S_PCB	2005-04	3	No
ORG	PCB	PCB 028	WPCL_L-211-05_BS375_KR_S_PCB	2005-04	12	No
ORG	PCB	PCB 031	WPCL_L-211-05_BS375_KR_S_PCB	2005-04	12	No
ORG	PCB	PCB 033	WPCL_L-192-05_BS373_KR_S_PCB	2005-04	3	No
ORG	PCB	PCB 044	WPCL_L-211-05_BS375_KR_S_PCB	2005-04	12	No
ORG	PCB	PCB 052	WPCL_L-192-05_BS373_KR_S_PCB	2005-04	3	No
ORG	PCB	PCB 052	WPCL_L-211-05_BS375_KR_S_PCB	2005-04	12	No
ORG	PCB	PCB 066	WPCL_L-192-05_BS373_KR_S_PCB	2005-04	3	No
ORG	PCB	PCB 066	WPCL_L-211-05_BS375_KR_S_PCB	2005-04	12	No
ORG	PCB	PCB 070	WPCL_L-211-05_BS375_KR_S_PCB	2005-04	12	No
ORG	PCB	PCB 095	WPCL_L-192-05_BS373_KR_S_PCB	2005-04	3	No
ORG	PCB	PCB 095	WPCL_L-211-05_BS375_KR_S_PCB	2005-04	12	No
ORG	PCB	PCB 101	WPCL_L-192-05_BS373_KR_S_PCB	2005-04	3	No
ORG	PCB	PCB 101	WPCL_L-211-05_BS375_KR_S_PCB	2005-04	12	No
ORG	PCB	PCB 110	WPCL_L-192-05_BS373_KR_S_PCB	2005-04	3	No
ORG	PCB	PCB 110	WPCL_L-211-05_BS375_KR_S_PCB	2005-04	12	No
ORG	PCB	PCB 118	WPCL_L-192-05_BS373_KR_S_PCB	2005-04	3	No
ORG	PCB	PCB 118	WPCL_L-211-05_BS375_KR_S_PCB	2005-04	12	No
ORG	PCB	PCB 138	WPCL_L-192-05_BS373_KR_S_PCB	2005-04	3	No
ORG	PCB	PCB 138	WPCL_L-211-05_BS375_KR_S_PCB	2005-04	12	No
TE	TE	Cu	05-0278	2005-04	8	Yes
TE	TE	Mn	05-0278	2005-04	8	Yes

A011606

Accuracy Review

Accuracy was evaluated based on reported Certified Reference Material (CRM) results or Matrix Spike (MS) results. Average percent error from certified (or spiked) target values were evaluated for several different Sample Types (CRM, LCM-Lab Control Material, LCS-Lab Control Spike, and MS) and average percent error for all Sample Types Avg % Error are reported here. Final QA Codes were assigned based preferentially on % Error of the CRM and MS samples. % error from other sample types reported here are informational only.

DQOs for organics are VRIU if Avg%Error > 70, VIU if Avg%Error > 35; for trace elements VRIU if Avg%Error > 50, VIU if Avg%Error > 25

CRUISE	RGROUP	Analyte	CRM	LCM	LCS	MS	Avg % Error	Final QA Code
2004-11	1DDT	o,p'-DDT			10	18.5	14.3	
2004-11	1DDT	p,p'-DDT	85.7		7.5	30.4		VRIU
2004-11	1LPAH	1-Methylfluorene			29	49.6	39.3	VIU
2004-11	1LPAH	2,3,5-Trimethylnaphthalene			26	96.1	61.1	VIU
2004-11	1LPAH	2,6-Dimethylnaphthalene			0	10.3	5.14	
2004-11	1LPAH	3,6-Dimethylphenanthrene			6	18.5	12.2	
2004-11	1LPAH	4-Methyldibenzothiophene			2	1.89	1.95	
2004-11	1LPAH	Acenaphthylene			7	9.37	8.18	
2004-11	2CHLR	alpha-Chlordane	79.3		6	5.1		VRIU
2004-11	2CHLR	cis-Nonachlor	48.9		5.6	5.46		VIU
2004-11	2CHLR	gamma-Chlordane	253		0.9	2.89		VRIU
2004-11	2CHLR	Heptachlor			52.6	47.4	50	VIU
2004-11	2CHLR	Heptachlor Epoxide			30.6	33.4	32	
2004-11	2CHLR	Oxychlordane			1	6.58	3.79	
2004-11	2CHLR	trans-Nonachlor	52.4		1	1.05		VIU
2004-11	2HPAH	2-Methylfluoranthene			5	7.33	6.17	
2004-11	2HPAH	Dibenz(a,h)anthracene			7	15.9	11.4	
2004-11	3HCH	alpha-HCH			3	2.41	2.71	
2004-11	3HCH	beta-HCH			1	2.8	1.9	
2004-11	3HCH	gamma-HCH			13.2	8.06	10.6	
2004-11	4CYCPENT	Aldrin			4.2	1.38	2.79	
2004-11	4CYCPENT	Dieldrin			15.2	30.9	23.1	
2004-11	4CYCPENT	Endrin			36	52.4	44.2	VIU
2004-11	4Other	Endosulfan I			1.5	4.18	2.84	
2004-11	4Other	Endosulfan II			4.5	3.68	4.09	
2004-11	4Other	Endosulfan Sulfate			2.5	2.23	2.36	
2004-11	5Other	Chlorpyrifos			31	38.8	34.9	
2004-11	5Other	Chlorpyrifos		35				
2004-11	5Other	Diazinon			4.5	5.82	5.16	
2004-11	5Other	Diazinon		40.6				
2004-11	5Other	Mirex			8.33	10.6	9.46	

A011607

CRUISE	RGROUP	Analyte	CRM	LCM	LCS	MS	Avg % Error	Final QA Code
2004-11	5Other	Oxadiazon			18	9.65	13.8	
2004-11	6PYRETH	Bifenthrin			9	7	8	
2004-11	6PYRETH	Cyfluthrin (isomer-1)			15.2	9.4	12.3	
2004-11	6PYRETH	Cyfluthrin (isomer-2)			24.4	21.6	23	
2004-11	6PYRETH	Cyfluthrin (isomer-3)			25.2	26.8	26	
2004-11	6PYRETH	Cyfluthrin (isomer-4)			21.6	20.4	21	
2004-11	6PYRETH	Cypermethrin (isomer-1)			7.2	18.4	12.8	
2004-11	6PYRETH	Cypermethrin (isomer-2)			8	10	9	
2004-11	6PYRETH	Cypermethrin (isomer-3)			8	15	11.5	
2004-11	6PYRETH	Cypermethrin (isomer-4)			12	10	11	
2004-11	6PYRETH	Esfenvalerate (isomer-1)			10	8	9	
2004-11	6PYRETH	Esfenvalerate (isomer-2)			10	15	12.5	
2004-11	6PYRETH	Lambda-cyhalothrin (isomer-1)			15	25	20	
2004-11	6PYRETH	Lambda-cyhalothrin (isomer-2)			28	1.5	14.8	
2004-11	6PYRETH	Permethrin (isomer-1)			20	8	14	
2004-11	6PYRETH	Permethrin (isomer-2)			20	18	19	
2004-11	PBDE	BDE 017			0.4	9.65	5.03	
2004-11	PBDE	BDE 028			4.2	14.8	9.52	
2004-11	PBDE	BDE 047			0.4	16	8.18	
2004-11	PBDE	BDE 066			7.2	17	12.1	
2004-11	PBDE	BDE 085			1	6.3	3.65	
2004-11	PBDE	BDE 099			0.8	10.5	5.64	
2004-11	PBDE	BDE 100			0.2	11.4	5.82	
2004-11	PBDE	BDE 138			2.8	2.88	2.84	
2004-11	PBDE	BDE 153			0.2	13	6.58	
2004-11	PBDE	BDE 154			3.6	9.28	6.44	
2004-11	PBDE	BDE 183			11.6	5.82	8.71	
2004-11	PBDE	BDE 190			3	7.51	5.25	
2004-11	PCB	PCB 008	85.8		17.6	8.73		VRIU
2004-11	PCB	PCB 027			8.8	8.61	8.7	
2004-11	PCB	PCB 029			15.8	11.1	13.5	
2004-11	PCB	PCB 033			1	2.95	1.97	
2004-11	PCB	PCB 056			11	12.7	11.9	
2004-11	PCB	PCB 060			15.2	18.6	16.9	
2004-11	PCB	PCB 070			5.2	14.3	9.73	
2004-11	PCB	PCB 074			25.2	7.46	16.3	
2004-11	PCB	PCB 097			0.2	8.3	4.25	
2004-11	PCB	PCB 110	64.6		450	268		VIU

A011608

CRUISE	RGROUP	Analyte	CRM	LCM	LCS	MS	Avg % Error	Final QA Code
2004-11	PCB	PCB 114			6.8	8.12	7.46	
2004-11	PCB	PCB 137			6.4	7.69	7.04	
2004-11	PCB	PCB 141			1.2	4.39	2.8	
2004-11	PCB	PCB 157			3.6	4.88	4.24	
2004-11	PCB	PCB 158			3.2	9.03	6.11	
2004-11	PCB	PCB 174			2.2	5.02	3.61	
2004-11	PCB	PCB 177			0.2	3.63	1.91	
2004-11	PCB	PCB 189			0.4	1.3	0.85	
2004-11	PCB	PCB 200			1.8	1.11	1.45	
2004-11	PCB	PCB 201			2.2	3.3	2.75	
2004-11	PCB	PCB 203			4.6	6.2	5.4	
2004-11	TE	Se	42.5			4.57		VIU
2004-11		C1-Dibenzothiophenes			3	2.52	2.76	
2004-11		C1-Fluoranthenes_Pyrenes			5	1.58	3.29	
2004-11		C1-Fluorenes			28	40.2	34.1	
2004-11		C1-Naphthalenes			4.5	165	85	VRIU
2004-11		C1-Phenanthrenes_Anthracenes			0	3.99	2	
2004-11		C2-Naphthalenes			1	31.5	16.2	
2004-11		C2-Phenanthrenes_Anthracenes			35	4.63	19.8	
2004-11		C3-Naphthalenes			25	77.2	51.1	VIU
2005-04	1DDT	o,p'-DDE	40.5		13.8	14.6		VIU
2005-04	1DDT	o,p'-DDT			14	16.5	15.2	
2005-04	1DDT	p,p'-DDT	71.4		6.5	38.9		VRIU
2005-04	1LPAH	1-Methylfluorene			32	25.7	28.8	
2005-04	1LPAH	2,3,5-Trimethylnaphthalene			33	33.3	33.2	
2005-04	1LPAH	2,6-Dimethylnaphthalene			7	9.02	8.01	
2005-04	1LPAH	3,6-Dimethylphenanthrene			18	32.4	25.2	
2005-04	1LPAH	4-Methyldibenzothiophene			10	11.7	10.9	
2005-04	1LPAH	Acenaphthene	51.8		5	8.16		VIU
2005-04	1LPAH	Acenaphthylene			10	3.82	6.91	
2005-04	1LPAH	Biphenyl	41.6		4	1.29		VIU
2005-04	1LPAH	Fluorene	49.5		20	10.2		VIU
2005-04	2CHLR	alpha-Chlordane	49.6		11.5	14		VIU
2005-04	2CHLR	gamma-Chlordane	195		8.5	6.56		VRIU
2005-04	2CHLR	Heptachlor			25.6	22.1	23.9	
2005-04	2CHLR	Heptachlor Epoxide			3	3.86	3.43	
2005-04	2CHLR	Oxychlordane			7	8.28	7.64	

A011609

CRUISE	RGROUP	Analyte	CRM	LCM	LCS	MS	Avg % Error	Final QA Code
2005-04	2HPAH	2-Methylfluoranthene			13	17.6	15.3	
2005-04	2HPAH	Dibenz(a,h)anthracene			39	40.3	39.7	VIU
2005-04	2HPAH	Perylene	38.8		2.3	11.3		VIU
2005-04	3HCH	alpha-HCH			11.5	15.9	13.7	
2005-04	3HCH	beta-HCH			8	13.3	10.6	
2005-04	3HCH	delta-HCH			89.4		89.4	VRIU
2005-04	3HCH	gamma-HCH			9.4	13	11.2	
2005-04	4CYCPENT	Aldrin			21	14.7	17.8	
2005-04	4CYCPENT	Dieldrin			12	28	20	
2005-04	4CYCPENT	Endrin			113	96.7	105	VRIU
2005-04	4Other	Endosulfan I			24.5	7.8	16.2	
2005-04	4Other	Endosulfan II			5.5	10.4	7.94	
2005-04	4Other	Endosulfan Sulfate			14.8	8.68	11.7	
2005-04	5Other	Chlorpyrifos			31.7	8.46	20.1	
2005-04	5Other	Chlorpyrifos		18				
2005-04	5Other	Diazinon			4.5	13.5	9.01	
2005-04	5Other	Diazinon		18				
2005-04	5Other	Mirex			3.67	5.75	4.71	
2005-04	5Other	Oxadiazon			24	13	18.5	
2005-04	6PYRETH	Bifenthrin			15.2	12.2	13.7	
2005-04	6PYRETH	Cyfluthrin (isomer-1)			3	20.3	11.6	
2005-04	6PYRETH	Cyfluthrin (isomer-2)			6.2	17.5	11.9	
2005-04	6PYRETH	Cyfluthrin (isomer-3)			3.8	17	10.4	
2005-04	6PYRETH	Cyfluthrin (isomer-4)			14.1	4.5	9.3	
2005-04	6PYRETH	Cypermethrin (isomer-1)			0.5	12	6.25	
2005-04	6PYRETH	Cypermethrin (isomer-2)			0	5.5	2.75	
2005-04	6PYRETH	Cypermethrin (isomer-3)			5.8	16.8	11.3	
2005-04	6PYRETH	Cypermethrin (isomer-4)			11.1	4	7.55	
2005-04	6PYRETH	Esfenvalerate (isomer-1)			5.5	4	4.75	
2005-04	6PYRETH	Esfenvalerate (isomer-2)			7	3	5	
2005-04	6PYRETH	Lambda-cyhalothrin (isomer-1)			3	19.5	11.3	
2005-04	6PYRETH	Lambda-cyhalothrin (isomer-2)			6	11.5	8.75	
2005-04	6PYRETH	Permethrin (isomer-1)			8.6	17.3	13	
2005-04	6PYRETH	Permethrin (isomer-2)			10.2	9.7	9.95	
2005-04	PBDE	BDE 017			3.2	21.2	12.2	
2005-04	PBDE	BDE 028			14.4	19.6	17	
2005-04	PBDE	BDE 047			1.4	82.1	41.8	VIU
2005-04	PBDE	BDE 066			2.2	18.1	10.1	
2005-04	PBDE	BDE 085			6.2	17.6	11.9	
2005-04	PBDE	BDE 099			2.2	106	54	VIU

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CRUISE	RGROUP	Analyte	CRM	LCM	LCS	MS	Avg % Error	Final QA Code
2005-04	PBDE	BDE 100			2.8	22	12.4	
2005-04	PBDE	BDE 138			7.4	15.7	11.5	
2005-04	PBDE	BDE 153			4.6	20	12.3	
2005-04	PBDE	BDE 154			3	17.9	10.4	
2005-04	PBDE	BDE 183			2.8	16.8	9.8	
2005-04	PBDE	BDE 190			16.8	19.3	18	
2005-04	PCB	PCB 008	55.9		25.6	20.5		VIU
2005-04	PCB	PCB 027			19.1	29.5	24.3	
2005-04	PCB	PCB 029			7.8	23	15.4	
2005-04	PCB	PCB 033			18	15.2	16.6	
2005-04	PCB	PCB 056			23.5	20.1	21.8	
2005-04	PCB	PCB 060			7.6	13.3	10.4	
2005-04	PCB	PCB 070			27.7	14.8	21.3	
2005-04	PCB	PCB 074			12.1	20.8	16.5	
2005-04	PCB	PCB 097			12.9	4.58	8.74	
2005-04	PCB	PCB 114			7.4	8.57	7.98	
2005-04	PCB	PCB 137			15.3	14.1	14.7	
2005-04	PCB	PCB 141			8.5	4.78	6.64	
2005-04	PCB	PCB 157			16.4	9.39	12.9	
2005-04	PCB	PCB 158			8.9	9.29	9.09	
2005-04	PCB	PCB 174			9.6	4.56	7.08	
2005-04	PCB	PCB 177			5.9	4.35	5.12	
2005-04	PCB	PCB 189			24.3	25.4	24.9	
2005-04	PCB	PCB 200			9.8	7.9	8.85	
2005-04	PCB	PCB 201			7.7	6.35	7.03	
2005-04	PCB	PCB 203			15.2	14.5	14.9	
2005-04	TE	Cd	70.6			22		VRIU
2005-04		C1-Dibenzothiophenes			10	10.1	10	
2005-04		C1-Fluoranthenes_Pyrenes			13	35.8	24.4	
2005-04		C1-Fluorenes			33	23.5	28.2	
2005-04		C1-Naphthalenes			13.5	12.9	13.2	
2005-04		C1-Phenanthrenes_Anthracenes			12	23.2	17.6	
2005-04		C2-Naphthalenes			17	17.9	17.5	
2005-04		C2-Phenanthrenes_Anthracenes			11	17.3	14.2	
2005-04		C3-Naphthalenes			38	56.2	47.1	VIU

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Precision Review

Evaluate Relative Standard Deviation (RSD) of replicate samples in a data submission (in this case by seasonal sampling event). First evaluate replicate field samples and lab replicates. If they are not available use reference material replicates. Precision is evaluated for those parameters whose AvgResult is >3*AvgMDL. This includes any non-detect (ND) results (set result to "0"), and any individual results that may be <3*MDL (as long as the sampling event overall average Result is > 3*AvgMDL).

DQOs for organics are VRIL if AvgRSD > 70, VIL if AvgRSD > 35; for trace elements VRIL if AvgRSD > 50, VIL if AvgRSD > 25

ProjectID	RGROUP	Analyte	Avg RSD	Num RSD Results	Units	Add QA Code	Avg SFEI Result	Avg StDev Of SFEIResult	Min Of xMDL[3]	Avg MDL
04ETP2TX	1LPAH	1-Methylnaphthalene	38	2	ug/kg	VIL	4.21	1.6122035	5	0.9
04ETP2TX	1LPAH	1-Methylphenanthrene	15	2	ug/kg		5.795	0.8838835	6	0.9
04ETP2TX	1LPAH	2,3,5-Trimethylnaphthalene	31	2	ug/kg		3.945	1.2232947	4	0.9
04ETP2TX	1LPAH	2,6-Dimethylnaphthalene	7	2	ug/kg		3.99	0.2687006	4	0.9
04ETP2TX	1LPAH	2-Methylnaphthalene	26	2	ug/kg		6.545	1.7182695	7	0.9
04ETP2TX	1LPAH	3,6-Dimethylphenanthrene	3	2	ug/kg		3.085	0.0777817	3	0.9
04ETP2TX	1LPAH	Anthracene	6	2	ug/kg		6.395	0.3606245	7	0.9
04ETP2TX	1LPAH	Dibenzothiophene	2	2	ug/kg		3.105	0.0636396	3	0.9
04ETP2TX	1LPAH	Fluorene	8	2	ug/kg		4.795	0.3889087	5	0.9
04ETP2TX	1LPAH	Naphthalene	20	2	ug/kg		6.56	1.3293607	7	0.9
04ETP2TX	1LPAH	Phenanthrene	4	2	ug/kg		33.5	1.4142136	37	0.9
04ETP2TX	2HPAH	2-Methylfluoranthene	19	2	ug/kg		9.55	1.767767	11	0.9
04ETP2TX	2HPAH	Benz(a)anthracene	17	2	ug/kg		25.4	4.2426407	28	0.9
04ETP2TX	2HPAH	Benzo(a)pyrene	18	2	ug/kg		30.6	5.5154329	34	0.9
04ETP2TX	2HPAH	Benzo(b)fluoranthene	12	2	ug/kg		59.25	7.2831998	66	0.9
04ETP2TX	2HPAH	Benzo(e)pyrene	9	2	ug/kg		33.4	3.1112698	37	0.9
04ETP2TX	2HPAH	Benzo(ghi)perylene	9	2	ug/kg		36.55	3.3234019	41	0.9
04ETP2TX	2HPAH	Benzo(k)fluoranthene	10	2	ug/kg		21.75	2.192031	24	0.9
04ETP2TX	2HPAH	Chrysene	29	2	ug/kg		48	13.859293	53	0.9
04ETP2TX	2HPAH	Dibenz(a,h)anthracene	18	2	ug/kg		9.34	1.6404877	10	0.9
04ETP2TX	2HPAH	Fluoranthene	6	2	ug/kg		113	7.0710678	126	0.9
04ETP2TX	2HPAH	Indeno(1,2,3-cd)pyrene	14	2	ug/kg		31.7	4.5254834	35	0.9
04ETP2TX	2HPAH	Perylene	5	2	ug/kg		18	0.9899495	20	0.9
04ETP2TX	2HPAH	Pyrene	7	2	ug/kg		95.35	6.2932504	106	0.9
04ETP2TX	PCB	PCB 052	30	2	ug/kg		0.617	0.1880904	3	0.1805
04ETP2TX	PCB	PCB 070	52	2	ug/kg	VIL	0.575	0.2983991	3	0.1805
04ETP2TX	PCB	PCB 087	17	2	ug/kg		0.564	0.0947523	3	0.1805
04ETP2TX	PCB	PCB 101	30	2	ug/kg		0.8425	0.2510229	5	0.1805
04ETP2TX	PCB	PCB 110	57	2	ug/kg	VIL	0.6865	0.3882016	4	0.1805
04ETP2TX	PCB	PCB 118	49	2	ug/kg	VIL	0.9205	0.4518412	5	0.1805
04ETP2TX	PCB	PCB 138	23	2	ug/kg		0.996	0.231931	6	0.1805

[3] Min Of xMDL = Minimum field sample result/MDL value (indicates how many time greater the lowest field sample result was than the reported method detection limit).

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ProjectID	RGROUP	Analyte	Avg RSD	Num RSD Results	Units	Add QA Code	Avg SFEI Result	Avg StDev Of SFEIResult	Min Of xMDL	Avg MDL
04ETP2TX	PCB	PCB 149	19	2	ug/kg		0.6	0.1159655	3	0.1805
04ETP2TX	PCB	PCB 153	12	2	ug/kg		0.676	0.0806102	4	0.1805
04ETP2TX		C1-Chrysenes	8	2	ug/kg		20.75	1.6263456	23	0.9
04ETP2TX		C1-Dibenzothiophenes	9	2	ug/kg		5.21	0.4808326	6	0.9
04ETP2TX		C1-Fluoranthenes_Pyrenes	16	2	ug/kg		79	13.010765	88	0.9
04ETP2TX		C1-Fluorenes	12	2	ug/kg		5.315	0.629325	6	0.9
04ETP2TX		C1-Naphthalenes	30	2	ug/kg		10.875	3.2880465	12	0.9
04ETP2TX		C1-Phenanthrenes_Anthracenes	13	2	ug/kg		27	3.5355339	30	0.9
04ETP2TX		C2-Chrysenes	3	2	ug/kg		18.7	0.5656854	21	0.9
04ETP2TX		C2-Dibenzothiophenes	18	2	ug/kg		9.25	1.6263456	10	0.9
04ETP2TX		C2-Fluorenes	4	2	ug/kg		6.28	0.2545584	7	0.9
04ETP2TX		C2-Naphthalenes	17	2	ug/kg		13.25	2.192031	15	0.9
04ETP2TX		C2-Phenanthrenes_Anthracenes	20	2	ug/kg		36.7	7.4953319	41	0.9
04ETP2TX		C3-Chrysenes	1	2	ug/kg		14	0.1414214	16	0.9
04ETP2TX		C3-Dibenzothiophenes	7	2	ug/kg		6.815	0.4454773	8	0.9
04ETP2TX		C3-Fluorenes	0	2	ug/kg		5.855	0.0070711	7	0.9
04ETP2TX		C3-Naphthalenes	18	2	ug/kg		13.45	2.4748737	15	0.9
04ETP2TX		C3-Phenanthrenes_Anthracenes	20	2	ug/kg		20.95	4.17193	23	0.9
04ETP2TX		C4-Naphthalenes	14	2	ug/kg		6.09	0.8626703	7	0.9
04ETP2TX		C4-Phenanthrenes_Anthracenes	19	2	ug/kg		5.55	1.0323759	6	0.9
04ETP2TX	AGS	% Clay (<4um)	3	3	%		21.48318	0.6459367	242	0.088831
04ETP2TX	AGS	% Sand (63um-2mm)	2	3	%		58.94485	1.2965474	54	1.090111
04ETP2TX	AGS	% Silt (4um-63um)	9	3	%		19.57197	1.8174114	17	1.173068
04ETP2TX	ANC	TOC	4	3	%		1.144333	0.040501	67	0.017
04ETP2TX	ANC	Total Nitrogen	5	3	%		0.1	0.0051962	100	0.001
04ETP2TX	ANC	% Solids - SED-TE-BRL-TE2	0	2	%		70.08	0.0565685	1168	0.06
04ETP2TX	TE	Al	22	3	mg/kg		42260.42	9191.8443	30186	1.4
04ETP2TX	TE	As	12	4	mg/kg		5.0675	0.6328606	28	0.1
04ETP2TX	TE	Se	4	4	mg/kg		0.2225	0.0091924	32	0.002
05ETP2TX	1DDT	p,p'-DDE	9	2	ug/kg		6.615	0.5868986	9	0.76
05ETP2TX	1LPAH	1-Methylfluorene	11	2	ug/kg		2.695	0.2899138	4	0.6645
05ETP2TX	1LPAH	1-Methylnaphthalene	21	2	ug/kg		3.91	0.8061017	6	0.6645
05ETP2TX	1LPAH	1-Methylphenanthrene	6	2	ug/kg		3.9	0.2262742	6	0.6645
05ETP2TX	1LPAH	2,6-Dimethylnaphthalene	11	2	ug/kg		4.325	0.4737615	7	0.6645
05ETP2TX	1LPAH	2-Methylnaphthalene	19	2	ug/kg		8.655	1.6758431	13	0.6645
05ETP2TX	1LPAH	3,6-Dimethylphenanthrene	4	2	ug/kg		2.24	0.0989949	3	0.6645
05ETP2TX	1LPAH	4-Methyldibenzothiophene	4	2	ug/kg		2.085	0.0777817	3	0.6645
05ETP2TX	1LPAH	Anthracene	21	2	ug/kg		2.135	0.4454773	3	0.6645
05ETP2TX	1LPAH	Biphenyl	10	2	ug/kg		3.785	0.3747666	6	0.6645
05ETP2TX	1LPAH	Dibenzothiophene	4	2	ug/kg		2.6	0.0989949	4	0.6645
05ETP2TX	1LPAH	Fluorene	18	2	ug/kg		2.31	0.4101219	3	0.6645
05ETP2TX	1LPAH	Naphthalene	10	2	ug/kg		6.91	0.6788225	7	1.03
05ETP2TX	1LPAH	Phenanthrene	16	2	ug/kg		22.35	3.6062446	12	1.84

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ProjectID	RGROUP	Analyte	Avg RSD	Num RSD Results	Units	Add QA Code	Avg SFEI Result	Avg StDev Of SFEIResult	Min Of xMDL	Avg MDL
05ETP2TX	2CHLR	gamma-Chlordane	25	2	ug/kg		1.61	0.3959798	3	0.535
05ETP2TX	2CHLR	trans-Nonachlor	10	2	ug/kg		1.55	0.1555635	3	0.515
05ETP2TX	2HPAH	2-Methylfluoranthene	12	2	ug/kg		3.62	0.4384062	5	0.6645
05ETP2TX	2HPAH	Benz(a)anthracene	21	2	ug/kg		9.56	2.0364675	14	0.6645
05ETP2TX	2HPAH	Benzo(a)pyrene	19	2	ug/kg		15.95	3.0405592	24	0.6645
05ETP2TX	2HPAH	Benzo(b)fluoranthene	12	2	ug/kg		33.3	3.959798	50	0.6645
05ETP2TX	2HPAH	Benzo(e)pyrene	8	2	ug/kg		22	1.6970563	33	0.6645
05ETP2TX	2HPAH	Benzo(ghi)perylene	6	2	ug/kg		26.4	1.6970563	3	8.11
05ETP2TX	2HPAH	Benzo(k)fluoranthene	12	2	ug/kg		10.075	1.1667262	15	0.6645
05ETP2TX	2HPAH	Chrysene	16	2	ug/kg		16.4	2.5455844	25	0.6645
05ETP2TX	2HPAH	Dibenz(a,h)anthracene	14	2	ug/kg		6.5	0.9192388	10	0.6645
05ETP2TX	2HPAH	Fluoranthene	26	2	ug/kg		31.1	8.2024387	47	0.6645
05ETP2TX	2HPAH	Indeno(1,2,3-cd)pyrene	17	2	ug/kg		21.1	3.6769553	32	0.6645
05ETP2TX	2HPAH	Perylene	10	2	ug/kg		8.58	0.8202439	13	0.6645
05ETP2TX	2HPAH	Pyrene	18	2	ug/kg		31.3	5.6568542	47	0.6645
05ETP2TX	5Other	Oxadiazon	9	2	ug/kg		4.875	0.4596194	4	1.235
05ETP2TX	PBDE	BDE 047	6	2	ug/kg		1.91	0.1131371	4	0.517
05ETP2TX	PBDE	BDE 099	4	2	ug/kg		2.87	0.1131371	6	0.521
05ETP2TX	PCB	PCB 031	26	2	ug/kg		0.405	0.1046518	3	0.1325
05ETP2TX	PCB	PCB 052	43	4	ug/kg		0.518	0.198697	3	0.13275
05ETP2TX	PCB	PCB 066	30	2	ug/kg		0.443	0.1343503	3	0.1325
05ETP2TX	PCB	PCB 070	5	2	ug/kg		0.4415	0.0205061	3	0.1325
05ETP2TX	PCB	PCB 095	16	2	ug/kg		0.688	0.1103087	5	0.1325
05ETP2TX	PCB	PCB 101	9	2	ug/kg		0.7135	0.0643467	5	0.1325
05ETP2TX	PCB	PCB 110	54	4	ug/kg		0.8105	0.350725	3	0.13275
05ETP2TX	PCB	PCB 118	34	4	ug/kg		0.7245	0.231931	5	0.13275
05ETP2TX	PCB	PCB 138	4	2	ug/kg		1.57	0.0565685	12	0.1325
05ETP2TX	PCB	PCB 149	3	2	ug/kg		1.295	0.0353553	10	0.1325
05ETP2TX	PCB	PCB 151	14	2	ug/kg		0.5355	0.0756604	4	0.1325
05ETP2TX	PCB	PCB 153	7	2	ug/kg		1.18	0.0848528	9	0.1325
05ETP2TX	PCB	PCB 170	5	2	ug/kg		0.4315	0.0205061	3	0.1325
05ETP2TX	PCB	PCB 174	7	2	ug/kg		0.5495	0.0360624	4	0.1325
05ETP2TX	PCB	PCB 180	2	2	ug/kg		1.15	0.0282843	9	0.1325
05ETP2TX	PCB	PCB 187	17	2	ug/kg		0.613	0.1018234	5	0.1325
05ETP2TX		C1-Chrysenes	14	2	ug/kg		13.5	1.8384776	20	0.6645
05ETP2TX		C1-Dibenzothiophenes	0	2	ug/kg		4.73	0	7	0.6645
05ETP2TX		C1-Fluoranthenes_Pyrenes	17	2	ug/kg		41.6	6.9296465	28	1.475
05ETP2TX		C1-Fluorenes	4	2	ug/kg		5.6	0.212132	8	0.6645
05ETP2TX		C1-Naphthalenes	20	2	ug/kg		13	2.5455844	6	2.21
05ETP2TX		C1-Phenanthrenes_Anthracenes	3	2	ug/kg		24	0.7071068	36	0.6645
05ETP2TX		C2-Chrysenes	18	2	ug/kg		15	2.6870058	23	0.6645
05ETP2TX		C2-Dibenzothiophenes	1	2	ug/kg		10.25	0.0707107	15	0.6645
05ETP2TX		C2-Fluorenes	12	2	ug/kg		9.085	1.0960155	14	0.6645

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ProjectID	RGROUP	Analyte	Avg RSD	Num RSD Results	Units	Add QA Code	Avg SFEI Result	Avg StDev Of SFEIResult	Min Of xMDL	Avg MDL
05ETP2TX		C2-Naphthalenes	12	2	ug/kg		13.7	1.6970563	7	1.915
05ETP2TX		C2-Phenanthrenes_Anthracenes	3	2	ug/kg		25.9	0.8485281	39	0.6645
05ETP2TX		C3-Chrysenes	0	2	ug/kg		13.8	0	21	0.6645
05ETP2TX		C3-Dibenzothiophenes	4	2	ug/kg		7.25	0.2969848	11	0.6645
05ETP2TX		C3-Fluorenes	16	2	ug/kg		6.31	1.0323759	9	0.6645
05ETP2TX		C3-Naphthalenes	9	2	ug/kg		9.375	0.8838835	14	0.6645
05ETP2TX		C3-Phenanthrenes_Anthracenes	5	2	ug/kg		18	0.9899495	27	0.6645
05ETP2TX		C4-Naphthalenes	4	2	ug/kg		3.405	0.1202082	5	0.6645
05ETP2TX		C4-Phenanthrenes_Anthracenes	22	2	ug/kg		7.535	1.6617009	11	0.6645
05ETP2TX	AGS	% Clay (<4um)	0	3	%		35.58985	0.0296105	401	0.088831
05ETP2TX	AGS	% Sand (63um-2mm)	1	3	%		35.44368	0.3633703	33	1.090111
05ETP2TX	AGS	% Silt (4um-63um)	1	3	%		28.96647	0.3910226	25	1.173068
05ETP2TX	ANC	TOC	2	3	%		1.679333	0.039145	14	0.117
05ETP2TX	ANC	Total Nitrogen	2	3	%		0.159333	0.0025166	20	0.008
05ETP2TX	ANC	% Solids - SED-TE-BRL	2	2	%		69.72	1.145513	872	0.08
05ETP2TX	TE	Ag	3	2	mg/kg		0.241578	0.0073135	81	0.003
05ETP2TX	TE	Al	3	2	mg/kg		49859.63	1577.6171	712	70
05ETP2TX	TE	As	5	4	mg/kg		4.937523	0.2393053	47	0.1
05ETP2TX	TE	Cd	10	2	mg/kg		0.23419	0.0240299	59	0.004
05ETP2TX	TE	Cu	0	2	mg/kg		29.03369	0.104478	726	0.04
05ETP2TX	TE	Fe	3	2	mg/kg		25258.57	637.31561	90	280
05ETP2TX	TE	Hg	9	4	mg/kg		0.194135	0.01501	1120	0.000126
05ETP2TX	TE	MeHg	5	4	ug/kg		0.72125	0.0392444	205	0.0035
05ETP2TX	TE	Mn	1	2	mg/kg		531.6194	6.6865889	10632	0.05
05ETP2TX	TE	Ni	2	2	mg/kg		86.73168	1.6716472	2168	0.04
05ETP2TX	TE	Pb	0	2	mg/kg		18.61702	0	2069	0.009
05ETP2TX	TE	Se	22	2	mg/kg		0.111	0.0240416	11	0.01
05ETP2TX	TE	Zn	1	2	mg/kg		117.0323	0.6113214	1463	0.08
05ETP2TX	TOXWQ	DO	11	10	mg/L		8.56	0.9050967	83	0.1
05ETP2TX	TOXWQ	pH	1	15	pH		8.422667	0.08495	834	0.01
05ETP2TX	TOXWQ	Salinity	0	10	o/oo		20.44	0.0848528	202	0.1
05ETP2TX	TOXWQ	Temperature	1	15	°C		25.37333	0.2804237	252	0.1

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ProjectID	RGROUP	Analyte	Avg RSD	Num RSD Results	Units	Add QA Code	Avg SFEI Result	Avg StDev Of SFEIResult	Min Of xMDL	Avg MDL
05ETP2TX	2CHLR	gamma-Chlordane	25	2	ug/kg		1.61	0.3959798	3	0.535
05ETP2TX	2CHLR	trans-Nonachlor	10	2	ug/kg		1.55	0.1555635	3	0.515
05ETP2TX	2HPAH	2-Methylfluoranthene	12	2	ug/kg		3.62	0.4384062	5	0.6645
05ETP2TX	2HPAH	Benz(a)anthracene	21	2	ug/kg		9.56	2.0364675	14	0.6645
05ETP2TX	2HPAH	Benzo(a)pyrene	19	2	ug/kg		15.95	3.0405592	24	0.6645
05ETP2TX	2HPAH	Benzo(b)fluoranthene	12	2	ug/kg		33.3	3.959798	50	0.6645
05ETP2TX	2HPAH	Benzo(e)pyrene	8	2	ug/kg		22	1.6970563	33	0.6645
05ETP2TX	2HPAH	Benzo(ghi)perylene	6	2	ug/kg		26.4	1.6970563	3	8.11
05ETP2TX	2HPAH	Benzo(k)fluoranthene	12	2	ug/kg		10.075	1.1667262	15	0.6645
05ETP2TX	2HPAH	Chrysene	16	2	ug/kg		16.4	2.5455844	25	0.6645
05ETP2TX	2HPAH	Dibenz(a,h)anthracene	14	2	ug/kg		6.5	0.9192388	10	0.6645
05ETP2TX	2HPAH	Fluoranthene	26	2	ug/kg		31.1	8.2024387	47	0.6645
05ETP2TX	2HPAH	Indeno(1,2,3-cd)pyrene	17	2	ug/kg		21.1	3.6769553	32	0.6645
05ETP2TX	2HPAH	Perylene	10	2	ug/kg		8.58	0.8202439	13	0.6645
05ETP2TX	2HPAH	Pyrene	18	2	ug/kg		31.3	5.6568542	47	0.6645
05ETP2TX	5Other	Oxadiazon	9	2	ug/kg		4.875	0.4596194	4	1.235
05ETP2TX	PBDE	BDE 047	6	2	ug/kg		1.91	0.1131371	4	0.517
05ETP2TX	PBDE	BDE 099	4	2	ug/kg		2.87	0.1131371	6	0.521
05ETP2TX	PCB	PCB 031	26	2	ug/kg		0.405	0.1046518	3	0.1325
05ETP2TX	PCB	PCB 052	43	4	ug/kg		0.518	0.198697	3	0.13275
05ETP2TX	PCB	PCB 066	30	2	ug/kg		0.443	0.1343503	3	0.1325
05ETP2TX	PCB	PCB 070	5	2	ug/kg		0.4415	0.0205061	3	0.1325
05ETP2TX	PCB	PCB 095	16	2	ug/kg		0.688	0.1103087	5	0.1325
05ETP2TX	PCB	PCB 101	9	2	ug/kg		0.7135	0.0643467	5	0.1325
05ETP2TX	PCB	PCB 110	54	4	ug/kg		0.8105	0.350725	3	0.13275
05ETP2TX	PCB	PCB 118	34	4	ug/kg		0.7245	0.231931	5	0.13275
05ETP2TX	PCB	PCB 138	4	2	ug/kg		1.57	0.0565685	12	0.1325
05ETP2TX	PCB	PCB 149	3	2	ug/kg		1.295	0.0353553	10	0.1325
05ETP2TX	PCB	PCB 151	14	2	ug/kg		0.5355	0.0756604	4	0.1325
05ETP2TX	PCB	PCB 153	7	2	ug/kg		1.18	0.0848528	9	0.1325
05ETP2TX	PCB	PCB 170	5	2	ug/kg		0.4315	0.0205061	3	0.1325
05ETP2TX	PCB	PCB 174	7	2	ug/kg		0.5495	0.0360624	4	0.1325
05ETP2TX	PCB	PCB 180	2	2	ug/kg		1.15	0.0282843	9	0.1325
05ETP2TX	PCB	PCB 187	17	2	ug/kg		0.613	0.1018234	5	0.1325

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ProjectID	RGROUP	Analyte	Avg RSD	Num RSD Results	Units	Add QA Code	Avg SFEI Result	Avg StDev Of SFEIResult	Min Of xMDL	Avg MDL
05ETP2TX		C1-Chrysenes	14	2	ug/kg		13.5	1.8384776	20	0.6645
05ETP2TX		C1-Dibenzothiophenes	0	2	ug/kg		4.73	0	7	0.6645
05ETP2TX		C1-Fluoranthenes_Pyrenes	17	2	ug/kg		41.6	6.9296465	28	1.475
05ETP2TX		C1-Fluorenes	4	2	ug/kg		5.6	0.212132	8	0.6645
05ETP2TX		C1-Naphthalenes	20	2	ug/kg		13	2.5455844	6	2.21
05ETP2TX		C1-Phenanthrenes_Anthracenes	3	2	ug/kg		24	0.7071068	36	0.6645
05ETP2TX		C2-Chrysenes	18	2	ug/kg		15	2.6870058	23	0.6645
05ETP2TX		C2-Dibenzothiophenes	1	2	ug/kg		10.25	0.0707107	15	0.6645
05ETP2TX		C2-Fluorenes	12	2	ug/kg		9.085	1.0960155	14	0.6645
05ETP2TX		C2-Naphthalenes	12	2	ug/kg		13.7	1.6970563	7	1.915
05ETP2TX		C2-Phenanthrenes_Anthracenes	3	2	ug/kg		25.9	0.8485281	39	0.6645
05ETP2TX		C3-Chrysenes	0	2	ug/kg		13.8	0	21	0.6645
05ETP2TX		C3-Dibenzothiophenes	4	2	ug/kg		7.25	0.2969848	11	0.6645
05ETP2TX		C3-Fluorenes	16	2	ug/kg		6.31	1.0323759	9	0.6645
05ETP2TX		C3-Naphthalenes	9	2	ug/kg		9.375	0.8838835	14	0.6645
05ETP2TX		C3-Phenanthrenes_Anthracenes	5	2	ug/kg		18	0.9899495	27	0.6645
05ETP2TX		C4-Naphthalenes	4	2	ug/kg		3.405	0.1202082	5	0.6645
05ETP2TX		C4-Phenanthrenes_Anthracenes	22	2	ug/kg		7.535	1.6617009	11	0.6645
05ETP2TX	AGS	% Clay (<4um)	0	3	%		35.58985	0.0296105	401	0.088831
05ETP2TX	AGS	% Sand (63um-2mm)	1	3	%		35.44368	0.3633703	33	1.090111
05ETP2TX	AGS	% Silt (4um-63um)	1	3	%		28.96647	0.3910226	25	1.173068
05ETP2TX	ANC	TOC	2	3	%		1.679333	0.039145	14	0.117
05ETP2TX	ANC	Total Nitrogen	2	3	%		0.159333	0.0025166	20	0.008
05ETP2TX	ANC	% Solids - SED-TE-BRL	2	2	%		69.72	1.145513	872	0.08
05ETP2TX	TE	Ag	3	2	mg/kg		0.241578	0.0073135	81	0.003
05ETP2TX	TE	Al	3	2	mg/kg		49859.63	1577.6171	712	70
05ETP2TX	TE	As	5	4	mg/kg		4.937523	0.2393053	47	0.1
05ETP2TX	TE	Cd	10	2	mg/kg		0.23419	0.0240299	59	0.004
05ETP2TX	TE	Cu	0	2	mg/kg		29.03369	0.104478	726	0.04
05ETP2TX	TE	Fe	3	2	mg/kg		25258.57	637.31561	90	280
05ETP2TX	TE	Hg	9	4	mg/kg		0.194135	0.01501	1120	0.000126
05ETP2TX	TE	MeHg	5	4	ug/kg		0.72125	0.0392444	205	0.0035
05ETP2TX	TE	Mn	1	2	mg/kg		531.6194	6.6865889	10632	0.05
05ETP2TX	TE	Ni	2	2	mg/kg		86.73168	1.6716472	2168	0.04
05ETP2TX	TE	Pb	0	2	mg/kg		18.61702	0	2069	0.009
05ETP2TX	TE	Se	22	2	mg/kg		0.111	0.0240416	11	0.01
05ETP2TX	TE	Zn	1	2	mg/kg		117.0323	0.6113214	1463	0.08
05ETP2TX	TOXWQ	DO	11	10	mg/L		8.56	0.9050967	83	0.1
05ETP2TX	TOXWQ	pH	1	15	pH		8.422667	0.08495	834	0.01
05ETP2TX	TOXWQ	Salinity	0	10	o/oo		20.44	0.0848528	202	0.1
05ETP2TX	TOXWQ	Temperature	1	15	°C		25.37333	0.2804237	252	0.1

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APPENDIX C. FIELD SAMPLE RESULTS (SEE CHAPTER 1)
CHEMICAL AND TOXICITY ANALYSES FROM AMBIENT SEDIMENT SAMPLING IN TRIBUTARIES OF THE SAN FRANCISCO ESTUARY (2004-2005)

A011618

QUALIFIER DEFINITIONS:

QACode Definitions

QACode	QACodeDescr
BRKA	Sample container broken but analyzed
GN	Surrogate recovery is outside of control limits
H	A holding time violation has occurred.
HT	Analytical value calculated using results from associated tests
IL	RPD exceeds laboratory control limit
J	Estimated value - EPA Flag
NBC	Result is not blank corrected (SFEI)
SC	Surrogate Corrected Value
SCR	Screening level analysis
DO	Coeluting congener
VIL	RPD exceeds control limit, flagged by QAO
VIP	Analyte detected in method, trip, or equipment blank, flagged by QAO
VIU	Percent Recovery exceeds laboratory control limit, flagged by QAO
VRIP	Analyte detected in method blank and result is deamed unusable, flagged by QAO
VRIU	Percent Recovery exceeds laboratory control limit and result is deamed unusable, flagged by QAO
X	None - No QA Qualifier (No blank cells are allowed in the QACode column)

ResQualCode Definitions

ResQualCode	ResQualDescription
DNQ	Detected Not Quantifiable (result is greater than MDL but less than Reporting Limit)
NA	Not Analyzed
ND	Not Detected

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Appendix Table C.1. Sediment quality results from the ambient tributary study in watersheds of the San Francisco Estuary (2004-2005). N = number of replicates. TOC = total organic carbon. The grainsize parameter % Fines, is a calculated result by summing clay and silt fractions. Lab codes are defined in table 1.1.

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2004-11	COYCRKLWR	01-Nov-04	1SEDQ	0ANC	TOC	3	VNBC	1.14	%	0.02	UCSCDETEPW04_UCSCDETTOCTN	
2004-11	COYCRKUP	01-Nov-04	1SEDQ	0ANC	TOC	1	VNBC	0.74	%	0.02	UCSCDETEPW04_UCSCDETTOCTN	
2004-11	NAPRIVLWR	02-Nov-04	1SEDQ	0ANC	TOC	1	VNBC	1.74	%	0.02	UCSCDETEPW04_UCSCDETTOCTN	
2004-11	NAPRIVUP	02-Nov-04	1SEDQ	0ANC	TOC	1	VNBC	0.94	%	0.02	UCSCDETEPW04_UCSCDETTOCTN	
2004-11	PETRIVLWR	02-Nov-04	1SEDQ	0ANC	TOC	1	VNBC	1.99	%	0.02	UCSCDETEPW04_UCSCDETTOCTN	
2004-11	PETRIVUP	02-Nov-04	1SEDQ	0ANC	TOC	1	VNBC	1.87	%	0.02	UCSCDETEPW04_UCSCDETTOCTN	
2004-11	SANLORCRKLWR	03-Nov-04	1SEDQ	0ANC	TOC	1	VNBC	1.55	%	0.02	UCSCDETEPW04_UCSCDETTOCTN	
2004-11	SANLORCRKUP	03-Nov-04	1SEDQ	0ANC	TOC	1	VNBC	0.49	%	0.02	UCSCDETEPW04_UCSCDETTOCTN	
2004-11	SANMATCRKLWR	04-Nov-04	1SEDQ	0ANC	TOC	1	VNBC	2.70	%	0.02	UCSCDETEPW04_UCSCDETTOCTN	
2004-11	SANMATCRKUP	04-Nov-04	1SEDQ	0ANC	TOC	1	VNBC	1.96	%	0.02	UCSCDETEPW04_UCSCDETTOCTN	
2004-11	SUICRKLWR	03-Nov-04	1SEDQ	0ANC	TOC	1	VNBC	1.92	%	0.02	UCSCDETEPW04_UCSCDETTOCTN	
2004-11	SUICRKUP	03-Nov-04	1SEDQ	0ANC	TOC	1	VNBC	1.00	%	0.02	UCSCDETEPW04_UCSCDETTOCTN	
2005-04	COYCRKLWR	18-Apr-05	1SEDQ	0ANC	TOC	3	VNBC,X	1.68	%	0.12	UCSCDETEPTOX05	
2005-04	COYCRKUP	18-Apr-05	1SEDQ	0ANC	TOC	1	VNBC,X	0.96	%	0.12	UCSCDETEPTOX05	
2005-04	NAPRIVLWR	19-Apr-05	1SEDQ	0ANC	TOC	1	VNBC,X	3.13	%	0.12	UCSCDETEPTOX05	
2005-04	NAPRIVUP	19-Apr-05	1SEDQ	0ANC	TOC	1	VNBC,X	1.25	%	0.12	UCSCDETEPTOX05	
2005-04	PETRIVLWR	20-Apr-05	1SEDQ	0ANC	TOC	1	VNBC,X	2.06	%	0.12	UCSCDETEPTOX05	
2005-04	PETRIVUP	20-Apr-05	1SEDQ	0ANC	TOC	1	VNBC,X	2.36	%	0.12	UCSCDETEPTOX05	
2005-04	SANLORCRKLWR	20-Apr-05	1SEDQ	0ANC	TOC	1	VNBC,X	0.52	%	0.12	UCSCDETEPTOX05	
2005-04	SANLORCRKUP	20-Apr-05	1SEDQ	0ANC	TOC	1	VNBC,X	3.03	%	0.12	UCSCDETEPTOX05	
2005-04	SANMATCRKLWR	18-Apr-05	1SEDQ	0ANC	TOC	1	VNBC,X	2.53	%	0.12	UCSCDETEPTOX05	
2005-04	SANMATCRKUP	18-Apr-05	1SEDQ	0ANC	TOC	1	VNBC,X	3.25	%	0.12	UCSCDETEPTOX05	
2005-04	SUICRKLWR	19-Apr-05	1SEDQ	0ANC	TOC	1	VNBC,X	1.82	%	0.12	UCSCDETEPTOX05	
2005-04	SUICRKUP	19-Apr-05	1SEDQ	0ANC	TOC	1	VNBC,X	0.57	%	0.12	UCSCDETEPTOX05	
2004-11	COYCRKLWR	01-Nov-04	1SEDQ	0ANC	Total Nitrogen	3	VNBC	0.10	%	0.00	UCSCDETEPW04_UCSCDETTOCTN	
2004-11	COYCRKUP	01-Nov-04	1SEDQ	0ANC	Total Nitrogen	1	VNBC	0.06	%	0.00	UCSCDETEPW04_UCSCDETTOCTN	

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2004-11	NAPRIVLWR	02-Nov-04	1SEDQ	0ANC	Total Nitrogen	1	VNBC	0.15	%	0.00	UCSCDET	EPW04_UCSCDETTOCTN
2004-11	NAPRIVUP	02-Nov-04	1SEDQ	0ANC	Total Nitrogen	1	VNBC	0.08	%	0.00	UCSCDET	EPW04_UCSCDETTOCTN
2004-11	PETRIVLWR	02-Nov-04	1SEDQ	0ANC	Total Nitrogen	1	VNBC	0.21	%	0.00	UCSCDET	EPW04_UCSCDETTOCTN
2004-11	PETRIVUP	02-Nov-04	1SEDQ	0ANC	Total Nitrogen	1	VNBC	0.16	%	0.00	UCSCDET	EPW04_UCSCDETTOCTN
2004-11	SANLORCRKLWR	03-Nov-04	1SEDQ	0ANC	Total Nitrogen	1	VNBC	0.13	%	0.00	UCSCDET	EPW04_UCSCDETTOCTN
2004-11	SANLORCRKUP	03-Nov-04	1SEDQ	0ANC	Total Nitrogen	1	VNBC	0.05	%	0.00	UCSCDET	EPW04_UCSCDETTOCTN
2004-11	SANMATCRKLWR	04-Nov-04	1SEDQ	0ANC	Total Nitrogen	1	VNBC	0.24	%	0.00	UCSCDET	EPW04_UCSCDETTOCTN
2004-11	SANMATCRKUP	04-Nov-04	1SEDQ	0ANC	Total Nitrogen	1	VNBC	0.13	%	0.00	UCSCDET	EPW04_UCSCDETTOCTN
2004-11	SUICRKLWR	03-Nov-04	1SEDQ	0ANC	Total Nitrogen	1	VNBC	0.15	%	0.00	UCSCDET	EPW04_UCSCDETTOCTN
2004-11	SUICRKUP	03-Nov-04	1SEDQ	0ANC	Total Nitrogen	1	VNBC	0.11	%	0.00	UCSCDET	EPW04_UCSCDETTOCTN
2005-04	COYCRKLWR	18-Apr-05	1SEDQ	0ANC	Total Nitrogen	3	VNBC,X	0.16	%	0.01	UCSCDET	EPTOX05
2005-04	COYCRKUP	18-Apr-05	1SEDQ	0ANC	Total Nitrogen	1	VNBC,X	0.07	%	0.01	UCSCDET	EPTOX05
2005-04	NAPRIVLWR	19-Apr-05	1SEDQ	0ANC	Total Nitrogen	1	VNBC,X	0.24	%	0.01	UCSCDET	EPTOX05
2005-04	NAPRIVUP	19-Apr-05	1SEDQ	0ANC	Total Nitrogen	1	VNBC,X	0.10	%	0.01	UCSCDET	EPTOX05
2005-04	PETRIVLWR	20-Apr-05	1SEDQ	0ANC	Total Nitrogen	1	VNBC,X	0.25	%	0.01	UCSCDET	EPTOX05
2005-04	PETRIVUP	20-Apr-05	1SEDQ	0ANC	Total Nitrogen	1	VNBC,X	0.18	%	0.01	UCSCDET	EPTOX05
2005-04	SANLORCRKLWR	20-Apr-05	1SEDQ	0ANC	Total Nitrogen	1	VNBC,X	0.05	%	0.01	UCSCDET	EPTOX05
2005-04	SANLORCRKUP	20-Apr-05	1SEDQ	0ANC	Total Nitrogen	1	VNBC,X	0.22	%	0.01	UCSCDET	EPTOX05
2005-04	SANMATCRKLWR	18-Apr-05	1SEDQ	0ANC	Total Nitrogen	1	VNBC,X	0.28	%	0.01	UCSCDET	EPTOX05
2005-04	SANMATCRKUP	18-Apr-05	1SEDQ	0ANC	Total Nitrogen	1	VNBC,X	0.24	%	0.01	UCSCDET	EPTOX05
2005-04	SUICRKLWR	19-Apr-05	1SEDQ	0ANC	Total Nitrogen	1	VNBC,X	0.15	%	0.01	UCSCDET	EPTOX05
2005-04	SUICRKUP	19-Apr-05	1SEDQ	0ANC	Total Nitrogen	1	VNBC,X	0.05	%	0.01	UCSCDET	EPTOX05
2004-11	COYCRKLWR	01-Nov-04	1SEDQ	AGS	% Clay (<4um)	3	VNBC	21.48	%	0.09	UCSCDET	UCSCDET-38476-GS
2004-11	COYCRKUP	01-Nov-04	1SEDQ	AGS	% Clay (<4um)	1	VNBC	15.28	%	0.09	UCSCDET	UCSCDET-38476-GS
2004-11	NAPRIVLWR	02-Nov-04	1SEDQ	AGS	% Clay (<4um)	1	VNBC	35.57	%	0.09	UCSCDET	UCSCDET-38476-GS
2004-11	NAPRIVUP	02-Nov-04	1SEDQ	AGS	% Clay (<4um)	1	VNBC	19.72	%	0.09	UCSCDET	UCSCDET-38476-GS
2004-11	PETRIVLWR	02-Nov-04	1SEDQ	AGS	% Clay (<4um)	1	VNBC	65.85	%	0.09	UCSCDET	UCSCDET-38476-GS
2004-11	PETRIVUP	02-Nov-04	1SEDQ	AGS	% Clay (<4um)	1	VNBC	23.83	%	0.09	UCSCDET	UCSCDET-38476-GS
2004-11	SANLORCRKLWR	03-Nov-04	1SEDQ	AGS	% Clay (<4um)	1	VNBC	22.40	%	0.09	UCSCDET	UCSCDET-38476-GS
2004-11	SANLORCRKUP	03-Nov-04	1SEDQ	AGS	% Clay (<4um)	1	VNBC	8.78	%	0.09	UCSCDET	UCSCDET-38476-GS

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2004-11	SANMATCRKLWR	04-Nov-04	1SEDQ	AGS	% Clay (<4um)	1 VNBC	67.17	%	0.09	UCSCDET	UCSCDET-38476-GS
2004-11	SANMATCRKUP	04-Nov-04	1SEDQ	AGS	% Clay (<4um)	1 VNBC	19.54	%	0.09	UCSCDET	UCSCDET-38476-GS
2004-11	SUICRKLWR	03-Nov-04	1SEDQ	AGS	% Clay (<4um)	1 VNBC	40.11	%	0.09	UCSCDET	UCSCDET-38476-GS
2004-11	SUICRKUP	03-Nov-04	1SEDQ	AGS	% Clay (<4um)	1 VNBC	29.39	%	0.09	UCSCDET	UCSCDET-38476-GS
2005-04	COYCRKLWR	18-Apr-05	1SEDQ	AGS	% Clay (<4um)	3 VNBC	35.59	%	0.09	UCSCDET	UCSCDET-38476-GS
2005-04	COYCRKUP	18-Apr-05	1SEDQ	AGS	% Clay (<4um)	1 VNBC	9.13	%	0.09	UCSCDET	UCSCDET-38476-GS
2005-04	NAPRIVLWR	19-Apr-05	1SEDQ	AGS	% Clay (<4um)	1 VNBC	33.21	%	0.09	UCSCDET	UCSCDET-38476-GS
2005-04	NAPRIVUP	19-Apr-05	1SEDQ	AGS	% Clay (<4um)	1 VNBC	17.50	%	0.09	UCSCDET	UCSCDET-38476-GS
2005-04	PETRIVLWR	20-Apr-05	1SEDQ	AGS	% Clay (<4um)	1 VNBC	70.52	%	0.09	UCSCDET	UCSCDET-38476-GS
2005-04	PETRIVUP	20-Apr-05	1SEDQ	AGS	% Clay (<4um)	1 VNBC	21.07	%	0.09	UCSCDET	UCSCDET-38476-GS
2005-04	SANLORCRKLWR	20-Apr-05	1SEDQ	AGS	% Clay (<4um)	1 VNBC	9.90	%	0.09	UCSCDET	UCSCDET-38476-GS
2005-04	SANLORCRKUP	20-Apr-05	1SEDQ	AGS	% Clay (<4um)	1 VNBC	12.13	%	0.09	UCSCDET	UCSCDET-38476-GS
2005-04	SANMATCRKLWR	18-Apr-05	1SEDQ	AGS	% Clay (<4um)	1 VNBC	63.85	%	0.09	UCSCDET	UCSCDET-38476-GS
2005-04	SANMATCRKUP	18-Apr-05	1SEDQ	AGS	% Clay (<4um)	1 VNBC	27.22	%	0.09	UCSCDET	UCSCDET-38476-GS
2005-04	SUICRKLWR	19-Apr-05	1SEDQ	AGS	% Clay (<4um)	1 VNBC	28.07	%	0.09	UCSCDET	UCSCDET-38476-GS
2005-04	SUICRKUP	19-Apr-05	1SEDQ	AGS	% Clay (<4um)	1 VNBC	10.47	%	0.09	UCSCDET	UCSCDET-38476-GS
2004-11	COYCRKLWR	01-Nov-04	1SEDQ	AGS	% Fines (<63 um)	3 VNBC	41.06	%		UCSCDET	UCSCDET-38476-GS
2004-11	COYCRKUP	01-Nov-04	1SEDQ	AGS	% Fines (<63 um)	1 VNBC	32.38	%		UCSCDET	UCSCDET-38476-GS
2004-11	NAPRIVLWR	02-Nov-04	1SEDQ	AGS	% Fines (<63 um)	1 VNBC	76.77	%		UCSCDET	UCSCDET-38476-GS
2004-11	NAPRIVUP	02-Nov-04	1SEDQ	AGS	% Fines (<63 um)	1 VNBC	36.78	%		UCSCDET	UCSCDET-38476-GS
2004-11	PETRIVLWR	02-Nov-04	1SEDQ	AGS	% Fines (<63 um)	1 VNBC	98.34	%		UCSCDET	UCSCDET-38476-GS
2004-11	PETRIVUP	02-Nov-04	1SEDQ	AGS	% Fines (<63 um)	1 VNBC	46.54	%		UCSCDET	UCSCDET-38476-GS
2004-11	SANLORCRKLWR	03-Nov-04	1SEDQ	AGS	% Fines (<63 um)	1 VNBC	46.15	%		UCSCDET	UCSCDET-38476-GS
2004-11	SANLORCRKUP	03-Nov-04	1SEDQ	AGS	% Fines (<63 um)	1 VNBC	18.48	%		UCSCDET	UCSCDET-38476-GS
2004-11	SANMATCRKLWR	04-Nov-04	1SEDQ	AGS	% Fines (<63 um)	1 VNBC	97.20	%		UCSCDET	UCSCDET-38476-GS
2004-11	SANMATCRKUP	04-Nov-04	1SEDQ	AGS	% Fines (<63 um)	1 VNBC	41.85	%		UCSCDET	UCSCDET-38476-GS
2004-11	SUICRKLWR	03-Nov-04	1SEDQ	AGS	% Fines (<63 um)	1 VNBC	78.34	%		UCSCDET	UCSCDET-38476-GS
2004-11	SUICRKUP	03-Nov-04	1SEDQ	AGS	% Fines (<63 um)	1 VNBC	54.66	%		UCSCDET	UCSCDET-38476-GS
2005-04	COYCRKLWR	18-Apr-05	1SEDQ	AGS	% Fines (<63 um)	3 VNBC	66.66	%		UCSCDET	UCSCDET-38476-GS
2005-04	COYCRKUP	18-Apr-05	1SEDQ	AGS	% Fines (<63 um)	1 VNBC	24.20	%		UCSCDET	UCSCDET-38476-GS

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	NAPRIVLWR	19-Apr-05	1SEDQ	AGS	% Fines (<63 um)	1 VNBC	86.26	%		UCSCDET	UCSCDET-38476-GS
2005-04	NAPRIVUP	19-Apr-05	1SEDQ	AGS	% Fines (<63 um)	1 VNBC	44.38	%		UCSCDET	UCSCDET-38476-GS
2005-04	PETRIVLWR	20-Apr-05	1SEDQ	AGS	% Fines (<63 um)	1 VNBC	99.62	%		UCSCDET	UCSCDET-38476-GS
2005-04	PETRIVUP	20-Apr-05	1SEDQ	AGS	% Fines (<63 um)	1 VNBC	43.52	%		UCSCDET	UCSCDET-38476-GS
2005-04	SANLORCRKLWR	20-Apr-05	1SEDQ	AGS	% Fines (<63 um)	1 VNBC	35.10	%		UCSCDET	UCSCDET-38476-GS
2005-04	SANLORCRKUP	20-Apr-05	1SEDQ	AGS	% Fines (<63 um)	1 VNBC	35.04	%		UCSCDET	UCSCDET-38476-GS
2005-04	SANMATCRKLWR	18-Apr-05	1SEDQ	AGS	% Fines (<63 um)	1 VNBC	98.55	%		UCSCDET	UCSCDET-38476-GS
2005-04	SANMATCRKUP	18-Apr-05	1SEDQ	AGS	% Fines (<63 um)	1 VNBC	68.96	%		UCSCDET	UCSCDET-38476-GS
2005-04	SUICRKLWR	19-Apr-05	1SEDQ	AGS	% Fines (<63 um)	1 VNBC	67.74	%		UCSCDET	UCSCDET-38476-GS
2005-04	SUICRKUP	19-Apr-05	1SEDQ	AGS	% Fines (<63 um)	1 VNBC	29.53	%		UCSCDET	UCSCDET-38476-GS
2004-11	COYCRKLWR	01-Nov-04	1SEDQ	AGS	% Gravel+Shell (>2mm)	3ND VNBC	0.00	%	1.09	UCSCDET	UCSCDET-38476-GS
2004-11	COYCRKUP	01-Nov-04	1SEDQ	AGS	% Gravel+Shell (>2mm)	1ND VNBC	0.00	%	1.09	UCSCDET	UCSCDET-38476-GS
2004-11	NAPRIVLWR	02-Nov-04	1SEDQ	AGS	% Gravel+Shell (>2mm)	1ND VNBC	0.00	%	1.09	UCSCDET	UCSCDET-38476-GS
2004-11	NAPRIVUP	02-Nov-04	1SEDQ	AGS	% Gravel+Shell (>2mm)	1ND VNBC	0.00	%	1.09	UCSCDET	UCSCDET-38476-GS
2004-11	PETRIVLWR	02-Nov-04	1SEDQ	AGS	% Gravel+Shell (>2mm)	1ND VNBC	0.00	%	1.09	UCSCDET	UCSCDET-38476-GS
2004-11	PETRIVUP	02-Nov-04	1SEDQ	AGS	% Gravel+Shell (>2mm)	1ND VNBC	0.00	%	1.09	UCSCDET	UCSCDET-38476-GS
2004-11	SANLORCRKLWR	03-Nov-04	1SEDQ	AGS	% Gravel+Shell (>2mm)	1ND VNBC	0.00	%	1.09	UCSCDET	UCSCDET-38476-GS
2004-11	SANLORCRKUP	03-Nov-04	1SEDQ	AGS	% Gravel+Shell (>2mm)	1 VNBC	21.70	%	1.09	UCSCDET	UCSCDET-38476-GS
2004-11	SANMATCRKLWR	04-Nov-04	1SEDQ	AGS	% Gravel+Shell (>2mm)	1ND VNBC	0.00	%	1.09	UCSCDET	UCSCDET-38476-GS
2004-11	SANMATCRKUP	04-Nov-04	1SEDQ	AGS	% Gravel+Shell (>2mm)	1ND VNBC	0.00	%	1.09	UCSCDET	UCSCDET-38476-GS
2004-11	SUICRKLWR	03-Nov-04	1SEDQ	AGS	% Gravel+Shell (>2mm)	1ND VNBC	0.00	%	1.09	UCSCDET	UCSCDET-38476-GS
2004-11	SUICRKUP	03-Nov-04	1SEDQ	AGS	% Gravel+Shell (>2mm)	1DNQ VJ,VNBC	1.27	%	1.09	UCSCDET	UCSCDET-38476-GS
2005-04	COYCRKLWR	18-Apr-05	1SEDQ	AGS	% Gravel+Shell (>2mm)	3ND VNBC	0.00	%	1.09	UCSCDET	UCSCDET-38476-GS
2005-04	COYCRKUP	18-Apr-05	1SEDQ	AGS	% Gravel+Shell (>2mm)	1ND VNBC	0.00	%	1.09	UCSCDET	UCSCDET-38476-GS
2005-04	NAPRIVLWR	19-Apr-05	1SEDQ	AGS	% Gravel+Shell (>2mm)	1ND VNBC	0.00	%	1.09	UCSCDET	UCSCDET-38476-GS
2005-04	NAPRIVUP	19-Apr-05	1SEDQ	AGS	% Gravel+Shell (>2mm)	1ND VNBC	0.00	%	1.09	UCSCDET	UCSCDET-38476-GS
2005-04	PETRIVLWR	20-Apr-05	1SEDQ	AGS	% Gravel+Shell (>2mm)	1ND VNBC	0.00	%	1.09	UCSCDET	UCSCDET-38476-GS
2005-04	PETRIVUP	20-Apr-05	1SEDQ	AGS	% Gravel+Shell (>2mm)	1 VNBC	34.74	%	1.09	UCSCDET	UCSCDET-38476-GS
2005-04	SANLORCRKLWR	20-Apr-05	1SEDQ	AGS	% Gravel+Shell (>2mm)	1ND VNBC	0.00	%	1.09	UCSCDET	UCSCDET-38476-GS
2005-04	SANLORCRKUP	20-Apr-05	1SEDQ	AGS	% Gravel+Shell (>2mm)	1ND VNBC	0.00	%	1.09	UCSCDET	UCSCDET-38476-GS

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	SANMATCRKLWR	18-Apr-05	1SEDQ	AGS	% Gravel+Shell (>2mm)	1	ND VNBC	0.00	%	1.09	UCSCDETUCSCDET-38476-GS
2005-04	SANMATCRKUP	18-Apr-05	1SEDQ	AGS	% Gravel+Shell (>2mm)	1	ND VNBC	0.00	%	1.09	UCSCDETUCSCDET-38476-GS
2005-04	SUICRKLWR	19-Apr-05	1SEDQ	AGS	% Gravel+Shell (>2mm)	1	ND VNBC	0.00	%	1.09	UCSCDETUCSCDET-38476-GS
2005-04	SUICRKUP	19-Apr-05	1SEDQ	AGS	% Gravel+Shell (>2mm)	1	VNBC	5.32	%	1.09	UCSCDETUCSCDET-38476-GS
2004-11	COYCRKLWR	01-Nov-04	1SEDQ	AGS	% Sand (63um-2mm)	3	VNBC	58.94	%	1.09	UCSCDETUCSCDET-38476-GS
2004-11	COYCRKUP	01-Nov-04	1SEDQ	AGS	% Sand (63um-2mm)	1	VNBC	67.62	%	1.09	UCSCDETUCSCDET-38476-GS
2004-11	NAPRIVLWR	02-Nov-04	1SEDQ	AGS	% Sand (63um-2mm)	1	VNBC	23.23	%	1.09	UCSCDETUCSCDET-38476-GS
2004-11	NAPRIVUP	02-Nov-04	1SEDQ	AGS	% Sand (63um-2mm)	1	VNBC	62.48	%	1.09	UCSCDETUCSCDET-38476-GS
2004-11	PETRIVLWR	02-Nov-04	1SEDQ	AGS	% Sand (63um-2mm)	1	DNQ VJ,VNBC	1.66	%	1.09	UCSCDETUCSCDET-38476-GS
2004-11	PETRIVUP	02-Nov-04	1SEDQ	AGS	% Sand (63um-2mm)	1	VNBC	53.46	%	1.09	UCSCDETUCSCDET-38476-GS
2004-11	SANLORCRKLWR	03-Nov-04	1SEDQ	AGS	% Sand (63um-2mm)	1	VNBC	53.85	%	1.09	UCSCDETUCSCDET-38476-GS
2004-11	SANLORCRKUP	03-Nov-04	1SEDQ	AGS	% Sand (63um-2mm)	1	VNBC	59.82	%	1.09	UCSCDETUCSCDET-38476-GS
2004-11	SANMATCRKLWR	04-Nov-04	1SEDQ	AGS	% Sand (63um-2mm)	1	DNQ VJ,VNBC	2.80	%	1.09	UCSCDETUCSCDET-38476-GS
2004-11	SANMATCRKUP	04-Nov-04	1SEDQ	AGS	% Sand (63um-2mm)	1	VNBC	58.15	%	1.09	UCSCDETUCSCDET-38476-GS
2004-11	SUICRKLWR	03-Nov-04	1SEDQ	AGS	% Sand (63um-2mm)	1	VNBC	21.66	%	1.09	UCSCDETUCSCDET-38476-GS
2004-11	SUICRKUP	03-Nov-04	1SEDQ	AGS	% Sand (63um-2mm)	1	VNBC	44.07	%	1.09	UCSCDETUCSCDET-38476-GS
2005-04	COYCRKLWR	18-Apr-05	1SEDQ	AGS	% Sand (63um-2mm)	3	VNBC	35.44	%	1.09	UCSCDETUCSCDET-38476-GS
2005-04	COYCRKUP	18-Apr-05	1SEDQ	AGS	% Sand (63um-2mm)	1	VNBC	75.80	%	1.09	UCSCDETUCSCDET-38476-GS
2005-04	NAPRIVLWR	19-Apr-05	1SEDQ	AGS	% Sand (63um-2mm)	1	VNBC	13.74	%	1.09	UCSCDETUCSCDET-38476-GS
2005-04	NAPRIVUP	19-Apr-05	1SEDQ	AGS	% Sand (63um-2mm)	1	VNBC	55.62	%	1.09	UCSCDETUCSCDET-38476-GS
2005-04	PETRIVLWR	20-Apr-05	1SEDQ	AGS	% Sand (63um-2mm)	1	ND VNBC	0.00	%	1.09	UCSCDETUCSCDET-38476-GS
2005-04	PETRIVUP	20-Apr-05	1SEDQ	AGS	% Sand (63um-2mm)	1	VNBC	21.73	%	1.09	UCSCDETUCSCDET-38476-GS
2005-04	SANLORCRKLWR	20-Apr-05	1SEDQ	AGS	% Sand (63um-2mm)	1	VNBC	64.90	%	1.09	UCSCDETUCSCDET-38476-GS
2005-04	SANLORCRKUP	20-Apr-05	1SEDQ	AGS	% Sand (63um-2mm)	1	VNBC	64.96	%	1.09	UCSCDETUCSCDET-38476-GS
2005-04	SANMATCRKLWR	18-Apr-05	1SEDQ	AGS	% Sand (63um-2mm)	1	DNQ J,VNBC	1.45	%	1.09	UCSCDETUCSCDET-38476-GS
2005-04	SANMATCRKUP	18-Apr-05	1SEDQ	AGS	% Sand (63um-2mm)	1	VNBC	31.04	%	1.09	UCSCDETUCSCDET-38476-GS
2005-04	SUICRKLWR	19-Apr-05	1SEDQ	AGS	% Sand (63um-2mm)	1	VNBC	32.26	%	1.09	UCSCDETUCSCDET-38476-GS
2005-04	SUICRKUP	19-Apr-05	1SEDQ	AGS	% Sand (63um-2mm)	1	VNBC	65.15	%	1.09	UCSCDETUCSCDET-38476-GS
2004-11	COYCRKLWR	01-Nov-04	1SEDQ	AGS	% Silt (4um-63um)	3	VNBC	19.57	%	1.17	UCSCDETUCSCDET-38476-GS
2004-11	COYCRKUP	01-Nov-04	1SEDQ	AGS	% Silt (4um-63um)	1	VNBC	17.10	%	1.17	UCSCDETUCSCDET-38476-GS

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2004-11	NAPRIVLWR	02-Nov-04	1SEDQ	AGS	% Silt (4um-63um)	1 VNBC	41.21	%	1.17	UCSCDET	UCSCDET-38476-GS
2004-11	NAPRIVUP	02-Nov-04	1SEDQ	AGS	% Silt (4um-63um)	1 VNBC	17.06	%	1.17	UCSCDET	UCSCDET-38476-GS
2004-11	PETRIVLWR	02-Nov-04	1SEDQ	AGS	% Silt (4um-63um)	1 VNBC	32.49	%	1.17	UCSCDET	UCSCDET-38476-GS
2004-11	PETRIVUP	02-Nov-04	1SEDQ	AGS	% Silt (4um-63um)	1 VNBC	22.71	%	1.17	UCSCDET	UCSCDET-38476-GS
2004-11	SANLORCRKLWR	03-Nov-04	1SEDQ	AGS	% Silt (4um-63um)	1 VNBC	23.75	%	1.17	UCSCDET	UCSCDET-38476-GS
2004-11	SANLORCRKUP	03-Nov-04	1SEDQ	AGS	% Silt (4um-63um)	1 VNBC	9.70	%	1.17	UCSCDET	UCSCDET-38476-GS
2004-11	SANMATCRKLWR	04-Nov-04	1SEDQ	AGS	% Silt (4um-63um)	1 VNBC	30.03	%	1.17	UCSCDET	UCSCDET-38476-GS
2004-11	SANMATCRKUP	04-Nov-04	1SEDQ	AGS	% Silt (4um-63um)	1 VNBC	22.31	%	1.17	UCSCDET	UCSCDET-38476-GS
2004-11	SUICRKLWR	03-Nov-04	1SEDQ	AGS	% Silt (4um-63um)	1 VNBC	38.23	%	1.17	UCSCDET	UCSCDET-38476-GS
2004-11	SUICRKUP	03-Nov-04	1SEDQ	AGS	% Silt (4um-63um)	1 VNBC	25.27	%	1.17	UCSCDET	UCSCDET-38476-GS
2005-04	COYCRKLWR	18-Apr-05	1SEDQ	AGS	% Silt (4um-63um)	3 VNBC	28.97	%	1.17	UCSCDET	UCSCDET-38476-GS
2005-04	COYCRKUP	18-Apr-05	1SEDQ	AGS	% Silt (4um-63um)	1 VNBC	15.07	%	1.17	UCSCDET	UCSCDET-38476-GS
2005-04	NAPRIVLWR	19-Apr-05	1SEDQ	AGS	% Silt (4um-63um)	1 VNBC	53.05	%	1.17	UCSCDET	UCSCDET-38476-GS
2005-04	NAPRIVUP	19-Apr-05	1SEDQ	AGS	% Silt (4um-63um)	1 VNBC	26.88	%	1.17	UCSCDET	UCSCDET-38476-GS
2005-04	PETRIVLWR	20-Apr-05	1SEDQ	AGS	% Silt (4um-63um)	1 VNBC	29.10	%	1.17	UCSCDET	UCSCDET-38476-GS
2005-04	PETRIVUP	20-Apr-05	1SEDQ	AGS	% Silt (4um-63um)	1 VNBC	22.45	%	1.17	UCSCDET	UCSCDET-38476-GS
2005-04	SANLORCRKLWR	20-Apr-05	1SEDQ	AGS	% Silt (4um-63um)	1 VNBC	25.20	%	1.17	UCSCDET	UCSCDET-38476-GS
2005-04	SANLORCRKUP	20-Apr-05	1SEDQ	AGS	% Silt (4um-63um)	1 VNBC	22.91	%	1.17	UCSCDET	UCSCDET-38476-GS
2005-04	SANMATCRKLWR	18-Apr-05	1SEDQ	AGS	% Silt (4um-63um)	1 VNBC	34.71	%	1.17	UCSCDET	UCSCDET-38476-GS
2005-04	SANMATCRKUP	18-Apr-05	1SEDQ	AGS	% Silt (4um-63um)	1 VNBC	41.74	%	1.17	UCSCDET	UCSCDET-38476-GS
2005-04	SUICRKLWR	19-Apr-05	1SEDQ	AGS	% Silt (4um-63um)	1 VNBC	39.67	%	1.17	UCSCDET	UCSCDET-38476-GS
2005-04	SUICRKUP	19-Apr-05	1SEDQ	AGS	% Silt (4um-63um)	1 VNBC	19.06	%	1.17	UCSCDET	UCSCDET-38476-GS

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Appendix Table C.2. Sediment Trace Element results from the ambient tributary study in watersheds of the San Francisco Estuary (2004-2005). N = number of replicates. % solids were reported by each analytical laboratory. Two laboratories, BRL and UCSCDET, analyzed trace element samples in this study. Lab codes are defined in table 1.1.

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2004-11	COYCRKUP	01-Nov-042TE	0ANC		% Solids - SED-TE-BRL	1	VNBC	67.01	%	0.05BRL		04-1051
2004-11	NAPRIVUP	02-Nov-042TE	0ANC		% Solids - SED-TE-BRL	1	VNBC	63.31	%	0.05BRL		04-1051
2004-11	PETRIVUP	02-Nov-042TE	0ANC		% Solids - SED-TE-BRL	1	VNBC	48.83	%	0.05BRL		04-1051
2004-11	SANLORCRKUP	03-Nov-042TE	0ANC		% Solids - SED-TE-BRL	1	VNBC	63.33	%	0.05BRL		04-1051
2004-11	SANMATCRKLWR	04-Nov-042TE	0ANC		% Solids - SED-TE-BRL	1	VNBC	38.43	%	0.06BRL		05-0074
2004-11	SANMATCRKUP	04-Nov-042TE	0ANC		% Solids - SED-TE-BRL	1	VNBC	62.52	%	0.05BRL		04-1051
2004-11	SUICRKUP	03-Nov-042TE	0ANC		% Solids - SED-TE-BRL	1	VNBC	50.67	%	0.05BRL		04-1051
2005-04	COYCRKUP	18-Apr-052TE	0ANC		% Solids - SED-TE-BRL	1	VNBC	67.68	%	0.08BRL		05-0279
2005-04	NAPRIVUP	19-Apr-052TE	0ANC		% Solids - SED-TE-BRL	1	VNBC	61.06	%	0.08BRL		05-0279
2005-04	PETRIVUP	20-Apr-052TE	0ANC		% Solids - SED-TE-BRL	1	VNBC	58.29	%	0.08BRL		05-0279
2005-04	SANLORCRKUP	20-Apr-052TE	0ANC		% Solids - SED-TE-BRL	1	VNBC	50.26	%	0.08BRL		05-0279
2005-04	SANMATCRKLWR	18-Apr-052TE	0ANC		% Solids - SED-TE-BRL	1	VNBC	26.03	%	0.08BRL		05-0279
2005-04	SANMATCRKUP	18-Apr-052TE	0ANC		% Solids - SED-TE-BRL	1	VNBC	41.29	%	0.08BRL		05-0279
2005-04	SUICRKUP	19-Apr-052TE	0ANC		% Solids - SED-TE-BRL	2	VNBC	69.72	%	0.08BRL		05-0279
2004-11	COYCRKUP	01-Nov-042TE	0ANC		% Solids - SED-TE-BRL-TE2	1	VNBC	74.91	%	0.06BRL		05-0074
2004-11	NAPRIVUP	02-Nov-042TE	0ANC		% Solids - SED-TE-BRL-TE2	1	VNBC	66.38	%	0.06BRL		05-0074
2004-11	PETRIVUP	02-Nov-042TE	0ANC		% Solids - SED-TE-BRL-TE2	1	VNBC	55.66	%	0.06BRL		05-0074
2004-11	SANLORCRKUP	03-Nov-042TE	0ANC		% Solids - SED-TE-BRL-TE2	1	VNBC	78.78	%	0.06BRL		05-0074
2004-11	SANMATCRKLWR	04-Nov-042TE	0ANC		% Solids - SED-TE-BRL-TE2	1	VNBC	42.65	%	0.06BRL		05-0074
2004-11	SANMATCRKUP	04-Nov-042TE	0ANC		% Solids - SED-TE-BRL-TE2	2	VNBC	70.08	%	0.06BRL		05-0074
2004-11	SUICRKUP	03-Nov-042TE	0ANC		% Solids - SED-TE-BRL-TE2	1	VNBC	61.75	%	0.06BRL		05-0074

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2004-11	COYCRKLWR	01-Nov-042TE		0ANC	% Solids - SED-TE-UCSCDET	1 VNBC	58.17	%		UCSCDETEPW	UCSCDETANC
2004-11	COYCRKUP	01-Nov-042TE		0ANC	% Solids - SED-TE-UCSCDET	1 VNBC	67.11	%		UCSCDETEPW	UCSCDETANC
2004-11	NAPRIVLWR	02-Nov-042TE		0ANC	% Solids - SED-TE-UCSCDET	1 VNBC	47.05	%		UCSCDETEPW	UCSCDETANC
2004-11	NAPRIVUP	02-Nov-042TE		0ANC	% Solids - SED-TE-UCSCDET	1 VNBC	60.94	%		UCSCDETEPW	UCSCDETANC
2004-11	PETRIVLWR	02-Nov-042TE		0ANC	% Solids - SED-TE-UCSCDET	1 VNBC	35.62	%		UCSCDETEPW	UCSCDETANC
2004-11	PETRIVUP	02-Nov-042TE		0ANC	% Solids - SED-TE-UCSCDET	1 VNBC	45.78	%		UCSCDETEPW	UCSCDETANC
2004-11	SANLORCRKLWR	03-Nov-042TE		0ANC	% Solids - SED-TE-UCSCDET	1 VNBC	55.73	%		UCSCDETEPW	UCSCDETANC
2004-11	SANLORCRKUP	03-Nov-042TE		0ANC	% Solids - SED-TE-UCSCDET	1 VNBC	65.10	%		UCSCDETEPW	UCSCDETANC
2004-11	SANMATCRKLWR	04-Nov-042TE		0ANC	% Solids - SED-TE-UCSCDET	2 VNBC	34.08	%		UCSCDETEPW	UCSCDETANC
2004-11	SANMATCRKUP	04-Nov-042TE		0ANC	% Solids - SED-TE-UCSCDET	1 VNBC	62.00	%		UCSCDETEPW	UCSCDETANC
2004-11	SANMATCRKUP-SUB	04-Nov-042TE		0ANC	% Solids - SED-TE-UCSCDET	1 VNBC	62.00	%		UCSCDETEPW	UCSCDETANC
2004-11	SUICRKLWR	03-Nov-042TE		0ANC	% Solids - SED-TE-UCSCDET	1 VNBC	43.98	%		UCSCDETEPW	UCSCDETANC
2004-11	SUICRKUP	03-Nov-042TE		0ANC	% Solids - SED-TE-UCSCDET	1 VNBC	43.19	%		UCSCDETEPW	UCSCDETANC
2005-04	COYCRKLWR	18-Apr-052TE		0ANC	% Solids - SED-TE-UCSCDET	3 VNBC	53.14	%		UCSCDETEPTOX05	
2005-04	COYCRKUP	18-Apr-052TE		0ANC	% Solids - SED-TE-UCSCDET	1 VNBC	64.65	%		UCSCDETEPTOX05	
2005-04	NAPRIVLWR	19-Apr-052TE		0ANC	% Solids - SED-TE-UCSCDET	3 VNBC	37.50	%		UCSCDETEPTOX05	
2005-04	NAPRIVUP	19-Apr-052TE		0ANC	% Solids - SED-TE-UCSCDET	3 VNBC	62.50	%		UCSCDETEPTOX05	
2005-04	PETRIVLWR	20-Apr-052TE		0ANC	% Solids - SED-TE-UCSCDET	1 VNBC	45.54	%		UCSCDETEPTOX05	
2005-04	PETRIVUP	20-Apr-052TE		0ANC	% Solids - SED-TE-UCSCDET	1 VNBC	53.89	%		UCSCDETEPTOX05	
2005-04	SANLORCRKLWR	20-Apr-052TE		0ANC	% Solids - SED-TE-	1 VNBC	66.39	%		UCSCDETEPTOX05	

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	SANLORCRKUP	20-Apr-052TE	0ANC	UCSCDET	% Solids - SED-TE-UCSCDET	1 VNBC	49.37	%		UCSCDETEPTOX05	
2005-04	SANMATCRKLWR	18-Apr-052TE	0ANC	UCSCDET	% Solids - SED-TE-UCSCDET	1 VNBC	26.64	%		UCSCDETEPTOX05	
2005-04	SANMATCRKUP	18-Apr-052TE	0ANC	UCSCDET	% Solids - SED-TE-UCSCDET	1 VNBC	41.18	%		UCSCDETEPTOX05	
2005-04	SUICRKLWR	19-Apr-052TE	0ANC	UCSCDET	% Solids - SED-TE-UCSCDET	1 VNBC	50.12	%		UCSCDETEPTOX05	
2005-04	SUICRKUP	19-Apr-052TE	0ANC	UCSCDET	% Solids - SED-TE-UCSCDET	1 VNBC	68.93	%		UCSCDETEPTOX05	
2004-11	COYCRKUP	01-Nov-042TE	TE		Ag	1 X	0.19	mg/kg	0.00	BRL	05-0073-1
2004-11	NAPRIVUP	02-Nov-042TE	TE		Ag	1 X	0.38	mg/kg	0.00	BRL	05-0073-1
2004-11	PETRIVUP	02-Nov-042TE	TE		Ag	1 X	0.29	mg/kg	0.00	BRL	05-0073-1
2004-11	SANLORCRKUP	03-Nov-042TE	TE		Ag	1 X	0.17	mg/kg	0.00	BRL	05-0073-1
2004-11	SANMATCRKLWR	04-Nov-042TE	TE		Ag	1 X	0.70	mg/kg	0.00	BRL	05-0073-1
2004-11	SANMATCRKUP	04-Nov-042TE	TE		Ag	1 X	0.28	mg/kg	0.00	BRL	05-0073-1
2004-11	SUICRKUP	03-Nov-042TE	TE		Ag	1 X	0.24	mg/kg	0.00	BRL	05-0073-1
2005-04	COYCRKUP	18-Apr-052TE	TE		Ag	2 VIP,X	0.24	mg/kg	0.00	BRL	05-0278
2005-04	NAPRIVUP	19-Apr-052TE	TE		Ag	1 VIP,X	0.62	mg/kg	0.00	BRL	05-0278
2005-04	PETRIVUP	20-Apr-052TE	TE		Ag	1 VIP,X	0.30	mg/kg	0.00	BRL	05-0278
2005-04	SANLORCRKUP	20-Apr-052TE	TE		Ag	1 VIP,X	0.35	mg/kg	0.00	BRL	05-0278
2005-04	SANMATCRKLWR	18-Apr-052TE	TE		Ag	1 VIP,X	0.68	mg/kg	0.00	BRL	05-0278
2005-04	SANMATCRKUP	18-Apr-052TE	TE		Ag	1 VIP,X	0.39	mg/kg	0.00	BRL	05-0278
2005-04	SUICRKUP	19-Apr-052TE	TE		Ag	1 VIP,X	0.28	mg/kg	0.00	BRL	05-0278
2004-11	COYCRKUP	01-Nov-042TE	TE		Al	1 VIU	46027.23	mg/kg	1.40	BRL	05-0073-2
2004-11	NAPRIVUP	02-Nov-042TE	TE		Al	1 VIU	36175.05	mg/kg	1.40	BRL	05-0073-2
2004-11	PETRIVUP	02-Nov-042TE	TE		Al	1 VIU	40923.46	mg/kg	1.40	BRL	05-0073-2
2004-11	SANLORCRKUP	03-Nov-042TE	TE		Al	1 VIU	44635.69	mg/kg	1.40	BRL	05-0073-2
2004-11	SANMATCRKLWR	04-Nov-042TE	TE		Al	1 VIU	54560.00	mg/kg	1.40	BRL	05-0073-2
2004-11	SANMATCRKUP	04-Nov-042TE	TE		Al	3 VIU	42260.42	mg/kg	1.40	BRL	05-0073-2
2004-11	SUICRKUP	03-Nov-042TE	TE		Al	1 VIU	56699.60	mg/kg	1.40	BRL	05-0073-2

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	COYCRKUP	18-Apr-05	2TE	TE	Al	2	X	49859.63	mg/kg	70.00	BRL	05-0278
2005-04	NAPRIVUP	19-Apr-05	2TE	TE	Al	1	X	66819.52	mg/kg	70.00	BRL	05-0278
2005-04	PETRIVUP	20-Apr-05	2TE	TE	Al	1	X	58157.49	mg/kg	70.00	BRL	05-0278
2005-04	SANLORCRKUP	20-Apr-05	2TE	TE	Al	1	X	41583.76	mg/kg	70.00	BRL	05-0278
2005-04	SANMATCRKLWR	18-Apr-05	2TE	TE	Al	1	X	89127.93	mg/kg	70.00	BRL	05-0278
2005-04	SANMATCRKUP	18-Apr-05	2TE	TE	Al	1	X	64422.38	mg/kg	70.00	BRL	05-0278
2005-04	SUICRKUP	19-Apr-05	2TE	TE	Al	1	X	53838.34	mg/kg	70.00	BRL	05-0278
2004-11	COYCRKUP	01-Nov-04	2TE	TE	As	1	VNBC	3.06	mg/kg	0.10	BRL	04-1050-1
2004-11	NAPRIVUP	02-Nov-04	2TE	TE	As	1	VNBC	5.37	mg/kg	0.10	BRL	04-1050-1
2004-11	PETRIVUP	02-Nov-04	2TE	TE	As	1	VNBC	2.91	mg/kg	0.10	BRL	04-1050-1
2004-11	SANLORCRKUP	03-Nov-04	2TE	TE	As	1	VNBC	2.53	mg/kg	0.10	BRL	04-1050-1
2004-11	SANMATCRKLWR	04-Nov-04	2TE	TE	As	2	VNBC	7.34	mg/kg	0.10	BRL	05-0075-1
2004-11	SANMATCRKUP	04-Nov-04	2TE	TE	As	2	VNBC	2.80	mg/kg	0.10	BRL	04-1050-1
2004-11	SUICRKUP	03-Nov-04	2TE	TE	As	1	VNBC	3.99	mg/kg	0.10	BRL	04-1050-1
2005-04	COYCRKUP	18-Apr-05	2TE	TE	As	2	VNBC,X	5.20	mg/kg	0.10	BRL	05-0281-2
2005-04	NAPRIVUP	19-Apr-05	2TE	TE	As	1	VNBC,X	6.98	mg/kg	0.10	BRL	05-0281-2
2005-04	PETRIVUP	20-Apr-05	2TE	TE	As	1	VNBC,X	4.56	mg/kg	0.10	BRL	05-0281-2
2005-04	SANLORCRKUP	20-Apr-05	2TE	TE	As	2	VNBC,X	4.67	mg/kg	0.10	BRL	05-0281-2
2005-04	SANMATCRKLWR	18-Apr-05	2TE	TE	As	1	VNBC,X	10.91	mg/kg	0.10	BRL	05-0281-2
2005-04	SANMATCRKUP	18-Apr-05	2TE	TE	As	1	VNBC,X	5.96	mg/kg	0.10	BRL	05-0281-2
2005-04	SUICRKUP	19-Apr-05	2TE	TE	As	1	VNBC,X	9.55	mg/kg	0.10	BRL	05-0281-2
2004-11	COYCRKUP	01-Nov-04	2TE	TE	Cd	1	X	0.32	mg/kg	0.00	BRL	05-0073-1
2004-11	NAPRIVUP	02-Nov-04	2TE	TE	Cd	1	X	0.19	mg/kg	0.00	BRL	05-0073-1
2004-11	PETRIVUP	02-Nov-04	2TE	TE	Cd	1	X	0.21	mg/kg	0.00	BRL	05-0073-1
2004-11	SANLORCRKUP	03-Nov-04	2TE	TE	Cd	1	X	0.17	mg/kg	0.00	BRL	05-0073-1
2004-11	SANMATCRKLWR	04-Nov-04	2TE	TE	Cd	1	X	0.39	mg/kg	0.00	BRL	05-0073-1
2004-11	SANMATCRKUP	04-Nov-04	2TE	TE	Cd	1	X	0.26	mg/kg	0.00	BRL	05-0073-1
2004-11	SUICRKUP	03-Nov-04	2TE	TE	Cd	1	X	0.13	mg/kg	0.00	BRL	05-0073-1
2005-04	COYCRKUP	18-Apr-05	2TE	TE	Cd	2	VRIU		mg/kg	0.00	BRL	05-0278
2005-04	NAPRIVUP	19-Apr-05	2TE	TE	Cd	1	VRIU		mg/kg	0.00	BRL	05-0278

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	PETRIVUP	20-Apr-05	2TE	TE	Cd	1	VRIU		mg/kg	0.00	BRL	05-0278
2005-04	SANLORCRKUP	20-Apr-05	2TE	TE	Cd	1	VRIU		mg/kg	0.00	BRL	05-0278
2005-04	SANMATCRKLWR	18-Apr-05	2TE	TE	Cd	1	VRIU		mg/kg	0.00	BRL	05-0278
2005-04	SANMATCRKUP	18-Apr-05	2TE	TE	Cd	1	VRIU		mg/kg	0.00	BRL	05-0278
2005-04	SUICRKUP	19-Apr-05	2TE	TE	Cd	1	VRIU		mg/kg	0.00	BRL	05-0278
2004-11	COYCRKUP	01-Nov-04	2TE	TE	Cu	1	X	27.20	mg/kg	0.04	BRL	05-0073-1
2004-11	NAPRIVUP	02-Nov-04	2TE	TE	Cu	1	X	33.40	mg/kg	0.04	BRL	05-0073-1
2004-11	PETRIVUP	02-Nov-04	2TE	TE	Cu	1	X	34.30	mg/kg	0.04	BRL	05-0073-1
2004-11	SANLORCRKUP	03-Nov-04	2TE	TE	Cu	1	X	20.10	mg/kg	0.04	BRL	05-0073-1
2004-11	SANMATCRKLWR	04-Nov-04	2TE	TE	Cu	1	X	34.30	mg/kg	0.04	BRL	05-0073-1
2004-11	SANMATCRKUP	04-Nov-04	2TE	TE	Cu	1	X	41.40	mg/kg	0.04	BRL	05-0073-1
2004-11	SUICRKUP	03-Nov-04	2TE	TE	Cu	1	X	56.80	mg/kg	0.04	BRL	05-0073-1
2005-04	COYCRKUP	18-Apr-05	2TE	TE	Cu	2	VIP,X	29.03	mg/kg	0.04	BRL	05-0278
2005-04	NAPRIVUP	19-Apr-05	2TE	TE	Cu	1	VIP,X	51.42	mg/kg	0.04	BRL	05-0278
2005-04	PETRIVUP	20-Apr-05	2TE	TE	Cu	1	VIP,X	38.94	mg/kg	0.04	BRL	05-0278
2005-04	SANLORCRKUP	20-Apr-05	2TE	TE	Cu	1	VIP,X	34.02	mg/kg	0.04	BRL	05-0278
2005-04	SANMATCRKLWR	18-Apr-05	2TE	TE	Cu	1	VIP,X	78.37	mg/kg	0.04	BRL	05-0278
2005-04	SANMATCRKUP	18-Apr-05	2TE	TE	Cu	1	VIP,X	67.33	mg/kg	0.04	BRL	05-0278
2005-04	SUICRKUP	19-Apr-05	2TE	TE	Cu	1	VIP,X	51.50	mg/kg	0.04	BRL	05-0278
2004-11	COYCRKUP	01-Nov-04	2TE	TE	Fe	1	X	22167.93	mg/kg	5.60	BRL	05-0073-1
2004-11	NAPRIVUP	02-Nov-04	2TE	TE	Fe	1	X	23157.58	mg/kg	5.60	BRL	05-0073-1
2004-11	PETRIVUP	02-Nov-04	2TE	TE	Fe	1	X	32694.93	mg/kg	5.60	BRL	05-0073-1
2004-11	SANLORCRKUP	03-Nov-04	2TE	TE	Fe	1	X	9313.00	mg/kg	5.60	BRL	05-0073-1
2004-11	SANMATCRKLWR	04-Nov-04	2TE	TE	Fe	1	X	32695.00	mg/kg	5.60	BRL	05-0073-1
2004-11	SANMATCRKUP	04-Nov-04	2TE	TE	Fe	1	X	21237.86	mg/kg	5.60	BRL	05-0073-1
2004-11	SUICRKUP	03-Nov-04	2TE	TE	Fe	1	X	30252.63	mg/kg	5.60	BRL	05-0073-1
2005-04	COYCRKUP	18-Apr-05	2TE	TE	Fe	2	X	25258.57	mg/kg	280.00	BRL	05-0278
2005-04	NAPRIVUP	19-Apr-05	2TE	TE	Fe	1	X	39305.60	mg/kg	280.00	BRL	05-0278
2005-04	PETRIVUP	20-Apr-05	2TE	TE	Fe	1	X	33796.53	mg/kg	280.00	BRL	05-0278
2005-04	SANLORCRKUP	20-Apr-05	2TE	TE	Fe	1	X	18901.71	mg/kg	280.00	BRL	05-0278

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	SANMATCRKLWR	18-Apr-05	2TE	TE	Fe	1	X	60315.02	mg/kg	280.00	BRL	05-0278
2005-04	SANMATCRKUP	18-Apr-05	2TE	TE	Fe	1	X	36328.41	mg/kg	280.00	BRL	05-0278
2005-04	SUICRKUP	19-Apr-05	2TE	TE	Fe	1	X	38891.31	mg/kg	280.00	BRL	05-0278
2004-11	COYCRKLWR	01-Nov-04	2TE	TE	Hg	1	VNBC	0.13	mg/kg	0.00	UCSCDET	UCSCDET-7/28/05-Sediment-HgTot
2004-11	COYCRKUP	01-Nov-04	2TE	TE	Hg	1	VNBC	0.11	mg/kg	0.00	UCSCDET	UCSCDET-7/28/05-Sediment-HgTot
2004-11	NAPRIVLWR	02-Nov-04	2TE	TE	Hg	1	VNBC	0.35	mg/kg	0.00	UCSCDET	UCSCDET-7/28/05-Sediment-HgTot
2004-11	NAPRIVUP	02-Nov-04	2TE	TE	Hg	1	VNBC	0.70	mg/kg	0.00	UCSCDET	UCSCDET-7/28/05-Sediment-HgTot
2004-11	PETRIVLWR	02-Nov-04	2TE	TE	Hg	1	VNBC	0.70	mg/kg	0.00	UCSCDET	UCSCDET-7/28/05-Sediment-HgTot
2004-11	PETRIVUP	02-Nov-04	2TE	TE	Hg	1	VNBC	0.30	mg/kg	0.00	UCSCDET	UCSCDET-7/28/05-Sediment-HgTot
2004-11	SANLORCRKLWR	03-Nov-04	2TE	TE	Hg	1	VNBC	0.08	mg/kg	0.00	UCSCDET	UCSCDET-7/28/05-Sediment-HgTot
2004-11	SANLORCRKUP	03-Nov-04	2TE	TE	Hg	1	VNBC	0.05	mg/kg	0.00	UCSCDET	UCSCDET-7/28/05-Sediment-HgTot
2004-11	SANMATCRKLWR	04-Nov-04	2TE	TE	Hg	1	VNBC	0.25	mg/kg	0.00	UCSCDET	UCSCDET-7/28/05-Sediment-HgTot
2004-11	SANMATCRKUP	04-Nov-04	2TE	TE	Hg	1	VNBC	0.14	mg/kg	0.00	UCSCDET	UCSCDET-7/28/05-Sediment-HgTot
2004-11	SANMATCRKUP-SUB	04-Nov-04	2TE	TE	Hg	1	VNBC	0.24	mg/kg	0.00	UCSCDET	UCSCDET-7/28/05-Sediment-HgTot
2004-11	SUICRKLWR	03-Nov-04	2TE	TE	Hg	1	VNBC	0.20	mg/kg	0.00	UCSCDET	UCSCDET-7/28/05-Sediment-HgTot
2004-11	SUICRKUP	03-Nov-04	2TE	TE	Hg	1	VNBC	0.06	mg/kg	0.00	UCSCDET	UCSCDET-7/28/05-Sediment-HgTot
2005-04	COYCRKLWR	18-Apr-05	2TE	TE	Hg	3	VNBC	0.17	mg/kg	0.00	UCSCDET	UCSCDET-7/28/05-Sediment-HgTot
2005-04	COYCRKUP	18-Apr-05	2TE	TE	Hg	1	VNBC	0.07	mg/kg	0.00	UCSCDET	UCSCDET-7/28/05-Sediment-HgTot
2005-04	NAPRIVLWR	19-Apr-05	2TE	TE	Hg	3	BRKA,VNBC	0.28	mg/kg	0.00	UCSCDET	UCSCDET-7/28/05-Sediment-HgTot
2005-04	NAPRIVUP	19-Apr-05	2TE	TE	Hg	2	BRKA,VNBC	1.53	mg/kg	0.00	UCSCDET	UCSCDET-7/28/05-Sediment-HgTot
2005-04	PETRIVLWR	20-Apr-05	2TE	TE	Hg	1	VNBC	0.33	mg/kg	0.00	UCSCDET	UCSCDET-7/28/05-Sediment-

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	PETRIVUP	20-Apr-052TE	TE		Hg	2	VNBC	0.30	mg/kg	0.00	UCSCDET	UCSCDET-7/28/05-Sediment-HgTot
2005-04	SANLORCRKLWR	20-Apr-052TE	TE		Hg	1	VNBC	0.03	mg/kg	0.00	UCSCDET	UCSCDET-7/28/05-Sediment-HgTot
2005-04	SANLORCRKUP	20-Apr-052TE	TE		Hg	1	VNBC	0.05	mg/kg	0.00	UCSCDET	UCSCDET-7/28/05-Sediment-HgTot
2005-04	SANMATCRKLWR	18-Apr-052TE	TE		Hg	1	VNBC	0.28	mg/kg	0.00	UCSCDET	UCSCDET-7/28/05-Sediment-HgTot
2005-04	SANMATCRKUP	18-Apr-052TE	TE		Hg	1	VNBC	0.15	mg/kg	0.00	UCSCDET	UCSCDET-7/28/05-Sediment-HgTot
2005-04	SUICRKLWR	19-Apr-052TE	TE		Hg	1	BRKA,VNBC	0.14	mg/kg	0.00	UCSCDET	UCSCDET-7/28/05-Sediment-HgTot
2005-04	SUICRKUP	19-Apr-052TE	TE		Hg	1	VNBC	0.04	mg/kg	0.00	UCSCDET	UCSCDET-7/28/05-Sediment-HgTot
2004-11	COYCRKLWR	01-Nov-042TE	TE		MeHg	1	VJ	0.83	ug/kg	0.02	UCSCDET	EPW04_UCSCDETMEHG
2004-11	COYCRKUP	01-Nov-042TE	TE		MeHg	1	X	0.05	ug/kg	0.02	UCSCDET	EPW04_UCSCDETMEHG
2004-11	NAPRIVLWR	02-Nov-042TE	TE		MeHg	1	VJ	0.68	ug/kg	0.04	UCSCDET	EPW04_UCSCDETMEHG
2004-11	NAPRIVUP	02-Nov-042TE	TE		MeHg	1	VJ	0.21	ug/kg	0.02	UCSCDET	EPW04_UCSCDETMEHG
2004-11	PETRIVLWR	02-Nov-042TE	TE		MeHg	1	X	0.15	ug/kg	0.05	UCSCDET	EPW04_UCSCDETMEHG
2004-11	PETRIVUP	02-Nov-042TE	TE		MeHg	1	X	1.18	ug/kg	0.04	UCSCDET	EPW04_UCSCDETMEHG
2004-11	SANLORCRKLWR	03-Nov-042TE	TE		MeHg	1	NA X		ug/kg		UCSCDET	EPW04_UCSCDETMEHG
2004-11	SANLORCRKUP	03-Nov-042TE	TE		MeHg	1	X	0.05	ug/kg	0.02	UCSCDET	EPW04_UCSCDETMEHG
2004-11	SANMATCRKLWR	04-Nov-042TE	TE		MeHg	2	X	2.41	ug/kg	0.04	UCSCDET	EPW04_UCSCDETMEHG
2004-11	SANMATCRKUP	04-Nov-042TE	TE		MeHg	1	X	1.35	ug/kg	0.01	UCSCDET	EPW04_UCSCDETMEHG
2004-11	SUICRKLWR	03-Nov-042TE	TE		MeHg	1	X	2.19	ug/kg	0.03	UCSCDET	EPW04_UCSCDETMEHG
2004-11	SUICRKUP	03-Nov-042TE	TE		MeHg	1	VJ	0.18	ug/kg	0.04	UCSCDET	EPW04_UCSCDETMEHG
2005-04	COYCRKLWR	18-Apr-052TE	TE		MeHg	4	VNBC,X	0.72	ug/kg	0.00	UCSCDET	EPTOX05
2005-04	COYCRKUP	18-Apr-052TE	TE		MeHg	1	VNBC,X	0.77	ug/kg	0.00	UCSCDET	EPTOX05
2005-04	NAPRIVLWR	19-Apr-052TE	TE		MeHg	1	VNBC,X	3.10	ug/kg	0.01	UCSCDET	EPTOX05
2005-04	NAPRIVUP	19-Apr-052TE	TE		MeHg	1	VNBC,X	0.45	ug/kg	0.00	UCSCDET	EPTOX05
2005-04	PETRIVLWR	20-Apr-052TE	TE		MeHg	2	ND VNBC,X	0.09	ug/kg	0.00	UCSCDET	EPTOX05
2005-04	PETRIVUP	20-Apr-052TE	TE		MeHg	1	VNBC,X	1.54	ug/kg	0.00	UCSCDET	EPTOX05

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	SANLORCRKLWR	20-Apr-05	2TE	TE	MeHg	1	VNBC,X	0.49	ug/kg	0.00	UCSCDETEPTOX	05
2005-04	SANLORCRKUP	20-Apr-05	2TE	TE	MeHg	1	VNBC,X	0.30	ug/kg	0.00	UCSCDETEPTOX	05
2005-04	SANMATCRKLWR	18-Apr-05	2TE	TE	MeHg	1	VNBC,X	5.15	ug/kg	0.01	UCSCDETEPTOX	05
2005-04	SANMATCRKUP	18-Apr-05	2TE	TE	MeHg	1	VNBC,X	5.31	ug/kg	0.00	UCSCDETEPTOX	05
2005-04	SUICRKLWR	19-Apr-05	2TE	TE	MeHg	1	VNBC,X	0.81	ug/kg	0.00	UCSCDETEPTOX	05
2005-04	SUICRKUP	19-Apr-05	2TE	TE	MeHg	1	VNBC,X	0.34	ug/kg	0.00	UCSCDETEPTOX	05
2004-11	COYCRKUP	01-Nov-04	2TE	TE	Mn	1	X	523.00	mg/kg	0.06	BRL	05-0073-2
2004-11	NAPRIVUP	02-Nov-04	2TE	TE	Mn	1	X	845.00	mg/kg	0.06	BRL	05-0073-2
2004-11	PETRIVUP	02-Nov-04	2TE	TE	Mn	1	X	686.00	mg/kg	0.06	BRL	05-0073-2
2004-11	SANLORCRKUP	03-Nov-04	2TE	TE	Mn	1	X	364.00	mg/kg	0.06	BRL	05-0073-2
2004-11	SANMATCRKLWR	04-Nov-04	2TE	TE	Mn	1	X	778.00	mg/kg	0.06	BRL	05-0073-2
2004-11	SANMATCRKUP	04-Nov-04	2TE	TE	Mn	1	X	567.00	mg/kg	0.06	BRL	05-0073-2
2004-11	SUICRKUP	03-Nov-04	2TE	TE	Mn	1	X	1134.00	mg/kg	0.06	BRL	05-0073-2
2005-04	COYCRKUP	18-Apr-05	2TE	TE	Mn	2	VIP,X	531.62	mg/kg	0.05	BRL	05-0278
2005-04	NAPRIVUP	19-Apr-05	2TE	TE	Mn	1	VIP,X	816.00	mg/kg	0.05	BRL	05-0278
2005-04	PETRIVUP	20-Apr-05	2TE	TE	Mn	1	VIP,X	1115.11	mg/kg	0.05	BRL	05-0278
2005-04	SANLORCRKUP	20-Apr-05	2TE	TE	Mn	1	VIP,X	646.64	mg/kg	0.05	BRL	05-0278
2005-04	SANMATCRKLWR	18-Apr-05	2TE	TE	Mn	1	VIP,X	749.14	mg/kg	0.05	BRL	05-0278
2005-04	SANMATCRKUP	18-Apr-05	2TE	TE	Mn	1	VIP,X	842.82	mg/kg	0.05	BRL	05-0278
2005-04	SUICRKUP	19-Apr-05	2TE	TE	Mn	1	VIP,X	837.32	mg/kg	0.05	BRL	05-0278
2004-11	COYCRKUP	01-Nov-04	2TE	TE	Ni	1	VIU	83.20	mg/kg	0.04	BRL	05-0073-1
2004-11	NAPRIVUP	02-Nov-04	2TE	TE	Ni	1	VIU	54.70	mg/kg	0.04	BRL	05-0073-1
2004-11	PETRIVUP	02-Nov-04	2TE	TE	Ni	1	VIU	63.80	mg/kg	0.04	BRL	05-0073-1
2004-11	SANLORCRKUP	03-Nov-04	2TE	TE	Ni	1	VIU	9.33	mg/kg	0.04	BRL	05-0073-1
2004-11	SANMATCRKLWR	04-Nov-04	2TE	TE	Ni	1	VIU	124.00	mg/kg	0.04	BRL	05-0073-1
2004-11	SANMATCRKUP	04-Nov-04	2TE	TE	Ni	1	VIU	125.00	mg/kg	0.04	BRL	05-0073-1
2004-11	SUICRKUP	03-Nov-04	2TE	TE	Ni	1	VIU	33.20	mg/kg	0.04	BRL	05-0073-1
2005-04	COYCRKUP	18-Apr-05	2TE	TE	Ni	2	VIP,X	86.73	mg/kg	0.04	BRL	05-0278
2005-04	NAPRIVUP	19-Apr-05	2TE	TE	Ni	1	VIP,X	97.61	mg/kg	0.04	BRL	05-0278
2005-04	PETRIVUP	20-Apr-05	2TE	TE	Ni	1	X	69.31	mg/kg	0.04	BRL	05-0278

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	SANLORCRKUP	20-Apr-052	TE		Ni	1	VIP,X	32.83	mg/kg	0.04	BRL	05-0278
2005-04	SANMATCRKLWR	18-Apr-052	TE		Ni	1	VIP,X	149.83	mg/kg	0.04	BRL	05-0278
2005-04	SANMATCRKUP	18-Apr-052	TE		Ni	1	VIP,X	196.66	mg/kg	0.04	BRL	05-0278
2005-04	SUICRKUP	19-Apr-052	TE		Ni	1	VIP,X	61.17	mg/kg	0.04	BRL	05-0278
2004-11	COYCRKUP	01-Nov-042	TE		Pb	1	VIL	23.00	mg/kg	0.01	BRL	05-0073-1
2004-11	NAPRIVUP	02-Nov-042	TE		Pb	1	VIL	63.00	mg/kg	0.01	BRL	05-0073-1
2004-11	PETRIVUP	02-Nov-042	TE		Pb	1	VIL	36.80	mg/kg	0.01	BRL	05-0073-1
2004-11	SANLORCRKUP	03-Nov-042	TE		Pb	1	VIL	18.80	mg/kg	0.01	BRL	05-0073-1
2004-11	SANMATCRKLWR	04-Nov-042	TE		Pb	1	VIL	58.60	mg/kg	0.01	BRL	05-0073-1
2004-11	SANMATCRKUP	04-Nov-042	TE		Pb	1	VIL	48.30	mg/kg	0.01	BRL	05-0073-1
2004-11	SUICRKUP	03-Nov-042	TE		Pb	1	VIL	18.50	mg/kg	0.01	BRL	05-0073-1
2005-04	COYCRKUP	18-Apr-052	TE		Pb	2	X	18.62	mg/kg	0.01	BRL	05-0278
2005-04	NAPRIVUP	19-Apr-052	TE		Pb	1	X	87.13	mg/kg	0.01	BRL	05-0278
2005-04	PETRIVUP	20-Apr-052	TE		Pb	1	X	33.80	mg/kg	0.01	BRL	05-0278
2005-04	SANLORCRKUP	20-Apr-052	TE		Pb	1	X	42.98	mg/kg	0.01	BRL	05-0278
2005-04	SANMATCRKLWR	18-Apr-052	TE		Pb	1	X	48.79	mg/kg	0.01	BRL	05-0278
2005-04	SANMATCRKUP	18-Apr-052	TE		Pb	1	X	52.56	mg/kg	0.01	BRL	05-0278
2005-04	SUICRKUP	19-Apr-052	TE		Pb	1	X	20.90	mg/kg	0.01	BRL	05-0278
2004-11	COYCRKUP	01-Nov-042	TE		Se	1	VIU,VNBC	0.35	mg/kg	0.00	BRL	04-1036-1
2004-11	NAPRIVUP	02-Nov-042	TE		Se	1	VIU,VNBC	0.09	mg/kg	0.00	BRL	04-1036-1
2004-11	PETRIVUP	02-Nov-042	TE		Se	1	VIU,VNBC	0.12	mg/kg	0.00	BRL	04-1036-1
2004-11	SANLORCRKUP	03-Nov-042	TE		Se	1	VIU,VNBC	0.68	mg/kg	0.00	BRL	04-1036-1
2004-11	SANMATCRKLWR	04-Nov-042	TE		Se	2	VIU,VNBC	0.38	mg/kg	0.00	BRL	05-0076-5
2004-11	SANMATCRKUP	04-Nov-042	TE		Se	2	VIU,VNBC	0.06	mg/kg	0.00	BRL	04-1036-1
2004-11	SUICRKUP	03-Nov-042	TE		Se	1	VIU,VNBC	0.17	mg/kg	0.00	BRL	04-1036-1
2005-04	COYCRKUP	18-Apr-052	TE		Se	1	X	0.13	mg/kg	0.01	BRL	05-0284-1
2005-04	NAPRIVUP	19-Apr-052	TE		Se	2	X	0.11	mg/kg	0.01	BRL	05-0284-1
2005-04	PETRIVUP	20-Apr-052	TE		Se	1	X	0.07	mg/kg	0.01	BRL	05-0284-1
2005-04	SANLORCRKUP	20-Apr-052	TE		Se	1	X	0.16	mg/kg	0.01	BRL	05-0284-1
2005-04	SANMATCRKLWR	18-Apr-052	TE		Se	1	X	0.11	mg/kg	0.01	BRL	05-0284-1

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	SANMATCRKUP	18-Apr-05	2TE	TE	Se	1	X	0.06	mg/kg	0.01	BRL	05-0284-1
2005-04	SUICRKUP	19-Apr-05	2TE	TE	Se	1	X	0.17	mg/kg	0.01	BRL	05-0284-1
2004-11	COYCRKUP	01-Nov-04	2TE	TE	Zn	1	X	123.00	mg/kg	0.08	BRL	05-0073-1
2004-11	NAPRIVUP	02-Nov-04	2TE	TE	Zn	1	X	123.00	mg/kg	0.08	BRL	05-0073-1
2004-11	PETRIVUP	02-Nov-04	2TE	TE	Zn	1	X	112.00	mg/kg	0.08	BRL	05-0073-1
2004-11	SANLORCRKUP	03-Nov-04	2TE	TE	Zn	1	X	62.50	mg/kg	0.08	BRL	05-0073-1
2004-11	SANMATCRKLWR	04-Nov-04	2TE	TE	Zn	1	X	198.00	mg/kg	0.08	BRL	05-0073-1
2004-11	SANMATCRKUP	04-Nov-04	2TE	TE	Zn	1	X	146.00	mg/kg	0.08	BRL	05-0073-1
2004-11	SUICRKUP	03-Nov-04	2TE	TE	Zn	1	X	90.00	mg/kg	0.08	BRL	05-0073-1
2005-04	COYCRKUP	18-Apr-05	2TE	TE	Zn	2	VIP,X	117.03	mg/kg	0.08	BRL	05-0278
2005-04	NAPRIVUP	19-Apr-05	2TE	TE	Zn	1	VIP,X	157.06	mg/kg	0.08	BRL	05-0278
2005-04	PETRIVUP	20-Apr-05	2TE	TE	Zn	1	X	133.99	mg/kg	0.08	BRL	05-0278
2005-04	SANLORCRKUP	20-Apr-05	2TE	TE	Zn	1	VIP,X	184.24	mg/kg	0.08	BRL	05-0278
2005-04	SANMATCRKLWR	18-Apr-05	2TE	TE	Zn	1	VIP,X	214.68	mg/kg	0.08	BRL	05-0278
2005-04	SANMATCRKUP	18-Apr-05	2TE	TE	Zn	1	VIP,X	228.38	mg/kg	0.08	BRL	05-0278
2005-04	SUICRKUP	19-Apr-05	2TE	TE	Zn	1	VIP,X	110.14	mg/kg	0.08	BRL	05-0278

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Appendix Table C.3. Sediment trace organic results for PAHs from the ambient tributary study in watersheds of the San Francisco Estuary (2004-2005). N = number of replicates. % solids was reported by each analytical laboratory. DFG-WPCL analyzed all trace organic samples in this study.

Sum of PAHs (all target PAHs listed in table 1.3) and low molecular weight PAHs:

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	COYCRKLWR	18-Apr-05	3ORG	0ANC	% Solids - SED-ORG-CDFGWPCL	1	VNBC	53.10	%		DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	0ANC	% Solids - SED-ORG-CDFGWPCL	1	VNBC	75.90	%		DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	0ANC	% Solids - SED-ORG-CDFGWPCL	2	VNBC	74.40	%		DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	0ANC	% Solids - SED-ORG-CDFGWPCL	1	VNBC	41.90	%		DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	0ANC	% Solids - SED-ORG-CDFGWPCL	1	VNBC	71.40	%		DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	0ANC	% Solids - SED-ORG-CDFGWPCL	1	VNBC	67.70	%		DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	0ANC	% Solids - SED-ORG-CDFGWPCL	1	VNBC	27.00	%		DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	0ANC	% Solids - SED-ORG-CDFGWPCL	2	VNBC	55.10	%		DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	0ANC	% Solids - SED-ORG-CDFGWPCL	1	VNBC	54.00	%		DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	0ANC	% Solids - SED-ORG-CDFGWPCL	1	VNBC	69.90	%		DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	0ANC	% Solids - SED-ORG-CDFGWPCL	1	VNBC	74.80	%		DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	0ANC	% Solids - SED-ORG-CDFGWPCL	1	VNBC	55.90	%		DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	0ANC	% Solids - SED-ORG-CDFGWPCL	1	VNBC	42.30	%		DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	0ANC	% Solids - SED-ORG-CDFGWPCL	1	VNBC	31.10	%		DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	0ANC	% Solids - SED-ORG-CDFGWPCL	1	VNBC	69.40	%		DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	0ANC	% Solids - SED-ORG-CDFGWPCL	1	VNBC	54.30	%		DFG-WPCL	WPCL_L-192-05_BS373_KR_S_OCH
2005-04	SUICRKLWR	19-Apr-05	3ORG	0ANC	% Solids - SED-ORG-CDFGWPCL	1	VNBC	52.10	%		DFG-WPCL	WPCL_L-211-05_S_PAH

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2004-11	SUICRKUP	03-Nov-04	3ORG	0ANC	% Solids - SED-ORG-CDFGWPCL	1 VNBC	64.90	%		DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	0ANC	% Solids - SED-ORG-CDFGWPCL	1 VNBC	72.00	%		DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	1APAH	Sum of PAHs (SFEI)	1 X	686.35	ug/kg	1.35	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	1APAH	Sum of PAHs (SFEI)	1 X	541.17	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	1APAH	Sum of PAHs (SFEI)	2 X	266.75	ug/kg	1.03	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	1APAH	Sum of PAHs (SFEI)	1 X	441.69	ug/kg	1.84	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	1APAH	Sum of PAHs (SFEI)	1 X	240.16	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	1APAH	Sum of PAHs (SFEI)	1 X	232.95	ug/kg	1.13	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	1APAH	Sum of PAHs (SFEI)	1 X	1147.50	ug/kg	2.86	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	1APAH	Sum of PAHs (SFEI)	2 X	600.87	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	1APAH	Sum of PAHs (SFEI)	1 X	534.17	ug/kg	1.44	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	1APAH	Sum of PAHs (SFEI)	1 X	803.59	ug/kg	1.08	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	1APAH	Sum of PAHs (SFEI)	1 X	1103.86	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	1APAH	Sum of PAHs (SFEI)	1 X	3014.98	ug/kg	1.35	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	1APAH	Sum of PAHs (SFEI)	1 X	1643.47	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	1APAH	Sum of PAHs (SFEI)	1 X	1549.76	ug/kg	2.43	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	1APAH	Sum of PAHs (SFEI)	1 X	3035.00	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	1APAH	Sum of PAHs (SFEI)	1 X	1603.55	ug/kg	1.42	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	1APAH	Sum of PAHs (SFEI)	1 X	237.16	ug/kg	1.49	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	1APAH	Sum of PAHs (SFEI)	1 X	66.84	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	1APAH	Sum of PAHs (SFEI)	1 X	42.52	ug/kg	1.08	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	1LAPAH	Sum of LPAHs (SFEI)	1 X	107.25	ug/kg	1.02	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	1LAPAH	Sum of LPAHs (SFEI)	1 X	147.17	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	1LAPAH	Sum of LPAHs (SFEI)	2 X	60.88	ug/kg	0.78	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	1LAPAH	Sum of LPAHs (SFEI)	1 X	210.45	ug/kg	1.39	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	1LAPAH	Sum of LPAHs (SFEI)	1 X	108.95	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	1LAPAH	Sum of LPAHs (SFEI)	1 X	123.22	ug/kg	0.86	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	1LAPAH	Sum of LPAHs (SFEI)	1 X	161.70	ug/kg	2.17	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	1LAPAH	Sum of LPAHs (SFEI)	2 X	78.53	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	PETRIVUP	20-Apr-05	3ORG	1LAPAH	Sum of LPAHs (SFEI)	1	X	134.47	ug/kg	1.09	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	1LAPAH	Sum of LPAHs (SFEI)	1	X	86.69	ug/kg	0.82	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	1LAPAH	Sum of LPAHs (SFEI)	1	X	120.86	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	1LAPAH	Sum of LPAHs (SFEI)	1	X	311.98	ug/kg	1.02	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	1LAPAH	Sum of LPAHs (SFEI)	1	X	236.47	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	1LAPAH	Sum of LPAHs (SFEI)	1	X	226.66	ug/kg	1.84	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	1LAPAH	Sum of LPAHs (SFEI)	1	X	393.90	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	1LAPAH	Sum of LPAHs (SFEI)	1	X	248.05	ug/kg	1.07	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	1LAPAH	Sum of LPAHs (SFEI)	1	X	45.91	ug/kg	1.13	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	1LAPAH	Sum of LPAHs (SFEI)	1	X	6.16	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	1LAPAH	Sum of LPAHs (SFEI)	1	X	12.92	ug/kg	0.82	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	1LPAH	1-Methylnaphthalene	1	SC,VNBC	5.35	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	1LPAH	1-Methylnaphthalene	1	ND VIL,GN,H,SC,VNBC	0.00	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	1LPAH	1-Methylnaphthalene	2	SC,VNBC	3.91	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	1LPAH	1-Methylnaphthalene	1	SC,VNBC	23.10	ug/kg	1.18	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	1LPAH	1-Methylnaphthalene	1	VIL,H,SC,VNBC	14.40	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	1LPAH	1-Methylnaphthalene	1	SC,VNBC	15.40	ug/kg	0.73	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	1LPAH	1-Methylnaphthalene	1	SC,VNBC	7.52	ug/kg	1.84	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	1LPAH	1-Methylnaphthalene	2	VIL,H,IL,SC,VNBC	4.21	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	1LPAH	1-Methylnaphthalene	1	SC,VNBC	6.56	ug/kg	0.92	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	1LPAH	1-Methylnaphthalene	1	ND SC,VNBC	0.00	ug/kg	0.70	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	1LPAH	1-Methylnaphthalene	1	ND VIL,H,SC,VNBC	0.00	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	1LPAH	1-Methylnaphthalene	1	SC,VNBC	5.37	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	1LPAH	1-Methylnaphthalene	1	VIL,H,SC,VNBC	11.50	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	1LPAH	1-Methylnaphthalene	1	SC,VNBC	8.88	ug/kg	1.56	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	1LPAH	1-Methylnaphthalene	1	VIL,H,SC,VNBC	11.80	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	1LPAH	1-Methylnaphthalene	1	SC,VNBC	11.10	ug/kg	0.91	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	1LPAH	1-Methylnaphthalene	1	SC,VNBC	3.51	ug/kg	0.96	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	1LPAH	1-Methylnaphthalene	1	ND VIL,H,SC,VNBC	0.00	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	SUICRKUP	19-Apr-05	3ORG	1LPAH	1-Methylnaphthalene	1 SC,VNBC	1.88	ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	1LPAH	1-Methylphenanthrene	1 SC,VNBC	6.27	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	1LPAH	1-Methylphenanthrene	1 H,SC,VNBC	5.13	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	1LPAH	1-Methylphenanthrene	2 SC,VNBC	3.90	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	1LPAH	1-Methylphenanthrene	1 SC,VNBC	13.30	ug/kg	1.18	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	1LPAH	1-Methylphenanthrene	1 H,SC,VNBC	8.97	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	1LPAH	1-Methylphenanthrene	1 SC,VNBC	10.10	ug/kg	0.73	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	1LPAH	1-Methylphenanthrene	1 SC,VNBC	8.99	ug/kg	1.84	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	1LPAH	1-Methylphenanthrene	2 H,SC,VNBC	5.80	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	1LPAH	1-Methylphenanthrene	1 SC,VNBC	8.45	ug/kg	0.92	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	1LPAH	1-Methylphenanthrene	1 SC,VNBC	5.79	ug/kg	0.70	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	1LPAH	1-Methylphenanthrene	1 H,SC,VNBC	6.74	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	1LPAH	1-Methylphenanthrene	1 SC,VNBC	17.50	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	1LPAH	1-Methylphenanthrene	1 H,SC,VNBC	14.00	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	1LPAH	1-Methylphenanthrene	1 SC,VNBC	13.30	ug/kg	1.56	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	1LPAH	1-Methylphenanthrene	1 H,SC,VNBC	29.00	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	1LPAH	1-Methylphenanthrene	1 SC,VNBC	19.70	ug/kg	0.91	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	1LPAH	1-Methylphenanthrene	1 SC,VNBC	2.68	ug/kg	0.96	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	1LPAH	1-Methylphenanthrene	1ND H,SC,VNBC	0.00	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	1LPAH	1-Methylphenanthrene	1ND SC,VNBC	0.00	ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	1LPAH	2,3,5-Trimethylnaphthalene	1 VIU,SC,VNBC	1.99	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	1LPAH	2,3,5-Trimethylnaphthalene	1 VRIU,H,SC,VNBC		ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	1LPAH	2,3,5-Trimethylnaphthalene	2ND VIU,SC,VNBC	0.00	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	1LPAH	2,3,5-Trimethylnaphthalene	1 VIU,SC,VNBC	6.64	ug/kg	1.18	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	1LPAH	2,3,5-Trimethylnaphthalene	1 VRIU,H,SC,VNBC		ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	1LPAH	2,3,5-Trimethylnaphthalene	1 VIU,SC,VNBC	5.21	ug/kg	0.73	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	1LPAH	2,3,5-Trimethylnaphthalene	1ND VIU,SC,VNBC	0.00	ug/kg	1.84	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	1LPAH	2,3,5-Trimethylnaphthalene	2 VRIU,H,IL,SC,VNBC		ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	1LPAH	2,3,5-Trimethylnaphthalene	1 VIU,SC,VNBC	3.03	ug/kg	0.92	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	1LPAH	2,3,5-Trimethylnaphthalene	1ND VIU,SC,VNBC	0.00	ug/kg	0.70	DFG-WPCL	WPCL_L-211-05_S_PAH

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2004-11	SANLORCRKUP	03-Nov-04	3ORG	1LPAH	2,3,5-Trimethylnaphthalene	1	ND VRIU,H,SC,VNBC	0.00	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	1LPAH	2,3,5-Trimethylnaphthalene	1	ND VIU,SC,VNBC	0.00	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	1LPAH	2,3,5-Trimethylnaphthalene	1	VRIU,H,SC,VNBC		ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	1LPAH	2,3,5-Trimethylnaphthalene	1	ND VIU,SC,VNBC	0.00	ug/kg	1.56	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	1LPAH	2,3,5-Trimethylnaphthalene	1	VRIU,H,SC,VNBC		ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	1LPAH	2,3,5-Trimethylnaphthalene	1	VIU,SC,VNBC	3.36	ug/kg	0.91	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	1LPAH	2,3,5-Trimethylnaphthalene	1	ND VIU,SC,VNBC	0.00	ug/kg	0.96	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	1LPAH	2,3,5-Trimethylnaphthalene	1	ND VRIU,H,SC,VNBC	0.00	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	1LPAH	2,3,5-Trimethylnaphthalene	1	ND VIU,SC,VNBC	0.00	ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	1LPAH	2,6-Dimethylnaphthalene	1	SC,VNBC	8.64	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	1LPAH	2,6-Dimethylnaphthalene	1	GN,H,SC,VNBC	5.66	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	1LPAH	2,6-Dimethylnaphthalene	2	SC,VNBC	4.33	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	1LPAH	2,6-Dimethylnaphthalene	1	SC,VNBC	20.90	ug/kg	1.18	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	1LPAH	2,6-Dimethylnaphthalene	1	H,SC,VNBC	14.20	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	1LPAH	2,6-Dimethylnaphthalene	1	SC,VNBC	13.30	ug/kg	0.73	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	1LPAH	2,6-Dimethylnaphthalene	1	SC,VNBC	12.90	ug/kg	1.84	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	1LPAH	2,6-Dimethylnaphthalene	2	H,SC,VNBC	3.99	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	1LPAH	2,6-Dimethylnaphthalene	1	SC,VNBC	9.29	ug/kg	0.92	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	1LPAH	2,6-Dimethylnaphthalene	1	SC,VNBC	2.55	ug/kg	0.70	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	1LPAH	2,6-Dimethylnaphthalene	1	H,SC,VNBC	5.30	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	1LPAH	2,6-Dimethylnaphthalene	1	SC,VNBC	5.05	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	1LPAH	2,6-Dimethylnaphthalene	1	H,SC,VNBC	11.40	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	1LPAH	2,6-Dimethylnaphthalene	1	SC,VNBC	14.80	ug/kg	1.56	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	1LPAH	2,6-Dimethylnaphthalene	1	H,SC,VNBC	10.30	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	1LPAH	2,6-Dimethylnaphthalene	1	SC,VNBC	17.30	ug/kg	0.91	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	1LPAH	2,6-Dimethylnaphthalene	1	SC,VNBC	4.64	ug/kg	0.96	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	1LPAH	2,6-Dimethylnaphthalene	1	ND H,SC,VNBC	0.00	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	1LPAH	2,6-Dimethylnaphthalene	1	SC,VNBC	1.60	ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	1LPAH	2-Methylnaphthalene	1	SC,VNBC	11.50	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	1LPAH	2-Methylnaphthalene	1	GN,H,SC,VNBC	44.70	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	COYCRKUP	18-Apr-05	3ORG	1LPAH	2-Methylnaphthalene	2	SC,VNBC	8.66	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	1LPAH	2-Methylnaphthalene	1	SC,VNBC	42.30	ug/kg	1.18	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	1LPAH	2-Methylnaphthalene	1	H,SC,VNBC	20.30	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	1LPAH	2-Methylnaphthalene	1	SC,VNBC	24.70	ug/kg	0.73	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	1LPAH	2-Methylnaphthalene	1	SC,VNBC	14.80	ug/kg	1.84	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	1LPAH	2-Methylnaphthalene	2	H,IL,SC,VNBC	6.55	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	1LPAH	2-Methylnaphthalene	1	SC,VNBC	11.40	ug/kg	0.92	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	1LPAH	2-Methylnaphthalene	1	SC,VNBC	2.65	ug/kg	0.70	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	1LPAH	2-Methylnaphthalene	1	H,SC,VNBC	2.41	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	1LPAH	2-Methylnaphthalene	1	SC,VNBC	9.65	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	1LPAH	2-Methylnaphthalene	1	H,SC,VNBC	20.10	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	1LPAH	2-Methylnaphthalene	1	SC,VNBC	16.10	ug/kg	1.56	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	1LPAH	2-Methylnaphthalene	1	H,SC,VNBC	18.90	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	1LPAH	2-Methylnaphthalene	1	SC,VNBC	18.90	ug/kg	0.91	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	1LPAH	2-Methylnaphthalene	1	SC,VNBC	6.37	ug/kg	0.96	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	1LPAH	2-Methylnaphthalene	1	ND H,SC,VNBC	0.00	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	1LPAH	2-Methylnaphthalene	1	SC,VNBC	2.84	ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	1LPAH	Acenaphthene	1	VIU,SC,VNBC	1.84	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	1LPAH	Acenaphthene	1	ND H,SC,VNBC	0.00	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	1LPAH	Acenaphthene	2	ND VIU,SC,VNBC	0.00	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	1LPAH	Acenaphthene	1	VIU,SC,VNBC	3.19	ug/kg	1.18	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	1LPAH	Acenaphthene	1	ND H,SC,VNBC	0.00	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	1LPAH	Acenaphthene	1	ND VIU,SC,VNBC	0.00	ug/kg	0.73	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	1LPAH	Acenaphthene	1	ND VIU,SC,VNBC	0.00	ug/kg	1.84	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	1LPAH	Acenaphthene	2	ND H,SC,VNBC	0.00	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	1LPAH	Acenaphthene	1	VIU,SC,VNBC	3.24	ug/kg	0.92	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	1LPAH	Acenaphthene	1	VIU,SC,VNBC	2.18	ug/kg	0.70	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	1LPAH	Acenaphthene	1	H,SC,VNBC	4.49	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	1LPAH	Acenaphthene	1	VIU,SC,VNBC	9.13	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	1LPAH	Acenaphthene	1	H,SC,VNBC	4.22	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	1LPAH	Acenaphthene	1	VIU,SC,VNBC	5.64	ug/kg	1.56	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	1LPAH	Acenaphthene	1	H,SC,VNBC	10.40	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	1LPAH	Acenaphthene	1	VIU,SC,VNBC	4.05	ug/kg	0.91	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	1LPAH	Acenaphthene	1	ND VIU,SC,VNBC	0.00	ug/kg	0.96	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	1LPAH	Acenaphthene	1	ND H,SC,VNBC	0.00	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	1LPAH	Acenaphthene	1	ND VIU,SC,VNBC	0.00	ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	1LPAH	Acenaphthylene	1	SC,VNBC	2.59	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	1LPAH	Acenaphthylene	1	ND H,SC,VNBC	0.00	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	1LPAH	Acenaphthylene	2	ND SC,VNBC	0.00	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	1LPAH	Acenaphthylene	1	ND SC,VNBC	0.00	ug/kg	1.18	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	1LPAH	Acenaphthylene	1	ND H,SC,VNBC	0.00	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	1LPAH	Acenaphthylene	1	ND SC,VNBC	0.00	ug/kg	0.73	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	1LPAH	Acenaphthylene	1	SC,VNBC	5.79	ug/kg	1.84	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	1LPAH	Acenaphthylene	2	H,SC,VNBC	2.65	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	1LPAH	Acenaphthylene	1	SC,VNBC	3.38	ug/kg	0.92	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	1LPAH	Acenaphthylene	1	ND SC,VNBC	0.00	ug/kg	0.70	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	1LPAH	Acenaphthylene	1	ND H,SC,VNBC	0.00	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	1LPAH	Acenaphthylene	1	SC,VNBC	3.17	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	1LPAH	Acenaphthylene	1	H,SC,VNBC	7.91	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	1LPAH	Acenaphthylene	1	SC,VNBC	7.49	ug/kg	1.56	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	1LPAH	Acenaphthylene	1	H,SC,VNBC	3.25	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	1LPAH	Acenaphthylene	1	SC,VNBC	2.17	ug/kg	0.91	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	1LPAH	Acenaphthylene	1	ND SC,VNBC	0.00	ug/kg	0.96	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	1LPAH	Acenaphthylene	1	ND H,SC,VNBC	0.00	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	1LPAH	Acenaphthylene	1	ND SC,VNBC	0.00	ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	1LPAH	Anthracene	1	SC,VNBC	7.23	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	1LPAH	Anthracene	1	H,SC,VNBC	4.11	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	1LPAH	Anthracene	2	SC,VNBC	2.14	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	1LPAH	Anthracene	1	SC,VNBC	3.93	ug/kg	1.18	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	1LPAH	Anthracene	1	H,SC,VNBC	1.47	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	NAPRIVUP	19-Apr-05	3ORG	1LPAH	Anthracene	1 SC,VNBC	1.51	ug/kg	0.73	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	1LPAH	Anthracene	1 SC,VNBC	16.90	ug/kg	1.84	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	1LPAH	Anthracene	2 H,SC,VNBC	6.40	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	1LPAH	Anthracene	1 SC,VNBC	8.45	ug/kg	0.92	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	1LPAH	Anthracene	1 SC,VNBC	9.96	ug/kg	0.70	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	1LPAH	Anthracene	1 H,SC,VNBC	12.10	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	1LPAH	Anthracene	1 SC,VNBC	38.40	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	1LPAH	Anthracene	1 H,SC,VNBC	18.50	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	1LPAH	Anthracene	1 SC,VNBC	22.00	ug/kg	1.56	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	1LPAH	Anthracene	1 H,SC,VNBC	35.40	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	1LPAH	Anthracene	1 SC,VNBC	15.50	ug/kg	0.91	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	1LPAH	Anthracene	1 SC,VNBC	2.79	ug/kg	0.96	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	1LPAH	Anthracene	1ND H,SC,VNBC	0.00	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	1LPAH	Anthracene	1ND SC,VNBC	0.00	ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	1LPAH	Biphenyl	1 VIU,SC,VNBC	5.09	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	1LPAH	Biphenyl	1 GN,H,SC,VNBC	3.67	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	1LPAH	Biphenyl	2 VIU,SC,VNBC	3.79	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	1LPAH	Biphenyl	1 VIU,SC,VNBC	11.90	ug/kg	1.18	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	1LPAH	Biphenyl	1 H,SC,VNBC	7.38	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	1LPAH	Biphenyl	1 VIU,SC,VNBC	7.40	ug/kg	0.73	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	1LPAH	Biphenyl	1 VIU,SC,VNBC	7.84	ug/kg	1.84	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	1LPAH	Biphenyl	2ND H,SC,VNBC	0.98	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	1LPAH	Biphenyl	1 VIU,SC,VNBC	4.12	ug/kg	0.92	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	1LPAH	Biphenyl	1ND VIU,SC,VNBC	0.00	ug/kg	0.70	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	1LPAH	Biphenyl	1ND H,SC,VNBC	0.00	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	1LPAH	Biphenyl	1 VIU,SC,VNBC	2.09	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	1LPAH	Biphenyl	1 H,SC,VNBC	9.91	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	1LPAH	Biphenyl	1 VIU,SC,VNBC	9.40	ug/kg	1.56	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	1LPAH	Biphenyl	1 H,SC,VNBC	7.95	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	1LPAH	Biphenyl	1 VIU,SC,VNBC	8.13	ug/kg	0.91	DFG-WPCL	WPCL_L-211-05_S_PAH

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	SUICRKLWR	19-Apr-05	3ORG	1LPAH	Biphenyl	1 VIU,SC,VNBC	2.32	ug/kg	0.96	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	1LPAH	Biphenyl	1 ND H,SC,VNBC	0.00	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	1LPAH	Biphenyl	1 ND VIU,SC,VNBC	0.00	ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	1LPAH	Dibenzothiophene	1 SC,VNBC	3.64	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	1LPAH	Dibenzothiophene	1 H,SC,VNBC	3.43	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	1LPAH	Dibenzothiophene	2 SC,VNBC	2.60	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	1LPAH	Dibenzothiophene	1 SC,VNBC	3.36	ug/kg	1.18	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	1LPAH	Dibenzothiophene	1 H,SC,VNBC	1.55	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	1LPAH	Dibenzothiophene	1 ND SC,VNBC	0.00	ug/kg	0.73	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	1LPAH	Dibenzothiophene	1 SC,VNBC	5.36	ug/kg	1.84	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	1LPAH	Dibenzothiophene	2 H,SC,VNBC	3.11	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	1LPAH	Dibenzothiophene	1 SC,VNBC	3.30	ug/kg	0.92	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	1LPAH	Dibenzothiophene	1 SC,VNBC	2.67	ug/kg	0.70	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	1LPAH	Dibenzothiophene	1 H,SC,VNBC	4.37	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	1LPAH	Dibenzothiophene	1 SC,VNBC	9.02	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	1LPAH	Dibenzothiophene	1 H,SC,VNBC	6.13	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	1LPAH	Dibenzothiophene	1 SC,VNBC	6.35	ug/kg	1.56	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	1LPAH	Dibenzothiophene	1 H,SC,VNBC	10.40	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	1LPAH	Dibenzothiophene	1 SC,VNBC	6.71	ug/kg	0.91	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	1LPAH	Dibenzothiophene	1 ND SC,VNBC	0.00	ug/kg	0.96	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	1LPAH	Dibenzothiophene	1 ND H,SC,VNBC	0.00	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	1LPAH	Dibenzothiophene	1 ND SC,VNBC	0.00	ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	1LPAH	Fluorene	1 VIU,SC,VNBC	4.71	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	1LPAH	Fluorene	1 H,SC,VNBC	4.37	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	1LPAH	Fluorene	2 VIU,SC,VNBC	2.31	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	1LPAH	Fluorene	1 VIU,SC,VNBC	9.63	ug/kg	1.18	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	1LPAH	Fluorene	1 H,SC,VNBC	4.08	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	1LPAH	Fluorene	1 VIU,SC,VNBC	3.90	ug/kg	0.73	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	1LPAH	Fluorene	1 VIU,SC,VNBC	10.40	ug/kg	1.84	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	1LPAH	Fluorene	2 H,SC,VNBC	4.80	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	PETRIVUP	20-Apr-05	3ORG	1LPAH	Fluorene	1 VIU,SC,VNBC	7.45	ug/kg	0.92	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	1LPAH	Fluorene	1 VIU,SC,VNBC	2.76	ug/kg	0.70	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	1LPAH	Fluorene	1 H,SC,VNBC	6.14	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	1LPAH	Fluorene	1 VIU,SC,VNBC	10.90	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	1LPAH	Fluorene	1 H,SC,VNBC	10.90	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	1LPAH	Fluorene	1 VIU,SC,VNBC	11.10	ug/kg	1.56	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	1LPAH	Fluorene	1 H,SC,VNBC	15.70	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	1LPAH	Fluorene	1 VIU,SC,VNBC	5.73	ug/kg	0.91	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	1LPAH	Fluorene	1 VIU,SC,VNBC	3.43	ug/kg	0.96	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	1LPAH	Fluorene	1 ND H,SC,VNBC	0.00	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	1LPAH	Fluorene	1 ND VIU,SC,VNBC	0.00	ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	1LPAH	Naphthalene	1 SC,VNBC	13.50	ug/kg	1.34	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	1LPAH	Naphthalene	1 GN,H,SC,VNBC	48.70	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	1LPAH	Naphthalene	2 SC,VNBC	6.91	ug/kg	1.03	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	1LPAH	Naphthalene	1 SC,VNBC	25.60	ug/kg	1.83	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	1LPAH	Naphthalene	1 H,SC,VNBC	10.40	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	1LPAH	Naphthalene	1 SC,VNBC	14.60	ug/kg	1.13	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	1LPAH	Naphthalene	1 SC,VNBC	21.20	ug/kg	2.85	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	1LPAH	Naphthalene	2 H,SC,VNBC	6.56	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	1LPAH	Naphthalene	1 SC,VNBC	16.50	ug/kg	1.43	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	1LPAH	Naphthalene	1 SC,VNBC	3.33	ug/kg	1.08	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	1LPAH	Naphthalene	1 H,SC,VNBC	3.51	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	1LPAH	Naphthalene	1 SC,VNBC	12.70	ug/kg	1.35	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	1LPAH	Naphthalene	1 H,SC,VNBC	38.30	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	1LPAH	Naphthalene	1 SC,VNBC	26.60	ug/kg	2.42	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	1LPAH	Naphthalene	1 H,SC,VNBC	16.80	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	1LPAH	Naphthalene	1 SC,VNBC	17.40	ug/kg	1.41	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	1LPAH	Naphthalene	1 SC,VNBC	6.27	ug/kg	1.48	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	1LPAH	Naphthalene	1 H,SC,VNBC	1.50	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	1LPAH	Naphthalene	1 SC,VNBC	1.75	ug/kg	1.07	DFG-WPCL	WPCL_L-211-05_S_PAH

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	COYCRKLWR	18-Apr-05	3ORG	1LPAH	Phenanthrene	1	SC,VNBC	34.90	ug/kg	2.40	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	1LPAH	Phenanthrene	1	H,SC,VNBC	27.40	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	1LPAH	Phenanthrene	2	SC,VNBC	22.35	ug/kg	1.84	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	1LPAH	Phenanthrene	1	SC,VNBC	46.60	ug/kg	3.27	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	1LPAH	Phenanthrene	1	H,SC,VNBC	26.20	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	1LPAH	Phenanthrene	1	SC,VNBC	27.10	ug/kg	2.02	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	1LPAH	Phenanthrene	1	SC,VNBC	50.00	ug/kg	5.10	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	1LPAH	Phenanthrene	2	H,SC,VNBC	33.50	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	1LPAH	Phenanthrene	1	SC,VNBC	49.30	ug/kg	2.56	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	1LPAH	Phenanthrene	1	SC,VNBC	54.80	ug/kg	1.93	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	1LPAH	Phenanthrene	1	H,SC,VNBC	75.80	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	1LPAH	Phenanthrene	1	SC,VNBC	189.00	ug/kg	2.40	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	1LPAH	Phenanthrene	1	H,SC,VNBC	83.60	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	1LPAH	Phenanthrene	1	SC,VNBC	85.00	ug/kg	4.32	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	1LPAH	Phenanthrene	1	H,SC,VNBC	224.00	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	1LPAH	Phenanthrene	1	SC,VNBC	118.00	ug/kg	2.53	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	1LPAH	Phenanthrene	1	SC,VNBC	13.90	ug/kg	2.65	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	1LPAH	Phenanthrene	1	H,SC,VNBC	4.66	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	1LPAH	Phenanthrene	1	SC,VNBC	4.85	ug/kg	1.92	DFG-WPCL	WPCL_L-211-05_S_PAH

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High molecular weight PAHs

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	COYCRKLWR	18-Apr-05	3ORG	2HAPAH	Sum of HPAHs (SFEI)	1	X	579.10	ug/kg	1.68	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	2HAPAH	Sum of HPAHs (SFEI)	1	X	394.00	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	2HAPAH	Sum of HPAHs (SFEI)	2	X	205.87	ug/kg	1.28	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	2HAPAH	Sum of HPAHs (SFEI)	1	X	231.24	ug/kg	2.28	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	2HAPAH	Sum of HPAHs (SFEI)	1	X	131.21	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	2HAPAH	Sum of HPAHs (SFEI)	1	X	109.73	ug/kg	1.41	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	2HAPAH	Sum of HPAHs (SFEI)	1	X	985.80	ug/kg	3.55	DFG-WPCL	WPCL_L-211-05_S_PAH

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2004-11	PETRIVUP	02-Nov-04	3ORG	2HAPAH	Sum of HPAHs (SFEI)	2	X	522.34	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	2HAPAH	Sum of HPAHs (SFEI)	1	X	399.70	ug/kg	1.79	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	2HAPAH	Sum of HPAHs (SFEI)	1	X	716.90	ug/kg	1.34	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	2HAPAH	Sum of HPAHs (SFEI)	1	X	983.00	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	2HAPAH	Sum of HPAHs (SFEI)	1	X	2703.00	ug/kg	1.68	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	2HAPAH	Sum of HPAHs (SFEI)	1	X	1407.00	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	2HAPAH	Sum of HPAHs (SFEI)	1	X	1323.10	ug/kg	3.01	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	2HAPAH	Sum of HPAHs (SFEI)	1	X	2641.10	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	2HAPAH	Sum of HPAHs (SFEI)	1	X	1355.50	ug/kg	1.76	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	2HAPAH	Sum of HPAHs (SFEI)	1	X	191.25	ug/kg	1.85	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	2HAPAH	Sum of HPAHs (SFEI)	1	X	60.68	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	2HAPAH	Sum of HPAHs (SFEI)	1	X	29.60	ug/kg	1.34	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	2HPAH	Benz(a)anthracene	1	SC,VNBC	23.20	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	2HPAH	Benz(a)anthracene	1	H,SC,VNBC	19.10	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	2HPAH	Benz(a)anthracene	2	SC,VNBC	9.56	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	2HPAH	Benz(a)anthracene	1	SC,VNBC	12.10	ug/kg	1.18	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	2HPAH	Benz(a)anthracene	1	H,SC,VNBC	7.73	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	2HPAH	Benz(a)anthracene	1	SC,VNBC	7.34	ug/kg	0.73	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	2HPAH	Benz(a)anthracene	1	SC,VNBC	44.10	ug/kg	1.84	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	2HPAH	Benz(a)anthracene	2	H,SC,VNBC	25.40	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	2HPAH	Benz(a)anthracene	1	SC,VNBC	21.50	ug/kg	0.92	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	2HPAH	Benz(a)anthracene	1	SC,VNBC	46.60	ug/kg	0.70	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	2HPAH	Benz(a)anthracene	1	H,SC,VNBC	72.40	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	2HPAH	Benz(a)anthracene	1	SC,VNBC	161.00	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	2HPAH	Benz(a)anthracene	1	H,SC,VNBC	67.70	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	2HPAH	Benz(a)anthracene	1	SC,VNBC	59.10	ug/kg	1.56	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	2HPAH	Benz(a)anthracene	1	H,SC,VNBC	171.00	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	2HPAH	Benz(a)anthracene	1	SC,VNBC	77.80	ug/kg	0.91	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	2HPAH	Benz(a)anthracene	1	SC,VNBC	8.28	ug/kg	0.96	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	2HPAH	Benz(a)anthracene	1	H,SC,VNBC	5.14	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	SUICRKUP	19-Apr-05	3ORG	2HPAH	Benz(a)anthracene	1	SC,VNBC	1.97	ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	2HPAH	Benzo(a)pyrene	1	SC,VNBC	49.70	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	2HPAH	Benzo(a)pyrene	1	H,SC,VNBC	31.30	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	2HPAH	Benzo(a)pyrene	2	SC,VNBC	15.95	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	2HPAH	Benzo(a)pyrene	1	SC,VNBC	15.60	ug/kg	1.18	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	2HPAH	Benzo(a)pyrene	1	H,SC,VNBC	8.92	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	2HPAH	Benzo(a)pyrene	1	SC,VNBC	8.60	ug/kg	0.73	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	2HPAH	Benzo(a)pyrene	1	SC,VNBC	90.80	ug/kg	1.84	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	2HPAH	Benzo(a)pyrene	2	H,SC,VNBC	30.60	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	2HPAH	Benzo(a)pyrene	1	SC,VNBC	29.40	ug/kg	0.92	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	2HPAH	Benzo(a)pyrene	1	SC,VNBC	59.30	ug/kg	0.70	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	2HPAH	Benzo(a)pyrene	1	H,SC,VNBC	70.40	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	2HPAH	Benzo(a)pyrene	1	SC,VNBC	207.00	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	2HPAH	Benzo(a)pyrene	1	H,SC,VNBC	132.00	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	2HPAH	Benzo(a)pyrene	1	SC,VNBC	135.00	ug/kg	1.56	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	2HPAH	Benzo(a)pyrene	1	H,SC,VNBC	153.00	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	2HPAH	Benzo(a)pyrene	1	SC,VNBC	103.00	ug/kg	0.91	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	2HPAH	Benzo(a)pyrene	1	SC,VNBC	13.40	ug/kg	0.96	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	2HPAH	Benzo(a)pyrene	1	H,SC,VNBC	4.67	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	2HPAH	Benzo(a)pyrene	1	SC,VNBC	1.89	ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	2HPAH	Benzo(b)fluoranthene	1	SC,VNBC	78.40	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	2HPAH	Benzo(b)fluoranthene	1	H,SC,VNBC	52.00	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	2HPAH	Benzo(b)fluoranthene	2	SC,VNBC	33.30	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	2HPAH	Benzo(b)fluoranthene	1	SC,VNBC	27.90	ug/kg	1.18	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	2HPAH	Benzo(b)fluoranthene	1	H,SC,VNBC	15.90	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	2HPAH	Benzo(b)fluoranthene	1	SC,VNBC	16.40	ug/kg	0.73	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	2HPAH	Benzo(b)fluoranthene	1	SC,VNBC	109.00	ug/kg	1.84	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	2HPAH	Benzo(b)fluoranthene	2	H,SC,VNBC	59.25	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	2HPAH	Benzo(b)fluoranthene	1	SC,VNBC	48.60	ug/kg	0.92	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	2HPAH	Benzo(b)fluoranthene	1	SC,VNBC	84.30	ug/kg	0.70	DFG-WPCL	WPCL_L-211-05_S_PAH

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2004-11	SANLORCRKUP	03-Nov-04	3ORG	2HPAH	Benzo(b)fluoranthene	1	H,SC,VNBC	99.60	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	2HPAH	Benzo(b)fluoranthene	1	SC,VNBC	293.00	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	2HPAH	Benzo(b)fluoranthene	1	H,SC,VNBC	163.00	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	2HPAH	Benzo(b)fluoranthene	1	SC,VNBC	159.00	ug/kg	1.56	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	2HPAH	Benzo(b)fluoranthene	1	H,SC,VNBC	205.00	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	2HPAH	Benzo(b)fluoranthene	1	SC,VNBC	156.00	ug/kg	0.91	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	2HPAH	Benzo(b)fluoranthene	1	SC,VNBC	19.50	ug/kg	0.96	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	2HPAH	Benzo(b)fluoranthene	1	H,SC,VNBC	6.59	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	2HPAH	Benzo(b)fluoranthene	1	SC,VNBC	4.15	ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	2HPAH	Benzo(e)pyrene	1	SC,VNBC	50.10	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	2HPAH	Benzo(e)pyrene	1	H,SC,VNBC	31.30	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	2HPAH	Benzo(e)pyrene	2	SC,VNBC	22.00	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	2HPAH	Benzo(e)pyrene	1	SC,VNBC	18.40	ug/kg	1.18	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	2HPAH	Benzo(e)pyrene	1	H,SC,VNBC	11.90	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	2HPAH	Benzo(e)pyrene	1	SC,VNBC	10.10	ug/kg	0.73	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	2HPAH	Benzo(e)pyrene	1	SC,VNBC	70.90	ug/kg	1.84	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	2HPAH	Benzo(e)pyrene	2	H,SC,VNBC	33.40	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	2HPAH	Benzo(e)pyrene	1	SC,VNBC	30.90	ug/kg	0.92	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	2HPAH	Benzo(e)pyrene	1	SC,VNBC	47.80	ug/kg	0.70	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	2HPAH	Benzo(e)pyrene	1	H,SC,VNBC	57.80	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	2HPAH	Benzo(e)pyrene	1	SC,VNBC	186.00	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	2HPAH	Benzo(e)pyrene	1	H,SC,VNBC	98.40	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	2HPAH	Benzo(e)pyrene	1	SC,VNBC	98.40	ug/kg	1.56	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	2HPAH	Benzo(e)pyrene	1	H,SC,VNBC	122.00	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	2HPAH	Benzo(e)pyrene	1	SC,VNBC	98.20	ug/kg	0.91	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	2HPAH	Benzo(e)pyrene	1	SC,VNBC	13.20	ug/kg	0.96	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	2HPAH	Benzo(e)pyrene	1	H,SC,VNBC	3.86	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	2HPAH	Benzo(e)pyrene	1	SC,VNBC	3.65	ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	2HPAH	Benzo(ghi)perylene	1	VIP,SC,VNBC	68.80	ug/kg	10.60	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	2HPAH	Benzo(ghi)perylene	1	H,SC,VNBC	51.00	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	COYCRKUP	18-Apr-05	3ORG	2HPAH	Benzo(ghi)perylene	2	VRIP,SC,VNBC		ug/kg	8.11	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	2HPAH	Benzo(ghi)perylene	1	VRIP,SC,VNBC		ug/kg	14.40	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	2HPAH	Benzo(ghi)perylene	1	H,SC,VNBC	11.80	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	2HPAH	Benzo(ghi)perylene	1	VRIP,SC,VNBC		ug/kg	8.89	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	2HPAH	Benzo(ghi)perylene	1	VIP,SC,VNBC	93.30	ug/kg	22.40	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	2HPAH	Benzo(ghi)perylene	2	H,SC,VNBC	36.55	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	2HPAH	Benzo(ghi)perylene	1	VRIP,SC,VNBC		ug/kg	11.30	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	2HPAH	Benzo(ghi)perylene	1	VIP,SC,VNBC	53.30	ug/kg	8.48	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	2HPAH	Benzo(ghi)perylene	1	H,SC,VNBC	74.80	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	2HPAH	Benzo(ghi)perylene	1	VIP,SC,VNBC	230.00	ug/kg	10.60	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	2HPAH	Benzo(ghi)perylene	1	H,SC,VNBC	169.00	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	2HPAH	Benzo(ghi)perylene	1	VIP,SC,VNBC	137.00	ug/kg	19.00	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	2HPAH	Benzo(ghi)perylene	1	H,SC,VNBC	175.00	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	2HPAH	Benzo(ghi)perylene	1	VIP,SC,VNBC	116.00	ug/kg	11.10	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	2HPAH	Benzo(ghi)perylene	1	VRIP,SC,VNBC		ug/kg	11.70	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	2HPAH	Benzo(ghi)perylene	1	H,SC,VNBC	4.96	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	2HPAH	Benzo(ghi)perylene	1	ND SC,VNBC	0.00	ug/kg	8.45	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	2HPAH	Benzo(k)fluoranthene	1	SC,VNBC	25.00	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	2HPAH	Benzo(k)fluoranthene	1	H,SC,VNBC	16.00	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	2HPAH	Benzo(k)fluoranthene	2	SC,VNBC	10.08	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	2HPAH	Benzo(k)fluoranthene	1	SC,VNBC	8.05	ug/kg	1.18	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	2HPAH	Benzo(k)fluoranthene	1	H,SC,VNBC	4.94	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	2HPAH	Benzo(k)fluoranthene	1	SC,VNBC	4.25	ug/kg	0.73	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	2HPAH	Benzo(k)fluoranthene	1	SC,VNBC	34.20	ug/kg	1.84	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	2HPAH	Benzo(k)fluoranthene	2	H,SC,VNBC	21.75	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	2HPAH	Benzo(k)fluoranthene	1	SC,VNBC	17.60	ug/kg	0.92	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	2HPAH	Benzo(k)fluoranthene	1	SC,VNBC	32.50	ug/kg	0.70	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	2HPAH	Benzo(k)fluoranthene	1	H,SC,VNBC	38.50	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	2HPAH	Benzo(k)fluoranthene	1	SC,VNBC	116.00	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	2HPAH	Benzo(k)fluoranthene	1	H,SC,VNBC	56.00	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	2HPAH	Benzo(k)fluoranthene	1	SC,VNBC	52.80	ug/kg	1.56	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	2HPAH	Benzo(k)fluoranthene	1	H,SC,VNBC	86.60	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	2HPAH	Benzo(k)fluoranthene	1	SC,VNBC	57.70	ug/kg	0.91	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	2HPAH	Benzo(k)fluoranthene	1	SC,VNBC	5.70	ug/kg	0.96	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	2HPAH	Benzo(k)fluoranthene	1	H,SC,VNBC	2.31	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	2HPAH	Benzo(k)fluoranthene	1	ND SC,VNBC	0.00	ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	2HPAH	Chrysene	1	SC,VNBC	30.00	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	2HPAH	Chrysene	1	H,SC,VNBC	24.20	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	2HPAH	Chrysene	2	SC,VNBC	16.40	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	2HPAH	Chrysene	1	SC,VNBC	15.00	ug/kg	1.18	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	2HPAH	Chrysene	1	H,SC,VNBC	10.50	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	2HPAH	Chrysene	1	SC,VNBC	9.93	ug/kg	0.73	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	2HPAH	Chrysene	1	SC,VNBC	38.10	ug/kg	1.84	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	2HPAH	Chrysene	2	H,IL,SC,VNBC	48.00	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	2HPAH	Chrysene	1	SC,VNBC	33.00	ug/kg	0.92	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	2HPAH	Chrysene	1	SC,VNBC	56.30	ug/kg	0.70	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	2HPAH	Chrysene	1	H,SC,VNBC	81.20	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	2HPAH	Chrysene	1	SC,VNBC	225.00	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	2HPAH	Chrysene	1	H,SC,VNBC	81.10	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	2HPAH	Chrysene	1	SC,VNBC	67.70	ug/kg	1.56	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	2HPAH	Chrysene	1	H,SC,VNBC	249.00	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	2HPAH	Chrysene	1	SC,VNBC	107.00	ug/kg	0.91	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	2HPAH	Chrysene	1	SC,VNBC	7.38	ug/kg	0.96	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	2HPAH	Chrysene	1	H,SC,VNBC	5.42	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	2HPAH	Chrysene	1	SC,VNBC	1.97	ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	2HPAH	Dibenz(a,h)anthracene	1	VIU,HT,SC,SCR,VNBC	13.10	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	2HPAH	Dibenz(a,h)anthracene	1	H,SC,VNBC	13.40	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	2HPAH	Dibenz(a,h)anthracene	2	VIU,HT,SC,SCR,VNBC	6.50	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	2HPAH	Dibenz(a,h)anthracene	1	VIU,HT,SC,SCR,VNBC	4.79	ug/kg	1.18	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	2HPAH	Dibenz(a,h)anthracene	1	H,SC,VNBC	3.97	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	NAPRIVUP	19-Apr-05	3ORG	2HPAH	Dibenz(a,h)anthracene	1	VIU,HT,SC,SCR,VNBC	3.17	ug/kg	0.73	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	2HPAH	Dibenz(a,h)anthracene	1	VIU,HT,SC,SCR,VNBC	17.40	ug/kg	1.84	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	2HPAH	Dibenz(a,h)anthracene	2	H,SC,VNBC	9.34	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	2HPAH	Dibenz(a,h)anthracene	1	VIU,HT,SC,SCR,VNBC	10.70	ug/kg	0.92	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	2HPAH	Dibenz(a,h)anthracene	1	VIU,HT,SC,SCR,VNBC	18.10	ug/kg	0.70	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	2HPAH	Dibenz(a,h)anthracene	1	H,SC,VNBC	23.10	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	2HPAH	Dibenz(a,h)anthracene	1	VIU,HT,SC,SCR,VNBC	78.30	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	2HPAH	Dibenz(a,h)anthracene	1	H,SC,VNBC	31.40	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	2HPAH	Dibenz(a,h)anthracene	1	VIU,HT,SC,SCR,VNBC	25.60	ug/kg	1.56	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	2HPAH	Dibenz(a,h)anthracene	1	H,SC,VNBC	56.80	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	2HPAH	Dibenz(a,h)anthracene	1	VIU,HT,SC,SCR,VNBC	32.50	ug/kg	0.91	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	2HPAH	Dibenz(a,h)anthracene	1	VIU,HT,SC,SCR,VNBC	3.09	ug/kg	0.96	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	2HPAH	Dibenz(a,h)anthracene	1	ND H,SC,VNBC	0.00	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	2HPAH	Dibenz(a,h)anthracene	1	ND VIU,HT,SC,SCR,VNBC	0.00	ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	2HPAH	Fluoranthene	1	SC,VNBC	71.50	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	2HPAH	Fluoranthene	1	H,SC,VNBC	50.00	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	2HPAH	Fluoranthene	2	IL,SC,VNBC	31.10	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	2HPAH	Fluoranthene	1	SC,VNBC	45.00	ug/kg	1.18	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	2HPAH	Fluoranthene	1	H,SC,VNBC	16.70	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	2HPAH	Fluoranthene	1	SC,VNBC	16.90	ug/kg	0.73	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	2HPAH	Fluoranthene	1	SC,VNBC	113.00	ug/kg	1.84	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	2HPAH	Fluoranthene	2	H,SC,VNBC	113.00	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	2HPAH	Fluoranthene	1	SC,VNBC	88.00	ug/kg	0.92	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	2HPAH	Fluoranthene	1	SC,VNBC	130.00	ug/kg	0.70	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	2HPAH	Fluoranthene	1	H,SC,VNBC	203.00	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	2HPAH	Fluoranthene	1	SC,VNBC	476.00	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	2HPAH	Fluoranthene	1	H,SC,VNBC	184.00	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	2HPAH	Fluoranthene	1	SC,VNBC	189.00	ug/kg	1.56	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	2HPAH	Fluoranthene	1	H,SC,VNBC	657.00	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	2HPAH	Fluoranthene	1	SC,VNBC	251.00	ug/kg	0.91	DFG-WPCL	WPCL_L-211-05_S_PAH

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	SUICRKLWR	19-Apr-05	3ORG	2HPAH	Fluoranthene	1	SC,VNBC	26.00	ug/kg	0.96	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	2HPAH	Fluoranthene	1	H,SC,VNBC	10.50	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	2HPAH	Fluoranthene	1	SC,VNBC	3.60	ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	2HPAH	Indeno(1,2,3-cd)pyrene	1	SC,VNBC	59.70	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	2HPAH	Indeno(1,2,3-cd)pyrene	1	H,SC,VNBC	44.00	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	2HPAH	Indeno(1,2,3-cd)pyrene	2	SC,VNBC	21.10	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	2HPAH	Indeno(1,2,3-cd)pyrene	1	SC,VNBC	16.10	ug/kg	1.18	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	2HPAH	Indeno(1,2,3-cd)pyrene	1	H,SC,VNBC	9.55	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	2HPAH	Indeno(1,2,3-cd)pyrene	1	SC,VNBC	8.42	ug/kg	0.73	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	2HPAH	Indeno(1,2,3-cd)pyrene	1	SC,VNBC	101.00	ug/kg	1.84	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	2HPAH	Indeno(1,2,3-cd)pyrene	2	H,SC,VNBC	31.70	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	2HPAH	Indeno(1,2,3-cd)pyrene	1	SC,VNBC	32.40	ug/kg	0.92	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	2HPAH	Indeno(1,2,3-cd)pyrene	1	SC,VNBC	59.70	ug/kg	0.70	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	2HPAH	Indeno(1,2,3-cd)pyrene	1	H,SC,VNBC	73.40	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	2HPAH	Indeno(1,2,3-cd)pyrene	1	SC,VNBC	250.00	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	2HPAH	Indeno(1,2,3-cd)pyrene	1	H,SC,VNBC	151.00	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	2HPAH	Indeno(1,2,3-cd)pyrene	1	SC,VNBC	133.00	ug/kg	1.56	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	2HPAH	Indeno(1,2,3-cd)pyrene	1	H,SC,VNBC	175.00	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	2HPAH	Indeno(1,2,3-cd)pyrene	1	SC,VNBC	104.00	ug/kg	0.91	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	2HPAH	Indeno(1,2,3-cd)pyrene	1	SC,VNBC	15.60	ug/kg	0.96	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	2HPAH	Indeno(1,2,3-cd)pyrene	1	H,SC,VNBC	4.04	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	2HPAH	Indeno(1,2,3-cd)pyrene	1	SC,VNBC	2.74	ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	2HPAH	Perylene	1	VIU,SC,VNBC	29.20	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	2HPAH	Perylene	1	H,SC,VNBC	13.90	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	2HPAH	Perylene	2	VIU,SC,VNBC	8.58	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	2HPAH	Perylene	1	VIU,SC,VNBC	28.20	ug/kg	1.18	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	2HPAH	Perylene	1	H,SC,VNBC	12.90	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	2HPAH	Perylene	1	VIU,SC,VNBC	9.82	ug/kg	0.73	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	2HPAH	Perylene	1	VIU,SC,VNBC	137.00	ug/kg	1.84	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	2HPAH	Perylene	2	H,SC,VNBC	18.00	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	PETRIVUP	20-Apr-05	3ORG	2HPAH	Perylene	1	VIU,SC,VNBC	16.40	ug/kg	0.92	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	2HPAH	Perylene	1	VIU,SC,VNBC	21.00	ug/kg	0.70	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	2HPAH	Perylene	1	H,SC,VNBC	25.80	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	2HPAH	Perylene	1	VIU,SC,VNBC	66.70	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	2HPAH	Perylene	1	H,SC,VNBC	59.40	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	2HPAH	Perylene	1	VIU,SC,VNBC	55.50	ug/kg	1.56	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	2HPAH	Perylene	1	H,SC,VNBC	47.70	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	2HPAH	Perylene	1	VIU,SC,VNBC	32.30	ug/kg	0.91	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	2HPAH	Perylene	1	VIU,SC,VNBC	53.10	ug/kg	0.96	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	2HPAH	Perylene	1	H,SC,VNBC	3.09	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	2HPAH	Perylene	1	VIU,SC,VNBC	6.11	ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	COYCRKLWR	18-Apr-05	3ORG	2HPAH	Pyrene	1	SC,VNBC	80.40	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	COYCRKUP	01-Nov-04	3ORG	2HPAH	Pyrene	1	H,SC,VNBC	47.80	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	COYCRKUP	18-Apr-05	3ORG	2HPAH	Pyrene	2	SC,VNBC	31.30	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	2HPAH	Pyrene	1	SC,VNBC	40.10	ug/kg	1.18	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	NAPRIVUP	02-Nov-04	3ORG	2HPAH	Pyrene	1	H,SC,VNBC	16.40	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	NAPRIVUP	19-Apr-05	3ORG	2HPAH	Pyrene	1	SC,VNBC	14.80	ug/kg	0.73	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	PETRIVLWR	20-Apr-05	3ORG	2HPAH	Pyrene	1	SC,VNBC	137.00	ug/kg	1.84	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	PETRIVUP	02-Nov-04	3ORG	2HPAH	Pyrene	2	H,SC,VNBC	95.35	ug/kg	0.90	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	PETRIVUP	20-Apr-05	3ORG	2HPAH	Pyrene	1	SC,VNBC	71.20	ug/kg	0.92	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	2HPAH	Pyrene	1	SC,VNBC	108.00	ug/kg	0.70	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	2HPAH	Pyrene	1	H,SC,VNBC	163.00	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	2HPAH	Pyrene	1	SC,VNBC	414.00	ug/kg	0.87	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	2HPAH	Pyrene	1	H,SC,VNBC	214.00	ug/kg	1.14	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	2HPAH	Pyrene	1	SC,VNBC	211.00	ug/kg	1.56	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	2HPAH	Pyrene	1	H,SC,VNBC	543.00	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	2HPAH	Pyrene	1	SC,VNBC	220.00	ug/kg	0.91	DFG-WPCL	WPCL_L-211-05_S_PAH
2005-04	SUICRKLWR	19-Apr-05	3ORG	2HPAH	Pyrene	1	SC,VNBC	26.00	ug/kg	0.96	DFG-WPCL	WPCL_L-211-05_S_PAH
2004-11	SUICRKUP	03-Nov-04	3ORG	2HPAH	Pyrene	1	H,SC,VNBC	10.10	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS348_S_PAH
2005-04	SUICRKUP	19-Apr-05	3ORG	2HPAH	Pyrene	1	SC,VNBC	3.52	ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_S_PAH

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Appendix Table C.4. Sediment PCB results from the ambient tributary study in watersheds of the San Francisco Estuary (2004-2005). N = number of replicates. % solids were reported by each analytical laboratory. DFG-WPCL analyzed all trace organic samples in this study (see Appendix C - Table C.3). Lab codes are defined in table 1.1.

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	COYCRKLWR	18-Apr-05	3ORG	APCB	Sum of PCBs (SFEI)	1	X	23.07	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	APCB	Sum of PCBs (SFEI)	1	X	8.70	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	APCB	Sum of PCBs (SFEI)	2	X	11.38	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	APCB	Sum of PCBs (SFEI)	1	X	4.09	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	APCB	Sum of PCBs (SFEI)	1	X	2.79	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	APCB	Sum of PCBs (SFEI)	1	X	1.95	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	APCB	Sum of PCBs (SFEI)	1	X	4.23	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	APCB	Sum of PCBs (SFEI)	2	X	6.82	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	APCB	Sum of PCBs (SFEI)	1	X	1.51	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	APCB	Sum of PCBs (SFEI)	1	X	3.82	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	APCB	Sum of PCBs (SFEI)	1	X	7.80	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	APCB	Sum of PCBs (SFEI)	1	X	15.59	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	APCB	Sum of PCBs (SFEI)	1	X	10.90	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	APCB	Sum of PCBs (SFEI)	1	X	18.90	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	APCB	Sum of PCBs (SFEI)	1	X	35.09	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	APCB	Sum of PCBs (SFEI)	1	X	34.14	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	APCB	Sum of PCBs (SFEI)	1	X	1.75	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	APCB	Sum of PCBs (SFEI)	1	X	1.08	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	APCB	Sum of PCBs (SFEI)	1	X	1.20	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 008	1	ND VIU,H,SC,VNBC	0.00	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 008	1	ND VRIU,H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 008	2	ND VIU,H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 008	1	ND VIU,H,SC,VNBC	0.00	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 008	1	ND VRIU,H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 008	1	ND VIU,H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 008	1	ND VIU,H,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 008	2	ND VRIU,H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 008	1	ND VIU,H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 008	1	ND VIU,H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 008	1	ND VRIU,H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 008	1	ND VIU,H,SC,VNBC	0.00	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 008	1	ND VRIU,H,SC,VNBC	0.00	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 008	1	ND VIU,H,SC,VNBC	0.00	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 008	1	ND VRIU,H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 008	1	ND VIU,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 008	1	ND VIU,H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 008	1	ND VRIU,H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 008	1	ND VIU,H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 018	1	DNQ VRIP,H,SC,VNBC		ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 018	1	ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 018	2	VRIP,H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 018	1 DNQ VRIP,H,SC,VNBC		ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 018	1 DNQ H,J,SC,VNBC	0.17	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 018	1 ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 018	1 ND H,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 018	2 DNQ H,J,SC,VNBC	0.11	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 018	1 ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 018	1 DNQ VRIP,H,SC,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 018	1 ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 018	1 DNQ VRIP,H,SC,VNBC		ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 018	1 DNQ H,J,SC,VNBC	0.34	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 018	1 DNQ VRIP,H,SC,VNBC		ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 018	1 DNQ H,J,SC,VNBC	0.23	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 018	1 DNQ SC,VNBC	0.21	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 018	1 VRIP,H,SC,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 018	1 H,SC,VNBC	0.33	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 018	1 VRIP,H,SC,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 028	1 VRIP,H,SC,VNBC		ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 028	1 VIL,H,SC,VRIP,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 028	2 VRIP,H,IL,SC,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 028	1 VRIP,H,SC,VNBC		ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 028	1 VIL,H,SC,VRIP,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 028	1 VRIP,H,SC,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 028	1	DNQ VRIP,H,VNBC		ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 028	2	VIL,H,SC,VRIP,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 028	1	DNQ VRIP,H,SC,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 028	1	DNQ VRIP,H,SC,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 028	1	VIL,H,SC,VRIP,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 028	1	DNQ VRIP,H,SC,VNBC		ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 028	1	VIL,H,SC,VRIP,VNBC		ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 028	1	DNQ VRIP,H,SC,VNBC		ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 028	1	VIL,H,SC,VRIP,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 028	1	DNQ VRIP,SC,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 028	1	VRIP,H,SC,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 028	1	VIL,H,SC,VRIP,VNBC		ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 028	1	VRIP,H,SC,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 031	1	VRIP,H,SC,VNBC		ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 031	1	DNQ H,J,SC,VRIP,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 031	2	VRIP,H,IL,SC,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 031	1	VRIP,H,SC,VNBC		ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 031	1	DNQ H,J,SC,VRIP,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 031	1	VRIP,H,SC,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 031	1	DNQ VRIP,H,VNBC		ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 031	2	DNQ H,J,SC,VRIP,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 031	1	VRIP,H,SC,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 031	1 VRIP,H,SC,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 031	1DNQ H,J,SC,VRIP,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 031	1DNQ VRIP,H,SC,VNBC		ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 031	1DNQ H,J,SC,VRIP,VNBC		ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 031	1DNQ VRIP,H,SC,VNBC		ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 031	1 H,SC,VRIP,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 031	1DNQ SC,VNBC	0.37	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 031	1 VRIP,H,SC,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 031	1 H,SC,VRIP,VNBC		ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 031	1 VRIP,H,SC,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 033	1DNQ H,SC,VNBC	0.31	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 033	1ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 033	2 H,SC,VNBC	0.30	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 033	1DNQ H,SC,VNBC	0.36	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 033	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 033	1DNQ H,SC,VNBC	0.19	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 033	1ND H,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 033	2ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 033	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 033	1DNQ H,SC,VNBC	0.17	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 033	1DNQ H,J,SC,VNBC	0.15	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 033	1DNQ H,SC,VNBC	0.25	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2004-11	SANMATCRKLWR	04-Nov-043ORG	PCB		PCB 033	1ND H,SC,VNBC	0.00	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-053ORG	PCB		PCB 033	1DNQ H,SC,VNBC	0.38	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-043ORG	PCB		PCB 033	1DNQ H,J,SC,VNBC	0.23	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-053ORG	PCB		PCB 033	1ND SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-053ORG	PCB		PCB 033	1DNQ H,SC,VNBC	0.28	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-043ORG	PCB		PCB 033	1DNQ H,J,SC,VNBC	0.18	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-053ORG	PCB		PCB 033	1 H,SC,VNBC	0.34	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-053ORG	PCB		PCB 044	1 VRIP,H,SC,VNBC		ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-043ORG	PCB		PCB 044	1 VIL,H,SC,VRIP,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-053ORG	PCB		PCB 044	2 VRIP,H,SC,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-053ORG	PCB		PCB 044	1 VRIP,H,SC,VNBC		ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-043ORG	PCB		PCB 044	1DNQ VIL,H,J,SC,VRIP,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-053ORG	PCB		PCB 044	1 VRIP,H,SC,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-053ORG	PCB		PCB 044	1ND VRIP,H,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-043ORG	PCB		PCB 044	2 VIL,H,SC,VRIP,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-053ORG	PCB		PCB 044	1DNQ VRIP,H,SC,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-053ORG	PCB		PCB 044	1 VRIP,H,SC,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-043ORG	PCB		PCB 044	1 VIL,H,SC,VRIP,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-053ORG	PCB		PCB 044	1 VRIP,H,SC,VNBC		ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-043ORG	PCB		PCB 044	1 VIL,H,SC,VIP,VNBC	0.65	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-053ORG	PCB		PCB 044	1 VRIP,H,SC,VNBC		ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-043ORG	PCB		PCB 044	1 VIL,H,SC,VIP,VNBC	1.09	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 044	1 SC,VNBC	0.85	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 044	1DNQ VRIP,H,SC,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 044	1DNQ VIL,H,J,SC,VRIP,VNBC		ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 044	1 VRIP,H,SC,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 049	1 H,SC,VNBC	0.48	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 049	1DNQ H,J,SC,VNBC	0.17	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 049	2DNQ H,SC,VNBC	0.13	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 049	1DNQ H,SC,VNBC	0.26	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 049	1DNQ H,J,SC,VNBC	0.15	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 049	1DNQ H,SC,VNBC	0.19	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 049	1ND H,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 049	2DNQ H,J,SC,VNBC	0.13	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 049	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 049	1DNQ H,SC,VNBC	0.17	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 049	1DNQ H,J,SC,VNBC	0.18	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 049	1DNQ H,SC,VNBC	0.25	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 049	1DNQ H,J,SC,VNBC	0.39	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 049	1DNQ H,SC,VNBC	0.43	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 049	1 H,SC,VNBC	0.51	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 049	1ND SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 049	1DNQ H,SC,VNBC	0.31	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 049	1DNQ H,J,SC,VNBC	0.19	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 049	1	H,SC,VNBC	0.27	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 052	1	VRIP,VIL,H,SC,VNBC		ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 052	1	H,SC,VRIP,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 052	2	VRIP,VIL,H,SC,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 052	1	VRIP,VIL,H,SC,VNBC		ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 052	1	H,SC,VRIP,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 052	1	VRIP,VIL,H,SC,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 052	1	VRIP,VIL,H,VNBC		ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 052	2	H,IL,SC,VRIP,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 052	1	VRIP,VIL,H,SC,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 052	1	VRIP,VIL,H,SC,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 052	1	H,SC,VRIP,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 052	1	VRIP,VIL,H,SC,VNBC		ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 052	1	H,SC,VRIP,VNBC		ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 052	1	VRIP,VIL,H,SC,VNBC		ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 052	1	H,SC,VIP,VNBC	1.15	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 052	1	VRIP,VIL,SC,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 052	1	VRIP,VIL,H,SC,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 052	1	H,SC,VRIP,VNBC		ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 052	1	VRIP,VIL,H,SC,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 056	1	ND H,SC,VNBC	0.00	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 056	1	ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 056	2ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 056	1ND H,SC,VNBC	0.00	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 056	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 056	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 056	1ND H,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 056	2ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 056	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 056	1ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 056	1ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 056	1ND H,SC,VNBC	0.00	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 056	1ND H,SC,VNBC	0.00	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 056	1ND H,SC,VNBC	0.00	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 056	1DNQ H,J,SC,VNBC	0.19	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 056	1ND SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 056	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 056	1ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 056	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 060	1ND H,SC,VNBC	0.00	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 060	1ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 060	2ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 060	1ND H,SC,VNBC	0.00	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 060	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 060	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 060	1ND H,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 060	2ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 060	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 060	1ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 060	1ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 060	1ND H,SC,VNBC	0.00	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 060	1ND H,SC,VNBC	0.00	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 060	1ND H,SC,VNBC	0.00	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 060	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 060	1ND SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 060	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 060	1ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 060	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 066	1 H,SC,VIP,VNBC	0.75	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 066	1 VIL,H,SC,VNBC	0.37	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 066	2 VRIP,H,IL,SC,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 066	1 VRIP,H,SC,VNBC		ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 066	1 VIL,H,SC,VNBC	0.33	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 066	1 VRIP,H,SC,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 066	1DNQ VRIP,H,VNBC		ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 066	2 H,IL,SC,VNBC	0.51	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 066	1DNQ VRIP,H,SC,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 066	1 H,SC,VRIP,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 066	1 VIL,H,SC,VNBC	0.50	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 066	1 H,SC,VIP,VNBC	1.23	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 066	1 VIL,H,SC,VNBC	1.00	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 066	1 H,SC,VIP,VNBC	0.87	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 066	1 VIL,H,SC,VNBC	3.21	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 066	1 SC,VIP,VNBC	2.50	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 066	1 VRIP,H,SC,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 066	1DNQ VIL,H,J,SC,VNBC	0.21	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 066	1 VRIP,H,SC,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 070	1 VRIP,H,SC,VNBC		ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 070	1 VIL,H,SC,VRIP,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 070	2 VRIP,H,SC,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 070	1 VRIP,H,SC,VNBC		ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 070	1 VIL,H,SC,VRIP,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 070	1 VRIP,H,SC,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 070	1 VRIP,H,VNBC		ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 070	2 H,IL,SC,VRIP,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 070	1 VRIP,H,SC,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 070	1 VRIP,H,SC,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 070	1 VIL,H,SC,VRIP,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 070	1	VRIP,H,SC,VNBC		ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 070	1	VIL,H,SC,VRIP,VNBC		ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 070	1	VRIP,H,SC,VNBC		ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 070	1	VIL,H,SC,VIP,VNBC	0.95	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 070	1	SC,VNBC	0.74	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 070	1	VRIP,H,SC,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 070	1	VIL,H,SC,VRIP,VNBC		ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 070	1	VRIP,H,SC,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 074	1	DNQ H,SC,VNBC	0.27	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 074	1	ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 074	2	DNQ H,SC,VNBC	0.33	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 074	1	ND H,SC,VNBC	0.00	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 074	1	ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 074	1	ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 074	1	ND H,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 074	2	DNQ H,J,SC,VNBC	0.11	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 074	1	ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 074	1	ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 074	1	DNQ H,J,SC,VNBC	0.14	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 074	1	ND H,SC,VNBC	0.00	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 074	1	ND H,SC,VNBC	0.00	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 074	1	ND H,SC,VNBC	0.00	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 074	1 H,SC,VNBC	0.34	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 074	1DNQ SC,VNBC	0.19	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 074	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 074	1ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 074	1DNQ H,SC,VNBC	0.20	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 087	1 H,SC,VNBC	0.61	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 087	1 H,SC,VNBC	0.35	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 087	2 H,SC,VNBC	0.32	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 087	1DNQ H,SC,VNBC	0.43	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 087	1 H,SC,VNBC	0.37	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 087	1 H,SC,VNBC	0.28	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 087	1DNQ H,VNBC	0.45	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 087	2 H,SC,VNBC	0.56	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 087	1DNQ H,SC,VNBC	0.22	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 087	1 H,SC,VNBC	0.28	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 087	1 H,SC,VNBC	0.38	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 087	1 H,SC,VNBC	0.59	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 087	1 H,SC,VNBC	0.52	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 087	1 H,SC,VNBC	0.75	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 087	1 H,SC,VNBC	0.76	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 087	1 SC,VNBC	1.05	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 087	1DNQ H,SC,VNBC	0.28	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB

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Year	Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2004	11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 087	1ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005	04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 087	1DNQ H,SC,VNBC	0.23	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005	04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 095	1 H,SC,VIP,VNBC	1.26	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004	11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 095	1 H,SC,VRIP,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005	04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 095	2 VRIP,H,SC,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005	04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 095	1 VRIP,H,SC,VNBC		ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004	11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 095	1 H,SC,VRIP,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005	04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 095	1 VRIP,H,SC,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005	04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 095	1 VRIP,H,VNBC		ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004	11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 095	2 H,SC,VIP,VNBC	0.82	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005	04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 095	1 VRIP,H,SC,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005	04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 095	1 VRIP,H,SC,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004	11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 095	1 H,SC,VRIP,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005	04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 095	1 H,SC,VIP,VNBC	1.24	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004	11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 095	1 H,SC,VIP,VNBC	0.97	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005	04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 095	1 H,SC,VIP,VNBC	1.37	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004	11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 095	1 H,SC,VIP,VNBC	1.19	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005	04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 095	1 SC,VIP,VNBC	1.46	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005	04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 095	1 VRIP,H,SC,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004	11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 095	1DNQ H,J,SC,VRIP,VNBC		ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005	04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 095	1 VRIP,H,SC,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005	04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 097	1 H,SC,VNBC	0.40	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 097	1DNQ H,J,SC,VNBC	0.14	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 097	2DNQ H,SC,VNBC	0.18	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 097	1DNQ H,SC,VNBC	0.27	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 097	1DNQ H,J,SC,VNBC	0.14	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 097	1DNQ H,SC,VNBC	0.16	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 097	1ND H,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 097	2DNQ H,J,SC,VNBC	0.15	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 097	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 097	1DNQ H,SC,VNBC	0.15	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 097	1DNQ H,J,SC,VNBC	0.18	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 097	1 H,SC,VNBC	0.38	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 097	1DNQ H,J,SC,VNBC	0.28	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 097	1DNQ H,SC,VNBC	0.33	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 097	1 H,SC,VNBC	0.61	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 097	1 SC,VNBC	0.74	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 097	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 097	1ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 097	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 099	1 H,SC,VNBC	0.61	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 099	1DNQ VIL,H,J,SC,VNBC	0.19	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 099	2DNQ H,SC,VNBC	0.21	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 099	1DNQ H,SC,VNBC	0.37	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB

6951643

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2004-11	NAPRIVUP	02-Nov-043	ORG	PCB	PCB 099	1	DNQ VIL,H,J,SC,VNBC	0.20	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-053	ORG	PCB	PCB 099	1	DNQ H,SC,VNBC	0.25	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-053	ORG	PCB	PCB 099	1	DNQ H,VNBC	0.49	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-043	ORG	PCB	PCB 099	2	VIL,H,SC,VNBC	0.28	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-053	ORG	PCB	PCB 099	1	ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-053	ORG	PCB	PCB 099	1	DNQ H,SC,VNBC	0.20	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-043	ORG	PCB	PCB 099	1	VIL,H,SC,VNBC	0.34	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-053	ORG	PCB	PCB 099	1	H,SC,VNBC	0.38	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-043	ORG	PCB	PCB 099	1	DNQ VIL,H,J,SC,VNBC	0.37	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-053	ORG	PCB	PCB 099	1	H,SC,VNBC	0.76	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-043	ORG	PCB	PCB 099	1	VIL,H,SC,VNBC	0.60	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-053	ORG	PCB	PCB 099	1	SC,VNBC	0.72	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-053	ORG	PCB	PCB 099	1	DNQ H,SC,VNBC	0.23	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-043	ORG	PCB	PCB 099	1	ND VIL,H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-053	ORG	PCB	PCB 099	1	DNQ H,SC,VNBC	0.16	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-053	ORG	PCB	PCB 101	1	H,SC,VIP,VNBC	1.58	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-043	ORG	PCB	PCB 101	1	H,SC,VRIP,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-053	ORG	PCB	PCB 101	2	VRIP,H,SC,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-053	ORG	PCB	PCB 101	1	VRIP,H,SC,VNBC		ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-043	ORG	PCB	PCB 101	1	H,SC,VRIP,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-053	ORG	PCB	PCB 101	1	VRIP,H,SC,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-053	ORG	PCB	PCB 101	1	VRIP,H,VNBC		ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 101	2 H,IL,SC,VIP,VNBC	1.02	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 101	1 VRIP,H,SC,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 101	1 VRIP,H,SC,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 101	1 H,SC,VRIP,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 101	1 VRIP,H,SC,VNBC		ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 101	1 H,SC,VIP,VNBC	1.15	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 101	1 H,SC,VIP,VNBC	1.90	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 101	1 H,SC,VIP,VNBC	1.49	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 101	1 SC,VIP,VNBC	2.03	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 101	1 VRIP,H,SC,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 101	1DNQ H,J,SC,VRIP,VNBC		ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 101	1 VRIP,H,SC,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 105	1DNQ H,SC,VNBC	0.33	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 105	1ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 105	2DNQ H,SC,VNBC	0.23	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 105	1DNQ H,SC,VNBC	0.26	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 105	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 105	1DNQ H,SC,VNBC	0.20	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 105	1ND H,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 105	2DNQ H,J,SC,VNBC	0.10	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 105	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 105	1DNQ H,SC,VNBC	0.20	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2004-11	SANLORCRKUP	03-Nov-043ORG	PCB		PCB 105	1ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-053ORG	PCB		PCB 105	1DNQ H,SC,VNBC	0.23	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-043ORG	PCB		PCB 105	1ND H,SC,VNBC	0.00	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-053ORG	PCB		PCB 105	1DNQ H,SC,VNBC	0.45	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-043ORG	PCB		PCB 105	1 H,SC,VNBC	0.33	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-053ORG	PCB		PCB 105	1 SC,VNBC	0.41	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-053ORG	PCB		PCB 105	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-043ORG	PCB		PCB 105	1ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-053ORG	PCB		PCB 105	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-053ORG	PCB		PCB 110	1 H,SC,VDO,VIP,VIL,VNBC	1.66	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-043ORG	PCB		PCB 110	1 VIU,VIL,H,SC,VRIP,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-053ORG	PCB		PCB 110	2VRIP,VIL,H,IL,SC,VDO,VNBC	1.47	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-053ORG	PCB		PCB 110	1 VRIP,VIL,H,SC,VDO,NBC		ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-043ORG	PCB		PCB 110	1 VIU,VIL,H,SC,VRIP,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-053ORG	PCB		PCB 110	1 VRIP,VIL,H,SC,VDO,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-053ORG	PCB		PCB 110	1 VRIP,VIL,H,VDO,VNBC		ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-043ORG	PCB		PCB 110	2 VIU,H,IL,SC,VIP,VNBC	0.96	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-053ORG	PCB		PCB 110	1 VRIP,VIL,H,SC,VDO,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-053ORG	PCB		PCB 110	1 VRIP,VIL,H,SC,VDO,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-043ORG	PCB		PCB 110	1 VIU,VIL,H,SC,VRIP,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-053ORG	PCB		PCB 110	1 H,SC,VDO,VIP,VIL,VNBC	1.63	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-043ORG	PCB		PCB 110	1 VIU,VIL,H,SC,VIP,VNBC	0.90	ug/kg	0.23	DFG-	WPCL_L-523-537-

AG1197

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
											WPCL	04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-053ORG	PCB		PCB 110	1	H,SC,VDO,VIP,VIL,VNBC	1.73	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-043ORG	PCB		PCB 110	1	VIU,VIL,H,SC,VIP,VNBC	1.81	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-053ORG	PCB		PCB 110	1	SC,VDO,VIP,VIL,VNBC	2.25	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-053ORG	PCB		PCB 110	1	VRIP,VIL,H,SC,VDO,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-043ORG	PCB		PCB 110	1	DNQ VIU,VIL,H,J,SC,VRIP,VNBC		ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-053ORG	PCB		PCB 110	1	VRIP,VIL,H,SC,VDO,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-053ORG	PCB		PCB 118	1	VRIP,H,SC,VNBC		ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-043ORG	PCB		PCB 118	1	VIL,H,SC,VRIP,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-053ORG	PCB		PCB 118	2	VRIP,H,SC,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-053ORG	PCB		PCB 118	1	VRIP,H,SC,VNBC		ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-043ORG	PCB		PCB 118	1	VIL,H,SC,VRIP,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-053ORG	PCB		PCB 118	1	VRIP,H,SC,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-053ORG	PCB		PCB 118	1	VRIP,H,VNBC		ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-043ORG	PCB		PCB 118	2	H,IL,SC,VIP,VNBC	1.24	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-053ORG	PCB		PCB 118	1	VRIP,H,SC,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-053ORG	PCB		PCB 118	1	VRIP,H,SC,VNBC		ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-043ORG	PCB		PCB 118	1	VIL,H,SC,VIP,VNBC	0.91	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-053ORG	PCB		PCB 118	1	VRIP,H,SC,VNBC		ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-043ORG	PCB		PCB 118	1	VIL,H,SC,VIP,VNBC	1.06	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-053ORG	PCB		PCB 118	1	H,SC,VIP,VNBC	2.05	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-043ORG	PCB		PCB 118	1	VIL,H,SC,VIP,VNBC	1.61	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 118	1 SC,VIP,VNBC	2.32	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 118	1 VRIP,H,SC,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 118	1 VIL,H,SC,VRIP,VNBC		ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 118	1 VRIP,H,SC,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 128	1DNQ H,SC,VNBC	0.22	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 128	1ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 128	2ND H,SC,VNBC	0.09	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 128	1ND H,SC,VNBC	0.00	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 128	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 128	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 128	1ND H,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 128	2ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 128	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 128	1ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 128	1ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 128	1DNQ H,SC,VNBC	0.22	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 128	1ND H,SC,VNBC	0.00	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 128	1ND H,SC,VNBC	0.00	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 128	1DNQ H,J,SC,VNBC	0.21	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 128	1DNQ SC,VNBC	0.30	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 128	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 128	1ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 128	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 138	1 H,SC,VIP,VNBC	2.72	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 138	1 H,SC,VNBC	1.23	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 138	2 H,SC,VIP,VNBC	1.57	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 138	1 H,SC,VIP,VNBC	0.97	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 138	1 H,SC,VNBC	0.61	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 138	1 VRIP,H,SC,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 138	1 H,VIP,VNBC	1.45	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 138	2 H,SC,VNBC	1.00	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 138	1 VRIP,H,SC,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 138	1 H,SC,VIP,VNBC	0.92	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 138	1 H,SC,VNBC	1.18	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 138	1 H,SC,VIP,VNBC	2.22	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 138	1 H,SC,VNBC	1.21	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 138	1 H,SC,VIP,VNBC	2.34	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 138	1 H,SC,VNBC	2.36	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 138	1 SC,VIP,VNBC	3.48	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 138	1 VRIP,H,SC,VNBC		ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 138	1DNQ H,J,SC,VNBC	0.17	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 138	1 VRIP,H,SC,VNBC		ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 141	1 H,SC,VNBC	0.39	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 141	1DNQ H,J,SC,VNBC	0.20	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 141	2	DNQ H,SC,VNBC	0.24	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 141	1	ND H,SC,VNBC	0.00	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 141	1	ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 141	1	ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 141	1	ND H,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 141	2	ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 141	1	ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 141	1	ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 141	1	ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 141	1	DNQ H,SC,VNBC	0.25	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 141	1	ND H,SC,VNBC	0.00	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 141	1	ND H,SC,VNBC	0.00	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 141	1	H,SC,VNBC	0.43	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 141	1	SC,VNBC	0.49	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 141	1	ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 141	1	ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 141	1	ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 149	1	H,SC,VNBC	2.07	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 149	1	H,SC,VNBC	1.15	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 149	2	H,SC,VNBC	1.30	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 149	1	H,SC,VNBC	0.52	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 149	1	H,SC,VNBC	0.32	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 149	1 H,SC,VNBC	0.32	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 149	1 H,VNBC	0.73	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 149	2 H,SC,VNBC	0.60	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 149	1 H,SC,VNBC	0.52	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 149	1 H,SC,VNBC	0.50	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 149	1 H,SC,VNBC	0.72	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 149	1 H,SC,VNBC	1.42	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 149	1 H,SC,VNBC	0.81	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 149	1 H,SC,VNBC	1.39	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 149	1 H,SC,VNBC	1.90	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 149	1 SC,VNBC	2.32	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 149	1DNQ H,SC,VNBC	0.29	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 149	1ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 149	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 151	1 H,SC,VNBC	0.71	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 151	1 H,SC,VNBC	0.38	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 151	2 H,SC,VNBC	0.54	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 151	1ND H,SC,VNBC	0.00	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 151	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 151	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 151	1ND H,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 151	2ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 151	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 151	1DNQ H,SC,VNBC	0.15	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 151	1DNQ H,J,SC,VNBC	0.15	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 151	1 H,SC,VNBC	0.38	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 151	1ND H,SC,VNBC	0.00	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 151	1DNQ H,SC,VNBC	0.35	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 151	1 H,SC,VNBC	0.69	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 151	1 SC,VNBC	0.60	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 151	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 151	1ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 151	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 153	1 H,SC,VNBC	2.22	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 153	1 H,SC,VNBC	0.94	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 153	2 H,SC,VNBC	1.18	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 153	1 H,SC,VNBC	0.66	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 153	1 H,SC,VNBC	0.37	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 153	1 H,SC,VNBC	0.36	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 153	1 H,VNBC	1.10	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 153	2 H,SC,VNBC	0.68	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 153	1 H,SC,VNBC	0.48	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 153	1 H,SC,VNBC	0.64	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 153	1 H,SC,VNBC	1.02	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	SANLORCRKUP	20-Apr-053ORG	PCB		PCB 153	1 H,SC,VNBC	1.33	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-043ORG	PCB		PCB 153	1 H,SC,VNBC	0.81	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-053ORG	PCB		PCB 153	1 H,SC,VNBC	1.81	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-043ORG	PCB		PCB 153	1 H,SC,VNBC	1.78	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-053ORG	PCB		PCB 153	1 SC,VNBC	2.29	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-053ORG	PCB		PCB 153	1 H,SC,VNBC	0.36	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-043ORG	PCB		PCB 153	1ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-053ORG	PCB		PCB 153	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-053ORG	PCB		PCB 156	1ND H,SC,VNBC	0.00	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-043ORG	PCB		PCB 156	1ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-053ORG	PCB		PCB 156	2ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-053ORG	PCB		PCB 156	1ND H,SC,VNBC	0.00	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-043ORG	PCB		PCB 156	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-053ORG	PCB		PCB 156	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-053ORG	PCB		PCB 156	1ND H,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-043ORG	PCB		PCB 156	2ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-053ORG	PCB		PCB 156	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-053ORG	PCB		PCB 156	1ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-043ORG	PCB		PCB 156	1ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-053ORG	PCB		PCB 156	1ND H,SC,VNBC	0.00	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-043ORG	PCB		PCB 156	1ND H,SC,VNBC	0.00	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-053ORG	PCB		PCB 156	1ND H,SC,VNBC	0.00	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 156	1 DNQ H,J,SC,VNBC	0.17	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 156	1 DNQ SC,VNBC	0.27	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 156	1 ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 156	1 ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 156	1 ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 158	1 ND H,SC,VNBC	0.00	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 158	1 ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 158	2 ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 158	1 ND H,SC,VNBC	0.00	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 158	1 ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 158	1 ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 158	1 ND H,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 158	2 ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 158	1 ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 158	1 ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 158	1 ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 158	1 ND H,SC,VNBC	0.00	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 158	1 ND H,SC,VNBC	0.00	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 158	1 ND H,SC,VNBC	0.00	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 158	1 DNQ H,J,SC,VNBC	0.23	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 158	1 DNQ SC,VNBC	0.25	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 158	1 ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 158	1ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 158	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 170	1 H,SC,VNBC	0.73	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 170	1 H,SC,VNBC	0.39	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 170	2 H,SC,VNBC	0.43	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 170	1ND H,SC,VNBC	0.00	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 170	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 170	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 170	1ND H,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 170	2ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 170	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 170	1DNQ H,SC,VNBC	0.14	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 170	1DNQ H,J,SC,VNBC	0.18	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 170	1 H,SC,VNBC	0.38	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 170	1ND H,SC,VNBC	0.00	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 170	1ND H,SC,VNBC	0.00	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 170	1 H,SC,VNBC	0.64	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 170	1 SC,VNBC	0.59	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 170	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 170	1ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 170	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 174	1 H,SC,VNBC	0.79	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2004-11	COYCRKUP	01-Nov-043ORG	PCB	PCB 174	1 H,SC,VNBC	0.46	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-053ORG	PCB	PCB 174	2 H,SC,VNBC	0.55	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-053ORG	PCB	PCB 174	1ND H,SC,VNBC	0.00	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-043ORG	PCB	PCB 174	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-053ORG	PCB	PCB 174	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-053ORG	PCB	PCB 174	1ND H,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-043ORG	PCB	PCB 174	2DNQ H,J,SC,VNBC	0.11	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-053ORG	PCB	PCB 174	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-053ORG	PCB	PCB 174	1ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-043ORG	PCB	PCB 174	1DNQ H,J,SC,VNBC	0.16	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-053ORG	PCB	PCB 174	1 H,SC,VNBC	0.41	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-043ORG	PCB	PCB 174	1ND H,SC,VNBC	0.00	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-053ORG	PCB	PCB 174	1ND H,SC,VNBC	0.00	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-043ORG	PCB	PCB 174	1 H,SC,VNBC	1.00	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-053ORG	PCB	PCB 174	1 SC,VNBC	0.79	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-053ORG	PCB	PCB 174	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-043ORG	PCB	PCB 174	1ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-053ORG	PCB	PCB 174	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-053ORG	PCB	PCB 177	1 H,SC,VNBC	0.51	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-043ORG	PCB	PCB 177	1DNQ H,J,SC,VNBC	0.23	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-053ORG	PCB	PCB 177	2 H,SC,VNBC	0.32	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-053ORG	PCB	PCB 177	1ND H,SC,VNBC	0.00	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 177	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 177	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 177	1ND H,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 177	2ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 177	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 177	1ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 177	1ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 177	1DNQ H,SC,VNBC	0.25	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 177	1ND H,SC,VNBC	0.00	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 177	1ND H,SC,VNBC	0.00	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 177	1 H,SC,VNBC	0.47	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 177	1DNQ SC,VNBC	0.31	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 177	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 177	1ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 177	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 180	1 H,SC,VNBC	1.77	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 180	1 H,SC,VNBC	1.02	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 180	2 H,SC,VNBC	1.15	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 180	1ND H,SC,VNBC	0.00	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 180	1DNQ H,J,SC,VNBC	0.14	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 180	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 180	1ND H,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2004-11	PETRIVUP	02-Nov-043ORG	PCB	PCB 180		2	H,SC,VNBC	0.37	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-053ORG	PCB	PCB 180		1	DNQ H,SC,VNBC	0.29	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-053ORG	PCB	PCB 180		1	H,SC,VNBC	0.30	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-043ORG	PCB	PCB 180		1	H,SC,VNBC	0.60	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-053ORG	PCB	PCB 180		1	H,SC,VNBC	1.03	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-043ORG	PCB	PCB 180		1	DNQ H,J,SC,VNBC	0.45	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-053ORG	PCB	PCB 180		1	H,SC,VNBC	0.98	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-043ORG	PCB	PCB 180		1	H,SC,VNBC	2.37	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-053ORG	PCB	PCB 180		1	SC,VNBC	2.08	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-053ORG	PCB	PCB 180		1	ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-043ORG	PCB	PCB 180		1	ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-053ORG	PCB	PCB 180		1	ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-053ORG	PCB	PCB 183		1	H,SC,VNBC	0.41	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-043ORG	PCB	PCB 183		1	DNQ H,J,SC,VNBC	0.21	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-053ORG	PCB	PCB 183		2	DNQ H,SC,VNBC	0.26	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-053ORG	PCB	PCB 183		1	ND H,SC,VNBC	0.00	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-043ORG	PCB	PCB 183		1	ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-053ORG	PCB	PCB 183		1	ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-053ORG	PCB	PCB 183		1	ND H,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-043ORG	PCB	PCB 183		2	ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-053ORG	PCB	PCB 183		1	ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-053ORG	PCB	PCB 183		1	ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 183	1ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 183	1DNQ H,SC,VNBC	0.18	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 183	1ND H,SC,VNBC	0.00	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 183	1ND H,SC,VNBC	0.00	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 183	1 H,SC,VNBC	0.60	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 183	1 SC,VNBC	0.48	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 183	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 183	1ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 183	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 187	1 H,SC,VNBC	1.08	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 187	1 H,SC,VNBC	0.62	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 187	2 H,SC,VNBC	0.61	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 187	1ND H,SC,VNBC	0.00	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 187	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 187	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 187	1ND H,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 187	2DNQ H,J,SC,VNBC	0.10	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 187	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 187	1ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 187	1 H,SC,VNBC	0.44	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 187	1 H,SC,VNBC	0.52	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 187	1ND H,SC,VNBC	0.00	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 187	1 H,SC,VNBC	0.69	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 187	1 H,SC,VNBC	1.51	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 187	1 SC,VNBC	1.24	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 187	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 187	1ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 187	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 194	1 H,SC,VNBC	0.41	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 194	1DNQ H,J,SC,VNBC	0.20	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 194	2DNQ H,SC,VNBC	0.20	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 194	1ND H,SC,VNBC	0.00	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 194	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 194	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 194	1ND H,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 194	2ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 194	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 194	1ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 194	1DNQ H,J,SC,VNBC	0.17	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 194	1DNQ H,SC,VNBC	0.22	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 194	1ND H,SC,VNBC	0.00	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 194	1ND H,SC,VNBC	0.00	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 194	1 H,SC,VNBC	1.13	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 194	1 SC,VNBC	0.76	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 194	1	ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 194	1	ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 194	1	ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 195	1	ND H,SC,VNBC	0.00	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 195	1	ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 195	2	ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 195	1	ND H,SC,VNBC	0.00	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 195	1	ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 195	1	ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 195	1	ND H,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 195	2	ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 195	1	ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 195	1	ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 195	1	ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 195	1	ND H,SC,VNBC	0.00	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 195	1	ND H,SC,VNBC	0.00	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 195	1	ND H,SC,VNBC	0.00	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 195	1	H,SC,VNBC	0.38	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 195	1	ND SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 195	1	ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 195	1	ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 195	1	ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 201	1 H,SC,VNBC	0.44	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 201	1 H,SC,VNBC	0.26	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 201	2 H,SC,VNBC	0.29	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 201	1ND H,SC,VNBC	0.00	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 201	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 201	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 201	1ND H,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 201	2ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 201	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 201	1ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 201	1DNQ H,J,SC,VNBC	0.22	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 201	1DNQ H,SC,VNBC	0.28	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 201	1ND H,SC,VNBC	0.00	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 201	1DNQ H,SC,VNBC	0.32	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 201	1 H,SC,VNBC	1.58	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 201	1 SC,VNBC	1.14	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 201	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 201	1ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 201	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	COYCRKLWR	18-Apr-05	3ORG	PCB	PCB 203	1DNQ H,SC,VNBC	0.34	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	COYCRKUP	01-Nov-04	3ORG	PCB	PCB 203	1DNQ H,J,SC,VNBC	0.19	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	COYCRKUP	18-Apr-05	3ORG	PCB	PCB 203	2DNQ H,SC,VNBC	0.25	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	NAPRIVLWR	19-Apr-05	3ORG	PCB	PCB 203	1ND H,SC,VNBC	0.00	ug/kg	0.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	NAPRIVUP	02-Nov-04	3ORG	PCB	PCB 203	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	NAPRIVUP	19-Apr-05	3ORG	PCB	PCB 203	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	PETRIVLWR	20-Apr-05	3ORG	PCB	PCB 203	1ND H,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	PETRIVUP	02-Nov-04	3ORG	PCB	PCB 203	2ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	PETRIVUP	20-Apr-05	3ORG	PCB	PCB 203	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	PCB	PCB 203	1ND H,SC,VNBC	0.00	ug/kg	0.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANLORCRKUP	03-Nov-04	3ORG	PCB	PCB 203	1DNQ H,J,SC,VNBC	0.20	ug/kg	0.13	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANLORCRKUP	20-Apr-05	3ORG	PCB	PCB 203	1DNQ H,SC,VNBC	0.32	ug/kg	0.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	PCB	PCB 203	1ND H,SC,VNBC	0.00	ug/kg	0.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	PCB	PCB 203	1ND H,SC,VNBC	0.00	ug/kg	0.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SANMATCRKUP	04-Nov-04	3ORG	PCB	PCB 203	1 H,SC,VNBC	1.34	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SANMATCRKUP	18-Apr-05	3ORG	PCB	PCB 203	1 SC,VNBC	0.92	ug/kg	0.18	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_PCB
2005-04	SUICRKLWR	19-Apr-05	3ORG	PCB	PCB 203	1ND H,SC,VNBC	0.00	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB
2004-11	SUICRKUP	03-Nov-04	3ORG	PCB	PCB 203	1ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_PCB
2005-04	SUICRKUP	19-Apr-05	3ORG	PCB	PCB 203	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_PCB

Appendix Table C.5. Sediment synthethic biocides (pesticides) results from the ambient tributary study in watersheds of the San Francisco Estuary (2004-2005). N = number of replicates. % solids were reported by each analytical laboratory. DFG-WPCL analyzed all trace organic samples in this study (see Appendix C - Table C.3). Lab codes are defined in table 1.1.

Cyclopentadienes

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	COYCRKLWR	18-Apr-05	3ORG	4CYCPENT	Aldrin	1	ND H,SC,VNBC	0.00	ug/kg	0.49	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	COYCRKUP	01-Nov-04	3ORG	4CYCPENT	Aldrin	1	ND H,SC,VNBC	0.00	ug/kg	0.33	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	COYCRKUP	18-Apr-05	3ORG	4CYCPENT	Aldrin	2	ND H,SC,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	4CYCPENT	Aldrin	1	ND H,SC,VNBC	0.00	ug/kg	0.57	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	NAPRIVUP	02-Nov-04	3ORG	4CYCPENT	Aldrin	1	ND H,SC,VNBC	0.00	ug/kg	0.36	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	NAPRIVUP	19-Apr-05	3ORG	4CYCPENT	Aldrin	1	ND H,SC,VNBC	0.00	ug/kg	0.36	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	PETRIVLWR	20-Apr-05	3ORG	4CYCPENT	Aldrin	1	ND H,SC,VNBC	0.00	ug/kg	0.92	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	PETRIVUP	02-Nov-04	3ORG	4CYCPENT	Aldrin	2	ND H,SC,VNBC	0.00	ug/kg	0.47	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	PETRIVUP	20-Apr-05	3ORG	4CYCPENT	Aldrin	1	ND H,SC,VNBC	0.00	ug/kg	0.46	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	4CYCPENT	Aldrin	1	ND H,SC,VNBC	0.00	ug/kg	0.34	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	4CYCPENT	Aldrin	1	ND H,SC,VNBC	0.00	ug/kg	0.34	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	4CYCPENT	Aldrin	1	DNQ H,SC,VNBC	0.50	ug/kg	0.44	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	4CYCPENT	Aldrin	1	ND H,SC,VNBC	0.00	ug/kg	0.61	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	4CYCPENT	Aldrin	1	ND H,SC,VNBC	0.00	ug/kg	0.80	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	4CYCPENT	Aldrin	1	DNQ H,J,SC,VNBC	0.52	ug/kg	0.37	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	4CYCPENT	Aldrin	1	DNQ SC,VNBC	0.55	ug/kg	0.48	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_OCH

CDFG 0691

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	SUICRKLWR	19-Apr-05	3ORG	4CYCPENT	Aldrin	1ND H,SC,VNBC	0.00	ug/kg	0.47	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SUICRKUP	03-Nov-04	3ORG	4CYCPENT	Aldrin	1ND H,SC,VNBC	0.00	ug/kg	0.40	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SUICRKUP	19-Apr-05	3ORG	4CYCPENT	Aldrin	1ND H,SC,VNBC	0.00	ug/kg	0.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	COYCRKLWR	18-Apr-05	3ORG	4CYCPENT	Dieldrin	1ND H,SC,VNBC	0.00	ug/kg	0.78	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	COYCRKUP	01-Nov-04	3ORG	4CYCPENT	Dieldrin	1DNQ H,J,SC,VNBC	0.63	ug/kg	0.54	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	COYCRKUP	18-Apr-05	3ORG	4CYCPENT	Dieldrin	2ND H,SC,VNBC	0.00	ug/kg	0.56	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	4CYCPENT	Dieldrin	1ND H,SC,VNBC	0.00	ug/kg	0.92	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	NAPRIVUP	02-Nov-04	3ORG	4CYCPENT	Dieldrin	1ND H,SC,VNBC	0.00	ug/kg	0.58	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	NAPRIVUP	19-Apr-05	3ORG	4CYCPENT	Dieldrin	1ND H,SC,VNBC	0.00	ug/kg	0.58	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	PETRIVLWR	20-Apr-05	3ORG	4CYCPENT	Dieldrin	1ND H,SC,VNBC	0.00	ug/kg	1.49	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	PETRIVUP	02-Nov-04	3ORG	4CYCPENT	Dieldrin	2ND H,SC,VNBC	0.00	ug/kg	0.76	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	PETRIVUP	20-Apr-05	3ORG	4CYCPENT	Dieldrin	1ND H,SC,VNBC	0.00	ug/kg	0.75	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	4CYCPENT	Dieldrin	1 H,SC,VNBC	1.02	ug/kg	0.55	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	4CYCPENT	Dieldrin	1 H,SC,VNBC	1.43	ug/kg	0.55	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	4CYCPENT	Dieldrin	1 H,SC,VNBC	3.58	ug/kg	0.72	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	4CYCPENT	Dieldrin	1 H,SC,VNBC	2.79	ug/kg	0.98	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	4CYCPENT	Dieldrin	1 H,SC,VNBC	2.00	ug/kg	1.28	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	4CYCPENT	Dieldrin	1 H,SC,VNBC	6.70	ug/kg	0.59	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	4CYCPENT	Dieldrin	1DNQ SC,VNBC	0.78	ug/kg	0.77	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_OCH
2005-04	SUICRKLWR	19-Apr-05	3ORG	4CYCPENT	Dieldrin	1ND H,SC,VNBC	0.00	ug/kg	0.75	DFG-	WPCL_L-211-

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2004-11	SUICRKUP	03-Nov-04	3ORG	4CYCPENT	Dieldrin	1DNQ H,J,SC,VNBC	0.73	ug/kg	0.64	WPCL	05_BS375_KR_S_OCH
2005-04	SUICRKUP	19-Apr-05	3ORG	4CYCPENT	Dieldrin	1ND H,SC,VNBC	0.00	ug/kg	0.57	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	COYCRKLWR	18-Apr-05	3ORG	4CYCPENT	Endrin	1ND VRIU,H,SC,VNBC	0.00	ug/kg	1.75	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	COYCRKUP	01-Nov-04	3ORG	4CYCPENT	Endrin	1ND VIU,H,SC,VNBC	0.00	ug/kg	1.21	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	COYCRKUP	18-Apr-05	3ORG	4CYCPENT	Endrin	2ND VRIU,H,SC,VNBC	0.00	ug/kg	1.25	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	4CYCPENT	Endrin	1ND VRIU,H,SC,VNBC	0.00	ug/kg	2.06	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	NAPRIVUP	02-Nov-04	3ORG	4CYCPENT	Endrin	1ND VIU,H,SC,VNBC	0.00	ug/kg	1.29	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	NAPRIVUP	19-Apr-05	3ORG	4CYCPENT	Endrin	1ND VRIU,H,SC,VNBC	0.00	ug/kg	1.30	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	PETRIVLWR	20-Apr-05	3ORG	4CYCPENT	Endrin	1ND VRIU,H,SC,VNBC	0.00	ug/kg	3.33	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2004-11	PETRIVUP	02-Nov-04	3ORG	4CYCPENT	Endrin	2ND VIU,H,SC,VNBC	0.00	ug/kg	1.70	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	PETRIVUP	20-Apr-05	3ORG	4CYCPENT	Endrin	1ND VRIU,H,SC,VNBC	0.00	ug/kg	1.68	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	4CYCPENT	Endrin	1ND VRIU,H,SC,VNBC	0.00	ug/kg	1.22	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	4CYCPENT	Endrin	1ND VIU,H,SC,VNBC	0.00	ug/kg	1.23	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	4CYCPENT	Endrin	1ND VRIU,H,SC,VNBC	0.00	ug/kg	1.60	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	4CYCPENT	Endrin	1ND VIU,H,SC,VNBC	0.00	ug/kg	2.20	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	4CYCPENT	Endrin	1ND VRIU,H,SC,VNBC	0.00	ug/kg	2.87	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	4CYCPENT	Endrin	1ND VIU,H,SC,VNBC	0.00	ug/kg	1.32	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_OCH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	4CYCPENT	Endrin	1ND VRIU,SC,VNBC	0.00	ug/kg	1.73	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SUICRKLWR	19-Apr-05	3ORG	4CYCPENT	Endrin	1ND VRIU,H,SC,VNBC	0.00	ug/kg	1.69	WPCL	

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2004-11	SUICRKUP	03-Nov-04	3ORG	4CYCPENT	Endrin	1ND VIU,H,SC,VNBC	0.00	ug/kg	1.44	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SUICRKUP	19-Apr-05	3ORG	4CYCPENT	Endrin	1ND VRIU,H,SC,VNBC	0.00	ug/kg	1.26	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH

Chlordanes

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	COYCRKLWR	18-Apr-05	3ORG	2CHLR	alpha-Chlordane	1 VIU,H,SC,VNBC	2.22	ug/kg	1.34	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	COYCRKUP	01-Nov-04	3ORG	2CHLR	alpha-Chlordane	1 VRIU,H,SC,VNBC		ug/kg	0.92	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	COYCRKUP	18-Apr-05	3ORG	2CHLR	alpha-Chlordane	2 VIU,H,SC,VNBC	0.98	ug/kg	0.95	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	2CHLR	alpha-Chlordane	1DNQ VIU,H,SC,VNBC	1.90	ug/kg	1.57	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	NAPRIVUP	02-Nov-04	3ORG	2CHLR	alpha-Chlordane	1ND VRIU,H,SC,VNBC	0.00	ug/kg	0.98	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	NAPRIVUP	19-Apr-05	3ORG	2CHLR	alpha-Chlordane	1ND VIU,H,SC,VNBC	0.00	ug/kg	0.99	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	PETRIVLWR	20-Apr-05	3ORG	2CHLR	alpha-Chlordane	1ND VIU,H,SC,VNBC	0.00	ug/kg	2.54	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	PETRIVUP	02-Nov-04	3ORG	2CHLR	alpha-Chlordane	2DNQ VRIU,H,J,SC,VNBC		ug/kg	1.29	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	PETRIVUP	20-Apr-05	3ORG	2CHLR	alpha-Chlordane	1DNQ VIU,H,SC,VNBC	1.63	ug/kg	1.28	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	2CHLR	alpha-Chlordane	1 VIU,H,SC,VNBC	2.67	ug/kg	0.93	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	2CHLR	alpha-Chlordane	1 VRIU,H,SC,VNBC		ug/kg	0.93	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	2CHLR	alpha-Chlordane	1 VIU,H,SC,VNBC	9.55	ug/kg	1.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	2CHLR	alpha-Chlordane	1 VRIU,H,SC,VNBC		ug/kg	1.67	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	2CHLR	alpha-Chlordane	1 VIU,H,SC,VNBC	4.37	ug/kg	2.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	2CHLR	alpha-Chlordane	1 VRIU,H,SC,VNBC		ug/kg	1.01	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	SANMATCRKUP	18-Apr-05	3ORG	2CHLR	alpha-Chlordane	1	VIU,SC,VNBC	15.60	ug/kg	1.32	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_OCH
2005-04	SUICRKLWR	19-Apr-05	3ORG	2CHLR	alpha-Chlordane	1	ND VIU,H,SC,VNBC	0.00	ug/kg	1.29	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SUICRKUP	03-Nov-04	3ORG	2CHLR	alpha-Chlordane	1	ND VRIU,H,SC,VNBC	0.00	ug/kg	1.10	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SUICRKUP	19-Apr-05	3ORG	2CHLR	alpha-Chlordane	1	ND VIU,H,SC,VNBC	0.00	ug/kg	0.96	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	COYCRKLWR	18-Apr-05	3ORG	2CHLR	cis-Nonachlor	1	ND H,SC,VNBC	0.00	ug/kg	1.83	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	COYCRKUP	01-Nov-04	3ORG	2CHLR	cis-Nonachlor	1	ND H,SC,VNBC	0.00	ug/kg	1.26	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	COYCRKUP	18-Apr-05	3ORG	2CHLR	cis-Nonachlor	2	ND H,SC,VNBC	0.00	ug/kg	1.30	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	2CHLR	cis-Nonachlor	1	ND H,SC,VNBC	0.00	ug/kg	2.15	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	NAPRIVUP	02-Nov-04	3ORG	2CHLR	cis-Nonachlor	1	ND H,SC,VNBC	0.00	ug/kg	1.35	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	NAPRIVUP	19-Apr-05	3ORG	2CHLR	cis-Nonachlor	1	ND H,SC,VNBC	0.00	ug/kg	1.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	PETRIVLWR	20-Apr-05	3ORG	2CHLR	cis-Nonachlor	1	ND H,SC,VNBC	0.00	ug/kg	3.47	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	PETRIVUP	02-Nov-04	3ORG	2CHLR	cis-Nonachlor	2	ND H,SC,VNBC	0.00	ug/kg	1.77	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	PETRIVUP	20-Apr-05	3ORG	2CHLR	cis-Nonachlor	1	ND H,SC,VNBC	0.00	ug/kg	1.75	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	2CHLR	cis-Nonachlor	1	ND H,SC,VNBC	0.00	ug/kg	1.28	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	2CHLR	cis-Nonachlor	1	ND H,SC,VNBC	0.00	ug/kg	1.28	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	2CHLR	cis-Nonachlor	1	H,SC,VNBC	3.22	ug/kg	1.67	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	2CHLR	cis-Nonachlor	1	ND H,SC,VNBC	0.00	ug/kg	2.29	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	2CHLR	cis-Nonachlor	1	ND H,SC,VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	2CHLR	cis-Nonachlor	1	H,SC,VNBC	5.35	ug/kg	1.38	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	2CHLR	cis-Nonachlor	1	SC,VNBC	5.25	ug/kg	1.80	DFG-	WPCL_L-192-

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
										WPCL	05_BS373_KR_S_OCH
2005-04	SUICRKLWR	19-Apr-05	3ORG	2CHLR	cis-Nonachlor	1 ND H,SC,VNBC	0.00	ug/kg	1.76	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SUICRKUP	03-Nov-04	3ORG	2CHLR	cis-Nonachlor	1 ND H,SC,VNBC	0.00	ug/kg	1.50	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SUICRKUP	19-Apr-05	3ORG	2CHLR	cis-Nonachlor	1 ND H,SC,VNBC	0.00	ug/kg	1.32	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	COYCRKLWR	18-Apr-05	3ORG	2CHLR	gamma-Chlordane	1 VRIU,H,SC,VNBC		ug/kg	0.75	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	COYCRKUP	01-Nov-04	3ORG	2CHLR	gamma-Chlordane	1 VRIU,H,SC,VNBC		ug/kg	0.52	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	COYCRKUP	18-Apr-05	3ORG	2CHLR	gamma-Chlordane	2 VRIU,H,SC,VNBC		ug/kg	0.54	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	2CHLR	gamma-Chlordane	1 DNQ VRIU,H,SC,VNBC		ug/kg	0.89	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	NAPRIVUP	02-Nov-04	3ORG	2CHLR	gamma-Chlordane	1 DNQ VRIU,H,J,SC,VNBC		ug/kg	0.55	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	NAPRIVUP	19-Apr-05	3ORG	2CHLR	gamma-Chlordane	1 DNQ VRIU,H,SC,VNBC		ug/kg	0.56	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	PETRIVLWR	20-Apr-05	3ORG	2CHLR	gamma-Chlordane	1 ND VRIU,H,SC,VNBC	0.00	ug/kg	1.43	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	PETRIVUP	02-Nov-04	3ORG	2CHLR	gamma-Chlordane	2 DNQ VRIU,H,J,SC,VNBC		ug/kg	0.73	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	PETRIVUP	20-Apr-05	3ORG	2CHLR	gamma-Chlordane	1 DNQ VRIU,H,SC,VNBC		ug/kg	0.72	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	2CHLR	gamma-Chlordane	1 VRIU,H,SC,VNBC		ug/kg	0.53	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	2CHLR	gamma-Chlordane	1 VRIU,H,SC,VNBC		ug/kg	0.53	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	2CHLR	gamma-Chlordane	1 VRIU,H,SC,VNBC		ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	2CHLR	gamma-Chlordane	1 VRIU,H,SC,VNBC		ug/kg	0.94	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	2CHLR	gamma-Chlordane	1 VRIU,H,SC,VNBC		ug/kg	1.24	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	2CHLR	gamma-Chlordane	1 VRIU,H,SC,VNBC		ug/kg	0.57	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	2CHLR	gamma-Chlordane	1 VRIU,SC,VNBC		ug/kg	0.74	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_OCH

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	SUICRKLWR	19-Apr-05	3ORG	2CHLR	gamma-Chlordane	1ND VRIU,H,SC,VNBC	0.00	ug/kg	0.73	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SUICRKUP	03-Nov-04	3ORG	2CHLR	gamma-Chlordane	1ND VRIU,H,SC,VNBC	0.00	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SUICRKUP	19-Apr-05	3ORG	2CHLR	gamma-Chlordane	1ND VRIU,H,SC,VNBC	0.00	ug/kg	0.54	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	COYCRKLWR	18-Apr-05	3ORG	2CHLR	Heptachlor	1ND H,SC,VNBC	0.00	ug/kg	0.96	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	COYCRKUP	01-Nov-04	3ORG	2CHLR	Heptachlor	1ND VIU,H,SC,VNBC	0.00	ug/kg	0.66	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	COYCRKUP	18-Apr-05	3ORG	2CHLR	Heptachlor	2ND H,SC,VNBC	0.00	ug/kg	0.68	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	2CHLR	Heptachlor	1ND H,SC,VNBC	0.00	ug/kg	1.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	NAPRIVUP	02-Nov-04	3ORG	2CHLR	Heptachlor	1ND VIU,H,SC,VNBC	0.00	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	NAPRIVUP	19-Apr-05	3ORG	2CHLR	Heptachlor	1ND H,SC,VNBC	0.00	ug/kg	0.71	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	PETRIVLWR	20-Apr-05	3ORG	2CHLR	Heptachlor	1ND H,SC,VNBC	0.00	ug/kg	1.83	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	PETRIVUP	02-Nov-04	3ORG	2CHLR	Heptachlor	2ND VIU,H,SC,VNBC	0.00	ug/kg	0.93	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	PETRIVUP	20-Apr-05	3ORG	2CHLR	Heptachlor	1ND H,SC,VNBC	0.00	ug/kg	0.92	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	2CHLR	Heptachlor	1ND H,SC,VNBC	0.00	ug/kg	0.67	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	2CHLR	Heptachlor	1ND VIU,H,SC,VNBC	0.00	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	2CHLR	Heptachlor	1ND H,SC,VNBC	0.00	ug/kg	0.88	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	2CHLR	Heptachlor	1ND VIU,H,SC,VNBC	0.00	ug/kg	1.21	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	2CHLR	Heptachlor	1ND H,SC,VNBC	0.00	ug/kg	1.58	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	2CHLR	Heptachlor	1ND VIU,H,SC,VNBC	0.00	ug/kg	0.73	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	2CHLR	Heptachlor	1ND SC,VNBC	0.00	ug/kg	0.95	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_OCH
2005-04	SUICRKLWR	19-Apr-05	3ORG	2CHLR	Heptachlor	1ND H,SC,VNBC	0.00	ug/kg	0.93	DFG-	WPCL_L-211-

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
										WPCL	05_BS375_KR_S_OCH
2004-11	SUICRKUP	03-Nov-04	3ORG	2CHLR	Heptachlor	1ND VIU,H,SC,VNBC	0.00	ug/kg	0.79	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SUICRKUP	19-Apr-05	3ORG	2CHLR	Heptachlor	1ND H,SC,VNBC	0.00	ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	COYCRKLWR	18-Apr-05	3ORG	2CHLR	Heptachlor Epoxide	1ND H,SC,VNBC	0.00	ug/kg	0.94	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	COYCRKUP	01-Nov-04	3ORG	2CHLR	Heptachlor Epoxide	1DNQ H,J,SC,VNBC	0.72	ug/kg	0.65	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	COYCRKUP	18-Apr-05	3ORG	2CHLR	Heptachlor Epoxide	2ND H,SC,VNBC	0.00	ug/kg	0.67	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	2CHLR	Heptachlor Epoxide	1ND H,SC,VNBC	0.00	ug/kg	1.11	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	NAPRIVUP	02-Nov-04	3ORG	2CHLR	Heptachlor Epoxide	1ND H,SC,VNBC	0.00	ug/kg	0.69	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	NAPRIVUP	19-Apr-05	3ORG	2CHLR	Heptachlor Epoxide	1ND H,SC,VNBC	0.00	ug/kg	0.70	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	PETRIVLWR	20-Apr-05	3ORG	2CHLR	Heptachlor Epoxide	1ND H,SC,VNBC	0.00	ug/kg	1.79	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	PETRIVUP	02-Nov-04	3ORG	2CHLR	Heptachlor Epoxide	2ND H,SC,VNBC	0.00	ug/kg	0.91	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	PETRIVUP	20-Apr-05	3ORG	2CHLR	Heptachlor Epoxide	1ND H,SC,VNBC	0.00	ug/kg	0.90	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	2CHLR	Heptachlor Epoxide	1DNQ H,SC,VNBC	0.72	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	2CHLR	Heptachlor Epoxide	1DNQ H,J,SC,VNBC	0.79	ug/kg	0.66	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	2CHLR	Heptachlor Epoxide	1 H,SC,VNBC	2.46	ug/kg	0.86	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	2CHLR	Heptachlor Epoxide	1DNQ H,J,SC,VNBC	1.59	ug/kg	1.18	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	2CHLR	Heptachlor Epoxide	1ND H,SC,VNBC	0.00	ug/kg	1.54	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	2CHLR	Heptachlor Epoxide	1 H,SC,VNBC	4.20	ug/kg	0.71	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	2CHLR	Heptachlor Epoxide	1 SC,VNBC	4.42	ug/kg	0.93	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_OCH
2005-04	SUICRKLWR	19-Apr-05	3ORG	2CHLR	Heptachlor Epoxide	1ND H,SC,VNBC	0.00	ug/kg	0.91	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2004-11	SUICRKUP	03-Nov-04	3ORG	2CHLR	Heptachlor Epoxide	1ND H,SC,VNBC	0.00	ug/kg	0.77	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SUICRKUP	19-Apr-05	3ORG	2CHLR	Heptachlor Epoxide	1ND H,SC,VNBC	0.00	ug/kg	0.68	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	COYCRKLWR	18-Apr-05	3ORG	2CHLR	Oxychlordane	1ND H,SC,VNBC	0.00	ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	COYCRKUP	01-Nov-04	3ORG	2CHLR	Oxychlordane	1ND H,SC,VNBC	0.00	ug/kg	0.47	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	COYCRKUP	18-Apr-05	3ORG	2CHLR	Oxychlordane	2ND H,SC,VNBC	0.00	ug/kg	0.49	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	2CHLR	Oxychlordane	1ND H,SC,VNBC	0.00	ug/kg	0.81	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	NAPRIVUP	02-Nov-04	3ORG	2CHLR	Oxychlordane	1ND H,SC,VNBC	0.00	ug/kg	0.51	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	NAPRIVUP	19-Apr-05	3ORG	2CHLR	Oxychlordane	1ND H,SC,VNBC	0.00	ug/kg	0.51	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	PETRIVLWR	20-Apr-05	3ORG	2CHLR	Oxychlordane	1ND H,SC,VNBC	0.00	ug/kg	1.30	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	PETRIVUP	02-Nov-04	3ORG	2CHLR	Oxychlordane	2ND H,SC,VNBC	0.00	ug/kg	0.66	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	PETRIVUP	20-Apr-05	3ORG	2CHLR	Oxychlordane	1ND H,SC,VNBC	0.00	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	2CHLR	Oxychlordane	1ND H,SC,VNBC	0.00	ug/kg	0.48	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	2CHLR	Oxychlordane	1ND H,SC,VNBC	0.00	ug/kg	0.48	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	2CHLR	Oxychlordane	1ND H,SC,VNBC	0.00	ug/kg	0.63	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	2CHLR	Oxychlordane	1ND H,SC,VNBC	0.00	ug/kg	0.86	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	2CHLR	Oxychlordane	1ND H,SC,VNBC	0.00	ug/kg	1.13	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	2CHLR	Oxychlordane	1DNQ H,J,SC,VNBC	1.07	ug/kg	0.52	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	2CHLR	Oxychlordane	1DNQ SC,VNBC	1.29	ug/kg	0.68	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_OCH
2005-04	SUICRKLWR	19-Apr-05	3ORG	2CHLR	Oxychlordane	1ND H,SC,VNBC	0.00	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SUICRKUP	03-Nov-04	3ORG	2CHLR	Oxychlordane	1ND H,SC,VNBC	0.00	ug/kg	0.56	DFG-	WPCL_L-523-537-

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
										WPCL	04_BS347_KR_S_OCH
2005-04	SUICRKUP	19-Apr-05	3ORG	2CHLR	Oxychlordane	1ND H,SC,VNBC	0.00	ug/kg	0.50	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	COYCRKLWR	18-Apr-05	3ORG	2CHLR	trans-Nonachlor	1DNQ H,SC,VNBC	1.83	ug/kg	0.72	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	COYCRKUP	01-Nov-04	3ORG	2CHLR	trans-Nonachlor	1 VIU,H,SC,VNBC	1.86	ug/kg	0.50	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	COYCRKUP	18-Apr-05	3ORG	2CHLR	trans-Nonachlor	2 H,SC,VNBC	1.55	ug/kg	0.52	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	2CHLR	trans-Nonachlor	1DNQ H,SC,VNBC	1.88	ug/kg	0.85	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	NAPRIVUP	02-Nov-04	3ORG	2CHLR	trans-Nonachlor	1DNQ VIU,H,J,SC,VNBC	0.54	ug/kg	0.53	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	NAPRIVUP	19-Apr-05	3ORG	2CHLR	trans-Nonachlor	1DNQ H,SC,VNBC	0.77	ug/kg	0.54	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	PETRIVLWR	20-Apr-05	3ORG	2CHLR	trans-Nonachlor	1ND H,VNBC	0.00	ug/kg	1.37	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	PETRIVUP	02-Nov-04	3ORG	2CHLR	trans-Nonachlor	2DNQ VIU,H,J,SC,VNBC	1.49	ug/kg	0.70	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	PETRIVUP	20-Apr-05	3ORG	2CHLR	trans-Nonachlor	1DNQ H,SC,VNBC	1.73	ug/kg	0.69	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	2CHLR	trans-Nonachlor	1 H,SC,VNBC	2.21	ug/kg	0.51	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	2CHLR	trans-Nonachlor	1 VIU,H,SC,VNBC	2.17	ug/kg	0.51	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	2CHLR	trans-Nonachlor	1 H,SC,VNBC	7.94	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	2CHLR	trans-Nonachlor	1 VIU,H,SC,VNBC	4.14	ug/kg	0.91	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	2CHLR	trans-Nonachlor	1 H,SC,VNBC	3.66	ug/kg	1.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	2CHLR	trans-Nonachlor	1 VIU,H,SC,VNBC	13.90	ug/kg	0.55	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	2CHLR	trans-Nonachlor	1 SC,VNBC	6.12	ug/kg	0.71	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_OCH
2005-04	SUICRKLWR	19-Apr-05	3ORG	2CHLR	trans-Nonachlor	1ND H,SC,VNBC	0.00	ug/kg	0.70	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SUICRKUP	03-Nov-04	3ORG	2CHLR	trans-Nonachlor	1ND VIU,H,SC,VNBC	0.00	ug/kg	0.59	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH

691699

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	SUICRKUP	19-Apr-05	3ORG	2CHLR	trans-Nonachlor	1	ND H,SC,VNBC	0.00	ug/kg	0.52	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH

DDTs

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	COYCRKLWR	18-Apr-05	3ORG	1ADDT	Sum of DDTs (SFEI)	1	X	15.79	ug/kg	1.99	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	COYCRKUP	01-Nov-04	3ORG	1ADDT	Sum of DDTs (SFEI)	1	X	14.69	ug/kg	1.37	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	COYCRKUP	18-Apr-05	3ORG	1ADDT	Sum of DDTs (SFEI)	2	X	11.20	ug/kg	1.41	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	1ADDT	Sum of DDTs (SFEI)	1	X	8.53	ug/kg	2.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	NAPRIVUP	02-Nov-04	3ORG	1ADDT	Sum of DDTs (SFEI)	1	X	11.82	ug/kg	1.46	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	NAPRIVUP	19-Apr-05	3ORG	1ADDT	Sum of DDTs (SFEI)	1	X	7.20	ug/kg	1.47	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	PETRIVLWR	20-Apr-05	3ORG	1ADDT	Sum of DDTs (SFEI)	1	X	3.74	ug/kg	3.78	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	PETRIVUP	02-Nov-04	3ORG	1ADDT	Sum of DDTs (SFEI)	2	X	3.74	ug/kg	1.92	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	PETRIVUP	20-Apr-05	3ORG	1ADDT	Sum of DDTs (SFEI)	1	X	2.29	ug/kg	1.91	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	1ADDT	Sum of DDTs (SFEI)	1	X	4.70	ug/kg	1.39	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	1ADDT	Sum of DDTs (SFEI)	1	X	8.61	ug/kg	1.39	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	1ADDT	Sum of DDTs (SFEI)	1	X	25.95	ug/kg	1.82	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	1ADDT	Sum of DDTs (SFEI)	1	X	13.25	ug/kg	2.50	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	1ADDT	Sum of DDTs (SFEI)	1	X	15.84	ug/kg	3.26	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	1ADDT	Sum of DDTs (SFEI)	1	X	64.23	ug/kg	1.50	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	1ADDT	Sum of DDTs (SFEI)	1	X	36.58	ug/kg	1.96	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_OCH

4701709

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	SUICRKLWR	19-Apr-05	3ORG	1ADDT	Sum of DDTs (SFEI)	1 X	6.22	ug/kg	1.92	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SUICRKUP	03-Nov-04	3ORG	1ADDT	Sum of DDTs (SFEI)	1 X	6.74	ug/kg	1.63	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SUICRKUP	19-Apr-05	3ORG	1ADDT	Sum of DDTs (SFEI)	1 X	8.32	ug/kg	1.44	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	COYCRKLWR	18-Apr-05	3ORG	1DDT	o,p'-DDD	1DNQ H,SC,VNBC	1.60	ug/kg	1.43	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	COYCRKUP	01-Nov-04	3ORG	1DDT	o,p'-DDD	1 H,SC,VNBC	1.44	ug/kg	0.99	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	COYCRKUP	18-Apr-05	3ORG	1DDT	o,p'-DDD	2DNQ H,SC,VNBC	1.16	ug/kg	1.02	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	1DDT	o,p'-DDD	1ND H,SC,VNBC	0.00	ug/kg	1.69	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	NAPRIVUP	02-Nov-04	3ORG	1DDT	o,p'-DDD	1ND H,SC,VNBC	0.00	ug/kg	1.05	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	NAPRIVUP	19-Apr-05	3ORG	1DDT	o,p'-DDD	1ND H,SC,VNBC	0.00	ug/kg	1.06	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	PETRIVLWR	20-Apr-05	3ORG	1DDT	o,p'-DDD	1ND H,SC,VNBC	0.00	ug/kg	2.72	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	PETRIVUP	02-Nov-04	3ORG	1DDT	o,p'-DDD	2ND H,SC,VNBC	0.00	ug/kg	1.38	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	PETRIVUP	20-Apr-05	3ORG	1DDT	o,p'-DDD	1ND H,SC,VNBC	0.00	ug/kg	1.37	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	1DDT	o,p'-DDD	1ND H,SC,VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	1DDT	o,p'-DDD	1ND H,SC,VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	1DDT	o,p'-DDD	1 H,SC,VNBC	2.78	ug/kg	1.31	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	1DDT	o,p'-DDD	1ND H,SC,VNBC	0.00	ug/kg	1.80	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	1DDT	o,p'-DDD	1ND H,SC,VNBC	0.00	ug/kg	2.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	1DDT	o,p'-DDD	1 H,SC,VNBC	3.07	ug/kg	1.08	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	1DDT	o,p'-DDD	1 SC,VNBC	2.48	ug/kg	1.41	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_OCH
2005-04	SUICRKLWR	19-Apr-05	3ORG	1DDT	o,p'-DDD	1ND H,SC,VNBC	0.00	ug/kg	1.38	DFG-	WPCL_L-211-

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
											WPCL	05_BS375_KR_S_OCH
											DFG-WPCL	L-523-537-04_BS347_KR_S_OCH
2004-11	SUICRKUP	03-Nov-04	3ORG	1DDT	o,p'-DDD	1	ND H,SC,VNBC	0.00	ug/kg	1.18	DFG-WPCL	L-211-05_BS375_KR_S_OCH
2005-04	SUICRKUP	19-Apr-05	3ORG	1DDT	o,p'-DDD	1	ND H,SC,VNBC	0.00	ug/kg	1.03	DFG-WPCL	L-211-05_BS375_KR_S_OCH
2005-04	COYCRKLWR	18-Apr-05	3ORG	1DDT	o,p'-DDE	1	ND VIU,H,SC,VNBC	0.00	ug/kg	1.25	DFG-WPCL	L-523-537-04_BS347_KR_S_OCH
2004-11	COYCRKUP	01-Nov-04	3ORG	1DDT	o,p'-DDE	1	ND H,SC,VNBC	0.00	ug/kg	0.86	DFG-WPCL	L-211-05_BS375_KR_S_OCH
2005-04	COYCRKUP	18-Apr-05	3ORG	1DDT	o,p'-DDE	2	ND VIU,H,SC,VNBC	0.00	ug/kg	0.89	DFG-WPCL	L-211-05_BS375_KR_S_OCH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	1DDT	o,p'-DDE	1	ND VIU,H,SC,VNBC	0.00	ug/kg	1.48	DFG-WPCL	L-523-537-04_BS347_KR_S_OCH
2004-11	NAPRIVUP	02-Nov-04	3ORG	1DDT	o,p'-DDE	1	ND H,SC,VNBC	0.00	ug/kg	0.92	DFG-WPCL	L-211-05_BS375_KR_S_OCH
2005-04	NAPRIVUP	19-Apr-05	3ORG	1DDT	o,p'-DDE	1	ND VIU,H,SC,VNBC	0.00	ug/kg	0.93	DFG-WPCL	L-211-05_BS375_KR_S_OCH
2005-04	PETRIVLWR	20-Apr-05	3ORG	1DDT	o,p'-DDE	1	ND VIU,H,VNBC	0.00	ug/kg	2.38	DFG-WPCL	L-523-537-04_BS347_KR_S_OCH
2004-11	PETRIVUP	02-Nov-04	3ORG	1DDT	o,p'-DDE	2	ND H,SC,VNBC	0.00	ug/kg	1.21	DFG-WPCL	L-211-05_BS375_KR_S_OCH
2005-04	PETRIVUP	20-Apr-05	3ORG	1DDT	o,p'-DDE	1	ND VIU,H,SC,VNBC	0.00	ug/kg	1.20	DFG-WPCL	L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	1DDT	o,p'-DDE	1	ND VIU,H,SC,VNBC	0.00	ug/kg	0.88	DFG-WPCL	L-523-537-04_BS347_KR_S_OCH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	1DDT	o,p'-DDE	1	ND H,SC,VNBC	0.00	ug/kg	0.88	DFG-WPCL	L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	1DDT	o,p'-DDE	1	ND VIU,H,SC,VNBC	0.00	ug/kg	1.15	DFG-WPCL	L-523-537-04_BS347_KR_S_OCH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	1DDT	o,p'-DDE	1	ND H,SC,VNBC	0.00	ug/kg	1.57	DFG-WPCL	L-211-05_BS375_KR_S_OCH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	1DDT	o,p'-DDE	1	ND VIU,H,SC,VNBC	0.00	ug/kg	2.05	DFG-WPCL	L-523-537-04_BS347_KR_S_OCH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	1DDT	o,p'-DDE	1	ND H,SC,VNBC	0.00	ug/kg	0.94	DFG-WPCL	L-192-05_BS373_KR_S_OCH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	1DDT	o,p'-DDE	1	ND VIU,SC,VNBC	0.00	ug/kg	1.23	DFG-WPCL	L-211-05_BS375_KR_S_OCH
2005-04	SUICRKLWR	19-Apr-05	3ORG	1DDT	o,p'-DDE	1	ND VIU,H,SC,VNBC	0.00	ug/kg	1.21		

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2004-11	SUICRKUP	03-Nov-04	3ORG	1DDT	o,p'-DDE	1ND H,SC,VNBC	0.00	ug/kg	1.03	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SUICRKUP	19-Apr-05	3ORG	1DDT	o,p'-DDE	1ND VIU,H,SC,VNBC	0.00	ug/kg	0.90	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	COYCRKLWR	18-Apr-05	3ORG	1DDT	o,p'-DDT	1ND H,SC,VNBC	0.00	ug/kg	1.89	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	COYCRKUP	01-Nov-04	3ORG	1DDT	o,p'-DDT	1ND H,SC,VNBC	0.00	ug/kg	1.30	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	COYCRKUP	18-Apr-05	3ORG	1DDT	o,p'-DDT	2ND H,SC,VNBC	0.00	ug/kg	1.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	1DDT	o,p'-DDT	1ND H,SC,VNBC	0.00	ug/kg	2.23	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	NAPRIVUP	02-Nov-04	3ORG	1DDT	o,p'-DDT	1ND H,SC,VNBC	0.00	ug/kg	1.39	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	NAPRIVUP	19-Apr-05	3ORG	1DDT	o,p'-DDT	1ND H,SC,VNBC	0.00	ug/kg	1.40	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	PETRIVLWR	20-Apr-05	3ORG	1DDT	o,p'-DDT	1ND H,VNBC	0.00	ug/kg	3.60	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	PETRIVUP	02-Nov-04	3ORG	1DDT	o,p'-DDT	2ND H,SC,VNBC	0.00	ug/kg	1.83	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	PETRIVUP	20-Apr-05	3ORG	1DDT	o,p'-DDT	1ND H,SC,VNBC	0.00	ug/kg	1.81	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	1DDT	o,p'-DDT	1ND H,SC,VNBC	0.00	ug/kg	1.32	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	1DDT	o,p'-DDT	1ND H,SC,VNBC	0.00	ug/kg	1.33	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	1DDT	o,p'-DDT	1ND H,SC,VNBC	0.00	ug/kg	1.73	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	1DDT	o,p'-DDT	1ND H,SC,VNBC	0.00	ug/kg	2.37	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	1DDT	o,p'-DDT	1ND H,SC,VNBC	0.00	ug/kg	3.11	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	1DDT	o,p'-DDT	1 H,SC,VNBC	8.06	ug/kg	1.43	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	1DDT	o,p'-DDT	1ND SC,VNBC	0.00	ug/kg	1.87	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_OCH
2005-04	SUICRKLWR	19-Apr-05	3ORG	1DDT	o,p'-DDT	1ND H,SC,VNBC	0.00	ug/kg	1.82	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SUICRKUP	03-Nov-04	3ORG	1DDT	o,p'-DDT	1ND H,SC,VNBC	0.00	ug/kg	1.55	DFG-	WPCL_L-523-537-

CDFG TOX

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
										WPCL	04_BS347_KR_S_OCH
2005-04	SUICRKUP	19-Apr-05	3ORG	1DDT	o,p'-DDT	1ND H,SC,VNBC	0.00	ug/kg	1.37	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	COYCRKLWR	18-Apr-05	3ORG	1DDT	p,p'-DDD	1 H,SC,VNBC	4.80	ug/kg	1.68	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	COYCRKUP	01-Nov-04	3ORG	1DDT	p,p'-DDD	1 H,SC,VNBC	4.12	ug/kg	1.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	COYCRKUP	18-Apr-05	3ORG	1DDT	p,p'-DDD	2 H,SC,VNBC	3.43	ug/kg	1.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	1DDT	p,p'-DDD	1DNQ H,SC,VNBC	2.05	ug/kg	1.98	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	NAPRIVUP	02-Nov-04	3ORG	1DDT	p,p'-DDD	1 H,SC,VNBC	4.09	ug/kg	1.24	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	NAPRIVUP	19-Apr-05	3ORG	1DDT	p,p'-DDD	1 H,SC,VNBC	2.22	ug/kg	1.24	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	PETRIVLWR	20-Apr-05	3ORG	1DDT	p,p'-DDD	1ND H,SC,VNBC	0.00	ug/kg	3.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	PETRIVUP	02-Nov-04	3ORG	1DDT	p,p'-DDD	2ND H,SC,VNBC	1.08	ug/kg	1.62	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	PETRIVUP	20-Apr-05	3ORG	1DDT	p,p'-DDD	1ND H,SC,VNBC	0.00	ug/kg	1.61	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	1DDT	p,p'-DDD	1 H,SC,VNBC	1.39	ug/kg	1.17	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	1DDT	p,p'-DDD	1 H,SC,VNBC	2.45	ug/kg	1.17	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	1DDT	p,p'-DDD	1 H,SC,VNBC	8.47	ug/kg	1.53	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	1DDT	p,p'-DDD	1 H,SC,VNBC	4.92	ug/kg	2.10	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	1DDT	p,p'-DDD	1 H,SC,VNBC	4.14	ug/kg	2.75	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	1DDT	p,p'-DDD	1 H,SC,VNBC	11.70	ug/kg	1.26	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	1DDT	p,p'-DDD	1 SC,VNBC	11.10	ug/kg	1.65	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_OCH
2005-04	SUICRKLWR	19-Apr-05	3ORG	1DDT	p,p'-DDD	1 H,SC,VNBC	1.99	ug/kg	1.62	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SUICRKUP	03-Nov-04	3ORG	1DDT	p,p'-DDD	1ND H,SC,VNBC	0.00	ug/kg	1.38	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	SUICRKUP	19-Apr-05	3ORG	1DDT	p,p'-DDD	1 H,SC,VNBC	2.06	ug/kg	1.21	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	COYCRKLWR	18-Apr-05	3ORG	1DDT	p,p'-DDE	1 H,SC,VNBC	9.39	ug/kg	1.07	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	COYCRKUP	01-Nov-04	3ORG	1DDT	p,p'-DDE	1 H,SC,VNBC	9.13	ug/kg	0.74	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	COYCRKUP	18-Apr-05	3ORG	1DDT	p,p'-DDE	2 H,SC,VNBC	6.62	ug/kg	0.76	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	1DDT	p,p'-DDE	1 H,SC,VNBC	6.48	ug/kg	1.26	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	NAPRIVUP	02-Nov-04	3ORG	1DDT	p,p'-DDE	1 H,SC,VNBC	7.73	ug/kg	0.79	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	NAPRIVUP	19-Apr-05	3ORG	1DDT	p,p'-DDE	1 H,SC,VNBC	4.98	ug/kg	0.80	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	PETRIVLWR	20-Apr-05	3ORG	1DDT	p,p'-DDE	1DNQ H,VNBC	3.74	ug/kg	2.04	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	PETRIVUP	02-Nov-04	3ORG	1DDT	p,p'-DDE	2DNQ H,J,SC,VNBC	2.66	ug/kg	1.04	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	PETRIVUP	20-Apr-05	3ORG	1DDT	p,p'-DDE	1DNQ H,SC,VNBC	2.29	ug/kg	1.03	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	1DDT	p,p'-DDE	1 H,SC,VNBC	3.31	ug/kg	0.75	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	1DDT	p,p'-DDE	1 H,SC,VNBC	6.16	ug/kg	0.75	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	1DDT	p,p'-DDE	1 H,SC,VNBC	14.70	ug/kg	0.98	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	1DDT	p,p'-DDE	1 H,SC,VNBC	8.33	ug/kg	1.35	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	1DDT	p,p'-DDE	1 H,SC,VNBC	11.70	ug/kg	1.76	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	1DDT	p,p'-DDE	1 H,SC,VNBC	41.40	ug/kg	0.81	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	1DDT	p,p'-DDE	1 SC,VNBC	23.00	ug/kg	1.06	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_OCH
2005-04	SUICRKLWR	19-Apr-05	3ORG	1DDT	p,p'-DDE	1 H,SC,VNBC	4.23	ug/kg	1.03	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SUICRKUP	03-Nov-04	3ORG	1DDT	p,p'-DDE	1 H,SC,VNBC	6.74	ug/kg	0.88	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SUICRKUP	19-Apr-05	3ORG	1DDT	p,p'-DDE	1 H,SC,VNBC	6.26	ug/kg	0.78	DFG-	WPCL_L-211-

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
											WPCL	05_BS375_KR_S_OCH
2005-04	COYCRKLWR	18-Apr-05	3ORG	1DDT	p,p'-DDT	1	DNQ VRIU,H,SC,VNBC		ug/kg	4.61	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	COYCRKUP	01-Nov-04	3ORG	1DDT	p,p'-DDT	1	DNQ VRIU,H,J,SC,VNBC		ug/kg	3.17	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	COYCRKUP	18-Apr-05	3ORG	1DDT	p,p'-DDT	2	DNQ VRIU,H,SC,VNBC		ug/kg	3.27	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	1DDT	p,p'-DDT	1	ND VRIU,H,SC,VNBC		ug/kg	5.43	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	NAPRIVUP	02-Nov-04	3ORG	1DDT	p,p'-DDT	1	VRIU,H,SC,VNBC		ug/kg	3.39	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	NAPRIVUP	19-Apr-05	3ORG	1DDT	p,p'-DDT	1	ND VRIU,H,SC,VNBC		ug/kg	3.41	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	PETRIVLWR	20-Apr-05	3ORG	1DDT	p,p'-DDT	1	ND VRIU,H,VNBC		ug/kg	8.76	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	PETRIVUP	02-Nov-04	3ORG	1DDT	p,p'-DDT	2	ND VRIU,H,SC,VNBC		ug/kg	4.46	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	PETRIVUP	20-Apr-05	3ORG	1DDT	p,p'-DDT	1	ND VRIU,H,SC,VNBC		ug/kg	4.41	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	1DDT	p,p'-DDT	1	DNQ VRIU,H,SC,VNBC		ug/kg	3.22	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	1DDT	p,p'-DDT	1	DNQ VRIU,H,J,SC,VNBC		ug/kg	3.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	1DDT	p,p'-DDT	1	VRIU,H,SC,VNBC		ug/kg	4.21	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	1DDT	p,p'-DDT	1	DNQ VRIU,H,J,SC,VNBC		ug/kg	5.78	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	1DDT	p,p'-DDT	1	ND VRIU,H,SC,VNBC		ug/kg	7.56	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	1DDT	p,p'-DDT	1	VRIU,H,SC,VNBC		ug/kg	3.47	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	1DDT	p,p'-DDT	1	ND VRIU,SC,VNBC		ug/kg	4.54	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_OCH
2005-04	SUICRKLWR	19-Apr-05	3ORG	1DDT	p,p'-DDT	1	ND VRIU,H,SC,VNBC		ug/kg	4.44	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SUICRKUP	03-Nov-04	3ORG	1DDT	p,p'-DDT	1	ND VRIU,H,SC,VNBC		ug/kg	3.78	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SUICRKUP	19-Apr-05	3ORG	1DDT	p,p'-DDT	1	DNQ VRIU,H,SC,VNBC		ug/kg	3.32	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH

HCHs (hexachlorocyclohexanes)

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	COYCRKLWR	18-Apr-05	3ORG	3HCH	alpha-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.89	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	COYCRKUP	01-Nov-04	3ORG	3HCH	alpha-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.61	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	COYCRKUP	18-Apr-05	3ORG	3HCH	alpha-HCH	2ND H,SC,VNBC	0.00	ug/kg	0.63	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	3HCH	alpha-HCH	1ND H,SC,VNBC	0.00	ug/kg	1.04	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	NAPRIVUP	02-Nov-04	3ORG	3HCH	alpha-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.65	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	NAPRIVUP	19-Apr-05	3ORG	3HCH	alpha-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.66	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	PETRIVLWR	20-Apr-05	3ORG	3HCH	alpha-HCH	1ND H,SC,VNBC	0.00	ug/kg	1.69	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	PETRIVUP	02-Nov-04	3ORG	3HCH	alpha-HCH	2ND H,SC,VNBC	0.00	ug/kg	0.86	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	PETRIVUP	20-Apr-05	3ORG	3HCH	alpha-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.85	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	3HCH	alpha-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.62	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	3HCH	alpha-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.62	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	3HCH	alpha-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.81	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	3HCH	alpha-HCH	1ND H,SC,VNBC	0.00	ug/kg	1.11	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	3HCH	alpha-HCH	1ND H,SC,VNBC	0.00	ug/kg	1.46	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	3HCH	alpha-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.67	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	3HCH	alpha-HCH	1ND SC,VNBC	0.00	ug/kg	0.88	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_OCH
2005-04	SUICRKLWR	19-Apr-05	3ORG	3HCH	alpha-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.85	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SUICRKUP	03-Nov-04	3ORG	3HCH	alpha-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.73	DFG-	WPCL_L-523-537-

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
										WPCL	04_BS347_KR_S_OCH
2005-04	SUICRKUP	19-Apr-05	3ORG	3HCH	alpha-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.64	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	COYCRKLWR	18-Apr-05	3ORG	3HCH	beta-HCH	1ND H,SC,VNBC	0.00	ug/kg	1.15	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	COYCRKUP	01-Nov-04	3ORG	3HCH	beta-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.79	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	COYCRKUP	18-Apr-05	3ORG	3HCH	beta-HCH	2ND H,SC,VNBC	0.00	ug/kg	0.82	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	3HCH	beta-HCH	1ND H,SC,VNBC	0.00	ug/kg	1.35	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	NAPRIVUP	02-Nov-04	3ORG	3HCH	beta-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.85	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	NAPRIVUP	19-Apr-05	3ORG	3HCH	beta-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.85	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	PETRIVLWR	20-Apr-05	3ORG	3HCH	beta-HCH	1ND H,SC,VNBC	0.00	ug/kg	2.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	PETRIVUP	02-Nov-04	3ORG	3HCH	beta-HCH	2ND H,SC,VNBC	0.00	ug/kg	1.11	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	PETRIVUP	20-Apr-05	3ORG	3HCH	beta-HCH	1ND H,SC,VNBC	0.00	ug/kg	1.10	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	3HCH	beta-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.80	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	3HCH	beta-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.80	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	3HCH	beta-HCH	1ND H,SC,VNBC	0.00	ug/kg	1.05	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	3HCH	beta-HCH	1ND H,SC,VNBC	0.00	ug/kg	1.44	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	3HCH	beta-HCH	1ND H,SC,VNBC	0.00	ug/kg	1.88	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	3HCH	beta-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.87	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	3HCH	beta-HCH	1ND SC,VNBC	0.00	ug/kg	1.13	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_OCH
2005-04	SUICRKLWR	19-Apr-05	3ORG	3HCH	beta-HCH	1ND H,SC,VNBC	0.00	ug/kg	1.11	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SUICRKUP	03-Nov-04	3ORG	3HCH	beta-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.94	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	SUICRKUP	19-Apr-05	3ORG	3HCH	beta-HCH	1 ND H,SC,VNBC	0.00	ug/kg	0.83	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	COYCRKLWR	18-Apr-05	3ORG	3HCH	delta-HCH	1 ND VRIU,H,SC,VNBC	0.00	ug/kg	0.67	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	COYCRKUP	01-Nov-04	3ORG	3HCH	delta-HCH	1 ND H,SC,VNBC	0.00	ug/kg	0.46	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	COYCRKUP	18-Apr-05	3ORG	3HCH	delta-HCH	2 ND VRIU,H,SC,VNBC	0.00	ug/kg	0.48	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	3HCH	delta-HCH	1 ND VRIU,H,SC,VNBC	0.00	ug/kg	0.79	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	NAPRIVUP	02-Nov-04	3ORG	3HCH	delta-HCH	1 ND H,SC,VNBC	0.00	ug/kg	0.49	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	NAPRIVUP	19-Apr-05	3ORG	3HCH	delta-HCH	1 ND VRIU,H,SC,VNBC	0.00	ug/kg	0.50	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	PETRIVLWR	20-Apr-05	3ORG	3HCH	delta-HCH	1 ND VRIU,H,SC,VNBC	0.00	ug/kg	1.28	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	PETRIVUP	02-Nov-04	3ORG	3HCH	delta-HCH	2 ND H,SC,VNBC	0.00	ug/kg	0.65	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	PETRIVUP	20-Apr-05	3ORG	3HCH	delta-HCH	1 ND VRIU,H,SC,VNBC	0.00	ug/kg	0.64	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	3HCH	delta-HCH	1 ND VRIU,H,SC,VNBC	0.00	ug/kg	0.47	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	3HCH	delta-HCH	1 ND H,SC,VNBC	0.00	ug/kg	0.47	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	3HCH	delta-HCH	1 ND VRIU,H,SC,VNBC	0.00	ug/kg	0.61	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	3HCH	delta-HCH	1 ND H,SC,VNBC	0.00	ug/kg	0.84	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	3HCH	delta-HCH	1 ND VRIU,H,SC,VNBC	0.00	ug/kg	1.10	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	3HCH	delta-HCH	1 ND H,SC,VNBC	0.00	ug/kg	0.51	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	3HCH	delta-HCH	1 ND VRIU,SC,VNBC	0.00	ug/kg	0.66	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_OCH
2005-04	SUICRKLWR	19-Apr-05	3ORG	3HCH	delta-HCH	1 ND VRIU,H,SC,VNBC	0.00	ug/kg	0.65	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SUICRKUP	03-Nov-04	3ORG	3HCH	delta-HCH	1 ND H,SC,VNBC	0.00	ug/kg	0.55	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SUICRKUP	19-Apr-05	3ORG	3HCH	delta-HCH	1 ND VRIU,H,SC,VNBC	0.00	ug/kg	0.48	DFG-	WPCL_L-211-

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
										WPCL	05_BS375_KR_S_OCH
2005-04	COYCRKLWR	18-Apr-05	3ORG	3HCH	gamma-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.63	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	COYCRKUP	01-Nov-04	3ORG	3HCH	gamma-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.44	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	COYCRKUP	18-Apr-05	3ORG	3HCH	gamma-HCH	2ND H,SC,VNBC	0.00	ug/kg	0.45	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	3HCH	gamma-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.75	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	NAPRIVUP	02-Nov-04	3ORG	3HCH	gamma-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.47	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	NAPRIVUP	19-Apr-05	3ORG	3HCH	gamma-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.47	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	PETRIVLWR	20-Apr-05	3ORG	3HCH	gamma-HCH	1ND H,SC,VNBC	0.00	ug/kg	1.20	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	PETRIVUP	02-Nov-04	3ORG	3HCH	gamma-HCH	2ND H,SC,VNBC	0.00	ug/kg	0.61	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	PETRIVUP	20-Apr-05	3ORG	3HCH	gamma-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.61	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	3HCH	gamma-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.44	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	3HCH	gamma-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.44	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	3HCH	gamma-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.58	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	3HCH	gamma-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.80	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	3HCH	gamma-HCH	1ND H,SC,VNBC	0.00	ug/kg	1.04	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	3HCH	gamma-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.48	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	3HCH	gamma-HCH	1ND SC,VNBC	0.00	ug/kg	0.63	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_OCH
2005-04	SUICRKLWR	19-Apr-05	3ORG	3HCH	gamma-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.61	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SUICRKUP	03-Nov-04	3ORG	3HCH	gamma-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.52	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SUICRKUP	19-Apr-05	3ORG	3HCH	gamma-HCH	1ND H,SC,VNBC	0.00	ug/kg	0.46	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	COYCRKLWR	18-Apr-05	3ORG	3HCH	Sum of HCHs (SFEI)	1	X	0.00	ug/kg	0.84	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	COYCRKUP	01-Nov-04	3ORG	3HCH	Sum of HCHs (SFEI)	1	X	0.00	ug/kg	0.57	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	COYCRKUP	18-Apr-05	3ORG	3HCH	Sum of HCHs (SFEI)	2	X	0.00	ug/kg	0.59	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	3HCH	Sum of HCHs (SFEI)	1	X	0.00	ug/kg	0.98	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	NAPRIVUP	02-Nov-04	3ORG	3HCH	Sum of HCHs (SFEI)	1	X	0.00	ug/kg	0.61	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	NAPRIVUP	19-Apr-05	3ORG	3HCH	Sum of HCHs (SFEI)	1	X	0.00	ug/kg	0.62	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	PETRIVLWR	20-Apr-05	3ORG	3HCH	Sum of HCHs (SFEI)	1	X	0.00	ug/kg	1.59	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	PETRIVUP	02-Nov-04	3ORG	3HCH	Sum of HCHs (SFEI)	2	X	0.00	ug/kg	0.81	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	PETRIVUP	20-Apr-05	3ORG	3HCH	Sum of HCHs (SFEI)	1	X	0.00	ug/kg	0.80	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	3HCH	Sum of HCHs (SFEI)	1	X	0.00	ug/kg	0.58	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	3HCH	Sum of HCHs (SFEI)	1	X	0.00	ug/kg	0.58	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	3HCH	Sum of HCHs (SFEI)	1	X	0.00	ug/kg	0.76	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	3HCH	Sum of HCHs (SFEI)	1	X	0.00	ug/kg	1.05	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	3HCH	Sum of HCHs (SFEI)	1	X	0.00	ug/kg	1.37	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	3HCH	Sum of HCHs (SFEI)	1	X	0.00	ug/kg	0.63	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	3HCH	Sum of HCHs (SFEI)	1	X	0.00	ug/kg	0.82	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_OCH
2005-04	SUICRKLWR	19-Apr-05	3ORG	3HCH	Sum of HCHs (SFEI)	1	X	0.00	ug/kg	0.81	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SUICRKUP	03-Nov-04	3ORG	3HCH	Sum of HCHs (SFEI)	1	X	0.00	ug/kg	0.69	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SUICRKUP	19-Apr-05	3ORG	3HCH	Sum of HCHs (SFEI)	1	X	0.00	ug/kg	0.60	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH

Other Synthetic Biocides

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	COYCRKLWR	18-Apr-05	3ORG	5Other	Hexachlorobenzene	1ND H,SC,VNBC	0.00	ug/kg	0.20	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	COYCRKUP	01-Nov-04	3ORG	5Other	Hexachlorobenzene	1DNQ H,J,SC,VNBC	0.17	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	COYCRKUP	18-Apr-05	3ORG	5Other	Hexachlorobenzene	2ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	5Other	Hexachlorobenzene	1ND H,SC,VNBC	0.00	ug/kg	0.24	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	NAPRIVUP	02-Nov-04	3ORG	5Other	Hexachlorobenzene	1ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	NAPRIVUP	19-Apr-05	3ORG	5Other	Hexachlorobenzene	1ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	PETRIVLWR	20-Apr-05	3ORG	5Other	Hexachlorobenzene	1ND H,VNBC	0.00	ug/kg	0.38	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	PETRIVUP	02-Nov-04	3ORG	5Other	Hexachlorobenzene	2ND H,SC,VNBC	0.00	ug/kg	0.19	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	PETRIVUP	20-Apr-05	3ORG	5Other	Hexachlorobenzene	1ND H,SC,VNBC	0.00	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	5Other	Hexachlorobenzene	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	5Other	Hexachlorobenzene	1ND H,SC,VNBC	0.00	ug/kg	0.14	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	5Other	Hexachlorobenzene	1 H,SC,VNBC	1.06	ug/kg	0.18	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	5Other	Hexachlorobenzene	1ND H,SC,VNBC	0.00	ug/kg	0.25	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	5Other	Hexachlorobenzene	1ND H,SC,VNBC	0.00	ug/kg	0.33	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	5Other	Hexachlorobenzene	1DNQ H,J,SC,VNBC	0.17	ug/kg	0.15	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	5Other	Hexachlorobenzene	1ND SC,VNBC	0.00	ug/kg	0.20	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_OCH
2005-04	SUICRKLWR	19-Apr-05	3ORG	5Other	Hexachlorobenzene	1ND H,SC,VNBC	0.00	ug/kg	0.19	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SUICRKUP	03-Nov-04	3ORG	5Other	Hexachlorobenzene	1ND H,SC,VNBC	0.00	ug/kg	0.17	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	SUICRKUP	19-Apr-05	3ORG	5Other	Hexachlorobenzene	1	ND H,SC,VNBC	0.00	ug/kg	0.15	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	COYCRKLWR	18-Apr-05	3ORG	5Other	Mirex	1	ND H,SC,VNBC	0.00	ug/kg	1.76	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	COYCRKUP	01-Nov-04	3ORG	5Other	Mirex	1	ND H,SC,VNBC	0.00	ug/kg	1.21	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	COYCRKUP	18-Apr-05	3ORG	5Other	Mirex	2	ND H,SC,VNBC	0.00	ug/kg	1.25	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	NAPRIVLWR	19-Apr-05	3ORG	5Other	Mirex	1	ND H,SC,VNBC	0.00	ug/kg	2.07	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	NAPRIVUP	02-Nov-04	3ORG	5Other	Mirex	1	ND H,SC,VNBC	0.00	ug/kg	1.30	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	NAPRIVUP	19-Apr-05	3ORG	5Other	Mirex	1	ND H,SC,VNBC	0.00	ug/kg	1.30	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	PETRIVLWR	20-Apr-05	3ORG	5Other	Mirex	1	ND H,SC,VNBC	0.00	ug/kg	3.34	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	PETRIVUP	02-Nov-04	3ORG	5Other	Mirex	2	ND H,SC,VNBC	0.00	ug/kg	1.70	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	PETRIVUP	20-Apr-05	3ORG	5Other	Mirex	1	ND H,SC,VNBC	0.00	ug/kg	1.69	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	5Other	Mirex	1	ND H,SC,VNBC	0.00	ug/kg	1.23	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANLORCRKUP	03-Nov-04	3ORG	5Other	Mirex	1	ND H,SC,VNBC	0.00	ug/kg	1.23	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANLORCRKUP	20-Apr-05	3ORG	5Other	Mirex	1	ND H,SC,VNBC	0.00	ug/kg	1.61	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	5Other	Mirex	1	ND H,SC,VNBC	0.00	ug/kg	2.21	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	5Other	Mirex	1	ND H,SC,VNBC	0.00	ug/kg	2.89	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SANMATCRKUP	04-Nov-04	3ORG	5Other	Mirex	1	ND H,SC,VNBC	0.00	ug/kg	1.33	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SANMATCRKUP	18-Apr-05	3ORG	5Other	Mirex	1	ND SC,VNBC	0.00	ug/kg	1.73	DFG-WPCL	WPCL_L-192-05_BS373_KR_S_OCH
2005-04	SUICRKLWR	19-Apr-05	3ORG	5Other	Mirex	1	ND H,SC,VNBC	0.00	ug/kg	1.69	DFG-WPCL	WPCL_L-211-05_BS375_KR_S_OCH
2004-11	SUICRKUP	03-Nov-04	3ORG	5Other	Mirex	1	ND H,SC,VNBC	0.00	ug/kg	1.44	DFG-WPCL	WPCL_L-523-537-04_BS347_KR_S_OCH
2005-04	SUICRKUP	19-Apr-05	3ORG	5Other	Mirex	1	ND H,SC,VNBC	0.00	ug/kg	1.27	DFG-	WPCL_L-211-

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
											WPCL	05_BS375_KR_S_OCH

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Pyrethroids

The individual pyrethroid compounds were analyzed as separate isomers with the exception of bifenthrin. The AnalyteGrp2: 6PYRETH is the sum of the individual isomers for each pyrethroid compound.

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	COYCRKLWR	18-Apr-05	3ORG	61PYRETH	Sum of Pyrethroids (SFEI)	1	X	2.03	ug/kg	1.67	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	COYCRKUP	01-Nov-04	3ORG	61PYRETH	Sum of Pyrethroids (SFEI)	1	X	1.90	ug/kg	1.67	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	COYCRKUP	18-Apr-05	3ORG	61PYRETH	Sum of Pyrethroids (SFEI)	2	X	0.66	ug/kg	1.67	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	NAPRIVLWR	19-Apr-05	3ORG	61PYRETH	Sum of Pyrethroids (SFEI)	1	X	1.07	ug/kg	1.67	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	NAPRIVUP	02-Nov-04	3ORG	61PYRETH	Sum of Pyrethroids (SFEI)	2	X	2.00	ug/kg	1.67	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	NAPRIVUP	19-Apr-05	3ORG	61PYRETH	Sum of Pyrethroids (SFEI)	1	X	0.00	ug/kg	1.67	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	PETRIVLWR	20-Apr-05	3ORG	61PYRETH	Sum of Pyrethroids (SFEI)	1	X	0.00	ug/kg	1.67	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	PETRIVUP	02-Nov-04	3ORG	61PYRETH	Sum of Pyrethroids (SFEI)	1	X	6.69	ug/kg	1.67	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	PETRIVUP	20-Apr-05	3ORG	61PYRETH	Sum of Pyrethroids (SFEI)	1	X	0.00	ug/kg	1.67	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	61PYRETH	Sum of Pyrethroids (SFEI)	1	X	0.00	ug/kg	1.67	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANLORCRKUP	03-Nov-04	3ORG	61PYRETH	Sum of Pyrethroids (SFEI)	1	X	8.17	ug/kg	1.67	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANLORCRKUP	20-Apr-05	3ORG	61PYRETH	Sum of Pyrethroids (SFEI)	1	X	2.05	ug/kg	1.67	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	61PYRETH	Sum of Pyrethroids (SFEI)	1	X	9.96	ug/kg	1.67	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	61PYRETH	Sum of Pyrethroids (SFEI)	1	X	2.38	ug/kg	1.67	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKUP	04-Nov-04	3ORG	61PYRETH	Sum of Pyrethroids (SFEI)	1	X	43.55	ug/kg	1.67	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKUP	18-Apr-05	3ORG	61PYRETH	Sum of Pyrethroids (SFEI)	1	X	0.00	ug/kg	1.67	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SUICRKLWR	19-Apr-05	3ORG	61PYRETH	Sum of Pyrethroids (SFEI)	1	X	0.00	ug/kg	1.67	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SUICRKUP	03-Nov-04	3ORG	61PYRETH	Sum of Pyrethroids (SFEI)	1	X	6.76	ug/kg	1.67	DFG-	WPCL_L-523-537-04_S_PYD-PYN

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	SUICRKUP	19-Apr-05	3ORG	61PYRETH	Sum of Pyrethroids (SFEI)	1	X	0.00	ug/kg	1.67	WPCL	
2005-04	COYCRKLWR	18-Apr-05	3ORG	6PYRETH	Bifenthrin	1	VNBC	2.03	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	COYCRKUP	01-Nov-04	3ORG	6PYRETH	Bifenthrin	1	DNQ J,VNBC	1.90	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	COYCRKUP	18-Apr-05	3ORG	6PYRETH	Bifenthrin	2	DNQ VNBC	0.66	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	NAPRIVLWR	19-Apr-05	3ORG	6PYRETH	Bifenthrin	1	DNQ VNBC	1.07	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	NAPRIVUP	02-Nov-04	3ORG	6PYRETH	Bifenthrin	2	VNBC	2.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	NAPRIVUP	19-Apr-05	3ORG	6PYRETH	Bifenthrin	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	PETRIVLWR	20-Apr-05	3ORG	6PYRETH	Bifenthrin	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	PETRIVUP	02-Nov-04	3ORG	6PYRETH	Bifenthrin	1	VNBC	6.69	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	PETRIVUP	20-Apr-05	3ORG	6PYRETH	Bifenthrin	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	6PYRETH	Bifenthrin	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANLORCRKUP	03-Nov-04	3ORG	6PYRETH	Bifenthrin	1	VNBC	4.40	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANLORCRKUP	20-Apr-05	3ORG	6PYRETH	Bifenthrin	1	VNBC	2.05	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	6PYRETH	Bifenthrin	1	VNBC	6.74	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	6PYRETH	Bifenthrin	1	VNBC	2.38	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKUP	04-Nov-04	3ORG	6PYRETH	Bifenthrin	1	VNBC	10.30	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKUP	18-Apr-05	3ORG	6PYRETH	Bifenthrin	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SUICRKLWR	19-Apr-05	3ORG	6PYRETH	Bifenthrin	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SUICRKUP	03-Nov-04	3ORG	6PYRETH	Bifenthrin	1	VNBC	3.55	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	SUICRKUP	19-Apr-05	3ORG	6PYRETH	Bifenthrin	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	COYCRKLWR	18-Apr-05	3ORG	6PYRETH	Cyfluthrin	1	ND X	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	COYCRKUP	01-Nov-04	3ORG	6PYRETH	Cyfluthrin	1	ND X	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	COYCRKUP	18-Apr-05	3ORG	6PYRETH	Cyfluthrin	2	ND X	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	NAPRIVLWR	19-Apr-05	3ORG	6PYRETH	Cyfluthrin	1	ND X	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	NAPRIVUP	02-Nov-04	3ORG	6PYRETH	Cyfluthrin	2	ND X	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	NAPRIVUP	19-Apr-05	3ORG	6PYRETH	Cyfluthrin	1	ND X	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	PETRIVLWR	20-Apr-05	3ORG	6PYRETH	Cyfluthrin	1	ND X	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	PETRIVUP	02-Nov-04	3ORG	6PYRETH	Cyfluthrin	1	ND X	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	PETRIVUP	20-Apr-05	3ORG	6PYRETH	Cyfluthrin	1	ND X	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	6PYRETH	Cyfluthrin	1	ND X	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANLORCRKUP	03-Nov-04	3ORG	6PYRETH	Cyfluthrin	1	ND X	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANLORCRKUP	20-Apr-05	3ORG	6PYRETH	Cyfluthrin	1	ND X	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	6PYRETH	Cyfluthrin	1	ND X	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	6PYRETH	Cyfluthrin	1	ND X	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKUP	04-Nov-04	3ORG	6PYRETH	Cyfluthrin	1	X	8.62	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKUP	18-Apr-05	3ORG	6PYRETH	Cyfluthrin	1	ND X	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SUICRKLWR	19-Apr-05	3ORG	6PYRETH	Cyfluthrin	1	ND X	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SUICRKUP	03-Nov-04	3ORG	6PYRETH	Cyfluthrin	1	ND X	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SUICRKUP	19-Apr-05	3ORG	6PYRETH	Cyfluthrin	1	ND X	0.00	ug/kg	2.00	DFG-	WPCL_L-211-05_S_PYD-PYN

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	COYCRKLWR	18-Apr-05	3ORG	6PYRETH	Cypermethrin	1	ND X	0.00	ug/kg	2.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	COYCRKUP	01-Nov-04	3ORG	6PYRETH	Cypermethrin	1	ND X	0.00	ug/kg	2.00	WPCL DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	COYCRKUP	18-Apr-05	3ORG	6PYRETH	Cypermethrin	2	ND X	0.00	ug/kg	2.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	NAPRIVLWR	19-Apr-05	3ORG	6PYRETH	Cypermethrin	1	ND X	0.00	ug/kg	2.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	NAPRIVUP	02-Nov-04	3ORG	6PYRETH	Cypermethrin	2	ND X	0.00	ug/kg	2.00	WPCL DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	NAPRIVUP	19-Apr-05	3ORG	6PYRETH	Cypermethrin	1	ND X	0.00	ug/kg	2.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	PETRIVLWR	20-Apr-05	3ORG	6PYRETH	Cypermethrin	1	ND X	0.00	ug/kg	2.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	PETRIVUP	02-Nov-04	3ORG	6PYRETH	Cypermethrin	1	ND X	0.00	ug/kg	2.00	WPCL DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	PETRIVUP	20-Apr-05	3ORG	6PYRETH	Cypermethrin	1	ND X	0.00	ug/kg	2.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	6PYRETH	Cypermethrin	1	ND X	0.00	ug/kg	2.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANLORCRKUP	03-Nov-04	3ORG	6PYRETH	Cypermethrin	1	ND X	0.00	ug/kg	2.00	WPCL DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANLORCRKUP	20-Apr-05	3ORG	6PYRETH	Cypermethrin	1	ND X	0.00	ug/kg	2.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	6PYRETH	Cypermethrin	1	ND X	0.00	ug/kg	2.00	WPCL DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	6PYRETH	Cypermethrin	1	ND X	0.00	ug/kg	2.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKUP	04-Nov-04	3ORG	6PYRETH	Cypermethrin	1	X	4.17	ug/kg	2.00	WPCL DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKUP	18-Apr-05	3ORG	6PYRETH	Cypermethrin	1	ND X	0.00	ug/kg	2.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SUICRKLWR	19-Apr-05	3ORG	6PYRETH	Cypermethrin	1	ND X	0.00	ug/kg	2.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SUICRKUP	03-Nov-04	3ORG	6PYRETH	Cypermethrin	1	ND X	0.00	ug/kg	2.00	WPCL DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SUICRKUP	19-Apr-05	3ORG	6PYRETH	Cypermethrin	1	ND X	0.00	ug/kg	2.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	COYCRKLWR	18-Apr-05	3ORG	6PYRETH	Esfenvalerate	1	ND	X 0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	COYCRKUP	01-Nov-04	3ORG	6PYRETH	Esfenvalerate	1	ND	X 0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	COYCRKUP	18-Apr-05	3ORG	6PYRETH	Esfenvalerate	2	ND	X 0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	NAPRIVLWR	19-Apr-05	3ORG	6PYRETH	Esfenvalerate	1	ND	X 0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	NAPRIVUP	02-Nov-04	3ORG	6PYRETH	Esfenvalerate	2	ND	X 0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	NAPRIVUP	19-Apr-05	3ORG	6PYRETH	Esfenvalerate	1	ND	X 0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	PETRIVLWR	20-Apr-05	3ORG	6PYRETH	Esfenvalerate	1	ND	X 0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	PETRIVUP	02-Nov-04	3ORG	6PYRETH	Esfenvalerate	1	ND	X 0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	PETRIVUP	20-Apr-05	3ORG	6PYRETH	Esfenvalerate	1	ND	X 0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	6PYRETH	Esfenvalerate	1	ND	X 0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANLORCRKUP	03-Nov-04	3ORG	6PYRETH	Esfenvalerate	1	ND	X 0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANLORCRKUP	20-Apr-05	3ORG	6PYRETH	Esfenvalerate	1	ND	X 0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	6PYRETH	Esfenvalerate	1	ND	X 0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	6PYRETH	Esfenvalerate	1	ND	X 0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKUP	04-Nov-04	3ORG	6PYRETH	Esfenvalerate	1	ND	X 0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKUP	18-Apr-05	3ORG	6PYRETH	Esfenvalerate	1	ND	X 0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SUICRKLWR	19-Apr-05	3ORG	6PYRETH	Esfenvalerate	1	ND	X 0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SUICRKUP	03-Nov-04	3ORG	6PYRETH	Esfenvalerate	1	ND	X 0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SUICRKUP	19-Apr-05	3ORG	6PYRETH	Esfenvalerate	1	ND	X 0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	COYCRKLWR	18-Apr-05	3ORG	6PYRETH	Lambda-cyhalothrin	1	ND	X 0.00	ug/kg	1.00	DFG-	WPCL_L-211-05_S_PYD-PYN

AQ1719

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2004-11	COYCRKUP	01-Nov-04	3ORG	6PYRETH	Lambda-cyhalothrin	1	ND X	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	COYCRKUP	18-Apr-05	3ORG	6PYRETH	Lambda-cyhalothrin	2	ND X	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	NAPRIVLWR	19-Apr-05	3ORG	6PYRETH	Lambda-cyhalothrin	1	ND X	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	NAPRIVUP	02-Nov-04	3ORG	6PYRETH	Lambda-cyhalothrin	2	ND X	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	NAPRIVUP	19-Apr-05	3ORG	6PYRETH	Lambda-cyhalothrin	1	ND X	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	PETRIVLWR	20-Apr-05	3ORG	6PYRETH	Lambda-cyhalothrin	1	ND X	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	PETRIVUP	02-Nov-04	3ORG	6PYRETH	Lambda-cyhalothrin	1	ND X	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	PETRIVUP	20-Apr-05	3ORG	6PYRETH	Lambda-cyhalothrin	1	ND X	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	6PYRETH	Lambda-cyhalothrin	1	ND X	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANLORCRKUP	03-Nov-04	3ORG	6PYRETH	Lambda-cyhalothrin	1	ND X	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANLORCRKUP	20-Apr-05	3ORG	6PYRETH	Lambda-cyhalothrin	1	ND X	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	6PYRETH	Lambda-cyhalothrin	1	ND X	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	6PYRETH	Lambda-cyhalothrin	1	ND X	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKUP	04-Nov-04	3ORG	6PYRETH	Lambda-cyhalothrin	1	ND X	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKUP	18-Apr-05	3ORG	6PYRETH	Lambda-cyhalothrin	1	ND X	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SUICRKLWR	19-Apr-05	3ORG	6PYRETH	Lambda-cyhalothrin	1	ND X	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SUICRKUP	03-Nov-04	3ORG	6PYRETH	Lambda-cyhalothrin	1	ND X	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SUICRKUP	19-Apr-05	3ORG	6PYRETH	Lambda-cyhalothrin	1	ND X	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	COYCRKLWR	18-Apr-05	3ORG	6PYRETH	Permethrin	1	ND X	0.00	ug/kg	3.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2004-11	COYCRKUP	01-Nov-04	3ORG	6PYRETH	Permethrin	1 ND X	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	COYCRKUP	18-Apr-05	3ORG	6PYRETH	Permethrin	2 ND X	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	NAPRIVLWR	19-Apr-05	3ORG	6PYRETH	Permethrin	1 ND X	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	NAPRIVUP	02-Nov-04	3ORG	6PYRETH	Permethrin	2 ND X	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	NAPRIVUP	19-Apr-05	3ORG	6PYRETH	Permethrin	1 ND X	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	PETRIVLWR	20-Apr-05	3ORG	6PYRETH	Permethrin	1 ND X	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	PETRIVUP	02-Nov-04	3ORG	6PYRETH	Permethrin	1 ND X	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	PETRIVUP	20-Apr-05	3ORG	6PYRETH	Permethrin	1 ND X	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	6PYRETH	Permethrin	1 ND X	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANLORCRKUP	03-Nov-04	3ORG	6PYRETH	Permethrin	1 X	3.77	ug/kg	3.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANLORCRKUP	20-Apr-05	3ORG	6PYRETH	Permethrin	1 ND X	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	6PYRETH	Permethrin	1 X	3.22	ug/kg	3.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	6PYRETH	Permethrin	1 ND X	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKUP	04-Nov-04	3ORG	6PYRETH	Permethrin	1 X	20.46	ug/kg	3.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKUP	18-Apr-05	3ORG	6PYRETH	Permethrin	1 ND X	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SUICRKLWR	19-Apr-05	3ORG	6PYRETH	Permethrin	1 ND X	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SUICRKUP	03-Nov-04	3ORG	6PYRETH	Permethrin	1 X	3.21	ug/kg	3.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SUICRKUP	19-Apr-05	3ORG	6PYRETH	Permethrin	1 ND X	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	COYCRKLWR	18-Apr-05	3ORG	6PYRETH	Cyfluthrin (isomer-1)	1 ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	COYCRKUP	01-Nov-04	3ORG	6PYRETH	Cyfluthrin (isomer-1)	1 ND VNBC	0.00	ug/kg	2.00	DFG-	WPCL_L-523-537-04_S_PYD-PYN

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	COYCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-1)	2	ND VNBC	0.00	ug/kg	2.00	WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	NAPRIVLWR	19-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	NAPRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-1)	2	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	NAPRIVUP	19-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	PETRIVLWR	20-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	PETRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	PETRIVUP	20-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANLORCRKUP	03-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANLORCRKUP	20-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKUP	04-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-1)	1	DNQ J,VNBC	2.65	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SUICRKLWR	19-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SUICRKUP	03-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SUICRKUP	19-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	COYCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	COYCRKUP	01-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	COYCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-2)	2	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	NAPRIVLWR	19-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	NAPRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-2)	2	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	NAPRIVUP	19-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	PETRIVLWR	20-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	PETRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	PETRIVUP	20-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANLORCRKUP	03-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANLORCRKUP	20-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKUP	04-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-2)	1	DNQ J,VNBC	2.91	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SUICRKLWR	19-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SUICRKUP	03-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SUICRKUP	19-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	COYCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-3)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	COYCRKUP	01-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-3)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	COYCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-3)	2	ND VNBC	0.00	ug/kg	2.00	DFG-	WPCL_L-211-05_S_PYD-PYN

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	NAPRIVLWR	19-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	NAPRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-3)	2ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	NAPRIVUP	19-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	PETRIVLWR	20-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	PETRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	PETRIVUP	20-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANLORCRKUP	03-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANLORCRKUP	20-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKUP	04-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-3)	1DNQ J,VNBC	3.06	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SUICRKLWR	19-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SUICRKUP	03-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SUICRKUP	19-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	COYCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-4)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	COYCRKUP	01-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-4)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	COYCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-4)	2ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	NAPRIVLWR	19-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-4)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	NAPRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-4)	2	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	NAPRIVUP	19-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-4)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	PETRIVLWR	20-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-4)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	PETRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-4)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	PETRIVUP	20-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-4)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-4)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANLORCRKUP	03-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-4)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANLORCRKUP	20-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-4)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-4)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-4)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKUP	04-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-4)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-4)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SUICRKLWR	19-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-4)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SUICRKUP	03-Nov-04	3ORG	6PYRETH_iso	Cyfluthrin (isomer-4)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SUICRKUP	19-Apr-05	3ORG	6PYRETH_iso	Cyfluthrin (isomer-4)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	COYCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	COYCRKUP	01-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	COYCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-1)	2	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	NAPRIVLWR	19-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-	WPCL_L-211-05_S_PYD-PYN

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2004-11	NAPRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-1)	2	ND VNBC	0.00	ug/kg	2.00	WPCL DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	NAPRIVUP	19-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	PETRIVLWR	20-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	PETRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	PETRIVUP	20-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANLORCRKUP	03-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANLORCRKUP	20-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKUP	04-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-1)	1	DNQ J,VNBC	4.17	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SUICRKLWR	19-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SUICRKUP	03-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SUICRKUP	19-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	COYCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	COYCRKUP	01-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	COYCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-2)	2	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	NAPRIVLWR	19-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2004-11	NAPRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-2)	2	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	NAPRIVUP	19-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	PETRIVLWR	20-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	PETRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	PETRIVUP	20-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANLORCRKUP	03-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANLORCRKUP	20-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKUP	04-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SUICRKLWR	19-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SUICRKUP	03-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SUICRKUP	19-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	COYCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-3)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	COYCRKUP	01-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-3)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	COYCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-3)	2	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	NAPRIVLWR	19-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-3)	1	ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	NAPRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-3)	2	ND VNBC	0.00	ug/kg	2.00	DFG-	WPCL_L-523-537-04_S_PYD-PYN

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	NAPRIVUP	19-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	PETRIVLWR	20-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	PETRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	PETRIVUP	20-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANLORCRKUP	03-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANLORCRKUP	20-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKUP	04-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SUICRKLWR	19-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SUICRKUP	03-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SUICRKUP	19-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-3)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	COYCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-4)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	COYCRKUP	01-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-4)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	COYCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-4)	2ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	NAPRIVLWR	19-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-4)	1ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	NAPRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-4)	2ND VNBC	0.00	ug/kg	2.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	NQual	Result	Units	MDL	Lab	LabBatch
2005-04	NAPRIVUP	19-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-4)	1 ND	VNBC	0.00	ug/kg	2.00	DFG-WPCL
2005-04	PETRIVLWR	20-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-4)	1 ND	VNBC	0.00	ug/kg	2.00	DFG-WPCL
2004-11	PETRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-4)	1 ND	VNBC	0.00	ug/kg	2.00	DFG-WPCL
2005-04	PETRIVUP	20-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-4)	1 ND	VNBC	0.00	ug/kg	2.00	DFG-WPCL
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-4)	1 ND	VNBC	0.00	ug/kg	2.00	DFG-WPCL
2004-11	SANLORCRKUP	03-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-4)	1 ND	VNBC	0.00	ug/kg	2.00	DFG-WPCL
2005-04	SANLORCRKUP	20-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-4)	1 ND	VNBC	0.00	ug/kg	2.00	DFG-WPCL
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-4)	1 ND	VNBC	0.00	ug/kg	2.00	DFG-WPCL
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-4)	1 ND	VNBC	0.00	ug/kg	2.00	DFG-WPCL
2004-11	SANMATCRKUP	04-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-4)	1 ND	VNBC	0.00	ug/kg	2.00	DFG-WPCL
2005-04	SANMATCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-4)	1 ND	VNBC	0.00	ug/kg	2.00	DFG-WPCL
2005-04	SUICRKLWR	19-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-4)	1 ND	VNBC	0.00	ug/kg	2.00	DFG-WPCL
2004-11	SUICRKUP	03-Nov-04	3ORG	6PYRETH_iso	Cypermethrin (isomer-4)	1 ND	VNBC	0.00	ug/kg	2.00	DFG-WPCL
2005-04	SUICRKUP	19-Apr-05	3ORG	6PYRETH_iso	Cypermethrin (isomer-4)	1 ND	VNBC	0.00	ug/kg	2.00	DFG-WPCL
2005-04	COYCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Esfenvalerate (isomer-1)	1 ND	VNBC	0.00	ug/kg	2.00	DFG-WPCL
2004-11	COYCRKUP	01-Nov-04	3ORG	6PYRETH_iso	Esfenvalerate (isomer-1)	1 ND	VNBC	0.00	ug/kg	1.00	DFG-WPCL
2005-04	COYCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Esfenvalerate (isomer-1)	1 ND	VNBC	0.00	ug/kg	1.00	DFG-WPCL
2005-04	NAPRIVLWR	19-Apr-05	3ORG	6PYRETH_iso	Esfenvalerate (isomer-1)	2 ND	VNBC	0.00	ug/kg	1.00	DFG-WPCL
2004-11	NAPRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Esfenvalerate (isomer-1)	1 ND	VNBC	0.00	ug/kg	1.00	DFG-WPCL
2005-04	NAPRIVUP	19-Apr-05	3ORG	6PYRETH_iso	Esfenvalerate (isomer-1)	2 ND	VNBC	0.00	ug/kg	1.00	DFG-WPCL
						1 ND	VNBC	0.00	ug/kg	1.00	DFG-

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	PETRIVLWR	20-Apr-05	3ORG	6PYRETH_iso	Esfenvalerate (isomer-1)	1	ND	VNBC	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	PETRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Esfenvalerate (isomer-1)	1	ND	VNBC	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	PETRIVUP	20-Apr-05	3ORG	6PYRETH_iso	Esfenvalerate (isomer-1)	1	ND	VNBC	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	6PYRETH_iso	Esfenvalerate (isomer-1)	1	ND	VNBC	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANLORCRKUP	03-Nov-04	3ORG	6PYRETH_iso	Esfenvalerate (isomer-1)	1	ND	VNBC	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANLORCRKUP	20-Apr-05	3ORG	6PYRETH_iso	Esfenvalerate (isomer-1)	1	ND	VNBC	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	6PYRETH_iso	Esfenvalerate (isomer-1)	1	ND	VNBC	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Esfenvalerate (isomer-1)	1	ND	VNBC	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKUP	04-Nov-04	3ORG	6PYRETH_iso	Esfenvalerate (isomer-1)	1	ND	VNBC	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Esfenvalerate (isomer-1)	1	ND	VNBC	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SUICRKLWR	19-Apr-05	3ORG	6PYRETH_iso	Esfenvalerate (isomer-1)	1	ND	VNBC	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SUICRKUP	03-Nov-04	3ORG	6PYRETH_iso	Esfenvalerate (isomer-1)	1	ND	VNBC	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SUICRKUP	19-Apr-05	3ORG	6PYRETH_iso	Esfenvalerate (isomer-1)	1	ND	VNBC	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	COYCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Esfenvalerate (isomer-2)	1	ND	VNBC	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	COYCRKUP	01-Nov-04	3ORG	6PYRETH_iso	Esfenvalerate (isomer-2)	1	ND	VNBC	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	COYCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Esfenvalerate (isomer-2)	2	ND	VNBC	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	NAPRIVLWR	19-Apr-05	3ORG	6PYRETH_iso	Esfenvalerate (isomer-2)	1	ND	VNBC	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	NAPRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Esfenvalerate (isomer-2)	2	ND	VNBC	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	NAPRIVUP	19-Apr-05	3ORG	6PYRETH_iso	Esfenvalerate (isomer-2)	1	ND	VNBC	0.00	ug/kg	1.00	WPCL DFG-WPCL	WPCL_L-211-05_S_PYD-PYN

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	PETRIVLWR	20-Apr-05	3ORG	6PYRETH_iso	Esfenvalerate (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	PETRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Esfenvalerate (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	PETRIVUP	20-Apr-05	3ORG	6PYRETH_iso	Esfenvalerate (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	6PYRETH_iso	Esfenvalerate (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANLORCRKUP	03-Nov-04	3ORG	6PYRETH_iso	Esfenvalerate (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANLORCRKUP	20-Apr-05	3ORG	6PYRETH_iso	Esfenvalerate (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	6PYRETH_iso	Esfenvalerate (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Esfenvalerate (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKUP	04-Nov-04	3ORG	6PYRETH_iso	Esfenvalerate (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Esfenvalerate (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SUICRKLWR	19-Apr-05	3ORG	6PYRETH_iso	Esfenvalerate (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SUICRKUP	03-Nov-04	3ORG	6PYRETH_iso	Esfenvalerate (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SUICRKUP	19-Apr-05	3ORG	6PYRETH_iso	Esfenvalerate (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	COYCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-1)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	COYCRKUP	01-Nov-04	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-1)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	COYCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-1)	2	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	NAPRIVLWR	19-Apr-05	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-1)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	NAPRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-1)	2	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	NAPRIVUP	19-Apr-05	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-1)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	PETRIVLWR	20-Apr-05	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-	1	ND VNBC	0.00	ug/kg	1.00	DFG-	WPCL_L-211-05_S_PYD-PYN

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
					1)						WPCL	
2004-11	PETRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-1)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	PETRIVUP	20-Apr-05	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-1)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-1)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANLORCRKUP	03-Nov-04	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-1)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANLORCRKUP	20-Apr-05	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-1)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-1)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-1)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKUP	04-Nov-04	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-1)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-1)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SUICRKLWR	19-Apr-05	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-1)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SUICRKUP	03-Nov-04	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-1)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SUICRKUP	19-Apr-05	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-1)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	COYCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	COYCRKUP	01-Nov-04	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	COYCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-2)	2	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	NAPRIVLWR	19-Apr-05	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	NAPRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-2)	2	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	NAPRIVUP	19-Apr-05	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	PETRIVLWR	20-Apr-05	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2004-11	PETRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	PETRIVUP	20-Apr-05	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANLORCRKUP	03-Nov-04	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANLORCRKUP	20-Apr-05	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKUP	04-Nov-04	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SUICRKLWR	19-Apr-05	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SUICRKUP	03-Nov-04	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SUICRKUP	19-Apr-05	3ORG	6PYRETH_iso	Lambda-cyhalothrin (isomer-2)	1	ND VNBC	0.00	ug/kg	1.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	COYCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Permethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	COYCRKUP	01-Nov-04	3ORG	6PYRETH_iso	Permethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	COYCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Permethrin (isomer-1)	2	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	NAPRIVLWR	19-Apr-05	3ORG	6PYRETH_iso	Permethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	NAPRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Permethrin (isomer-1)	2	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	NAPRIVUP	19-Apr-05	3ORG	6PYRETH_iso	Permethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	PETRIVLWR	20-Apr-05	3ORG	6PYRETH_iso	Permethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	PETRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Permethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	3.00	DFG-	WPCL_L-523-537-04_S_PYD-PYN

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Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
											WPCL	
2005-04	PETRIVUP	20-Apr-05	3ORG	6PYRETH_iso	Permethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	6PYRETH_iso	Permethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANLORCRKUP	03-Nov-04	3ORG	6PYRETH_iso	Permethrin (isomer-1)	1	DNQ J,VNBC	3.77	ug/kg	3.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANLORCRKUP	20-Apr-05	3ORG	6PYRETH_iso	Permethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	6PYRETH_iso	Permethrin (isomer-1)	1	DNQ J,VNBC	3.22	ug/kg	3.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Permethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKUP	04-Nov-04	3ORG	6PYRETH_iso	Permethrin (isomer-1)	1	VNBC	12.20	ug/kg	3.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Permethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SUICRKLWR	19-Apr-05	3ORG	6PYRETH_iso	Permethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SUICRKUP	03-Nov-04	3ORG	6PYRETH_iso	Permethrin (isomer-1)	1	DNQ J,VNBC	3.21	ug/kg	3.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SUICRKUP	19-Apr-05	3ORG	6PYRETH_iso	Permethrin (isomer-1)	1	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	COYCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Permethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	COYCRKUP	01-Nov-04	3ORG	6PYRETH_iso	Permethrin (isomer-2)	1	ND VIL,VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	COYCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Permethrin (isomer-2)	2	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	NAPRIVLWR	19-Apr-05	3ORG	6PYRETH_iso	Permethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	NAPRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Permethrin (isomer-2)	2	ND VIL,VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	NAPRIVUP	19-Apr-05	3ORG	6PYRETH_iso	Permethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	PETRIVLWR	20-Apr-05	3ORG	6PYRETH_iso	Permethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	PETRIVUP	02-Nov-04	3ORG	6PYRETH_iso	Permethrin (isomer-2)	1	ND VIL,VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN

Year_Mo	StationCode	SampleDate	AnalyteGrp1	AnalyteGrp2	Analyte	N	Qual	Result	Units	MDL	Lab	LabBatch
2005-04	PETRIVUP	20-Apr-05	3ORG	6PYRETH_iso	Permethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SANLORCRKLWR	20-Apr-05	3ORG	6PYRETH_iso	Permethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANLORCRKUP	03-Nov-04	3ORG	6PYRETH_iso	Permethrin (isomer-2)	1	ND VIL,VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANLORCRKUP	20-Apr-05	3ORG	6PYRETH_iso	Permethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKLWR	04-Nov-04	3ORG	6PYRETH_iso	Permethrin (isomer-2)	1	ND VIL,VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKLWR	18-Apr-05	3ORG	6PYRETH_iso	Permethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SANMATCRKUP	04-Nov-04	3ORG	6PYRETH_iso	Permethrin (isomer-2)	1	VIL,VNBC	8.26	ug/kg	3.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SANMATCRKUP	18-Apr-05	3ORG	6PYRETH_iso	Permethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2005-04	SUICRKLWR	19-Apr-05	3ORG	6PYRETH_iso	Permethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN
2004-11	SUICRKUP	03-Nov-04	3ORG	6PYRETH_iso	Permethrin (isomer-2)	1	ND VIL,VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-523-537-04_S_PYD-PYN
2005-04	SUICRKUP	19-Apr-05	3ORG	6PYRETH_iso	Permethrin (isomer-2)	1	ND VNBC	0.00	ug/kg	3.00	DFG-WPCL	WPCL_L-211-05_S_PYD-PYN

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Appendix Table C.6. Sediment toxicity results from the ambient tributary study in watersheds of the San Francisco Estuary (2004-2005). CNEG = laboratory control sample. UCD-MPSL analyzed all sediment toxicity samples in this study. Lab codes are defined in table 1.1. Note: the initial 2005-04 *H. azteca* experiment was initiated on May 29th, 39 days after sample collection. A sample was considered toxic if both the separate variance t-test and the MSD threshold evaluation indicated toxicity (Qualifier = SL_SFEI).

Qualifer Description:

Qualifier	Description
NSG_SFEI	SFEI-Not significant compared to negative control based on statistical test, alpha of 1%, and the difference between the mean control response and the mean sample response was below the 90th percentile MSD (No criteria met)
NSL_SFEI	SFEI-Not significant compared to negative control based on statistical test, alpha less than 1%, but the difference between the mean control response and the mean sample response was greater than the 90th percentile MSD (Second criteria met)
SG_SFEI	SFEI-Significant compared to negative control based on statistical test, alpha less than 1%, BUT the difference between the mean control response and the mean sample response was below the 90th percentile MSD (Only the first criteria met)
SL_SFEI	SFEI-Significant compared to negative control based on statistical test, alpha of less than 1%, AND the difference between the mean control response and the mean sample response was greater than the 90th percentile MSD (Both criteria met)
X	None - Sample is control or reference and statistical significance is not applicable.

Year-Month	Sample Type Code	StationCode	SampleDate	*Eohaustorius estuarius* Survival (%) n=5 MSD threshold Nov. = 76% MSD threshold Apr. = 84%			*Hyalella azteca* Growth (weight mg/ind) n=8			*Hyalella azteca* Survival (%) n=8 MSD threshold (default)= 80%		
				Qualifier	Result	StDev	Qualifier	Result	StDev	Qualifier	Result	StDev
2004-11	CNEG	CONTROL	12/Nov/2004	X	95	6	X	0.14	0.03	X	98	5
2004-11	Integrated	COYCRKLWR	01/Nov/2004	NSG_SFEI	82	1						
2004-11	Integrated	COYCRKUP	01/Nov/2004				NSG_SFEI	0.13	0.05	NSG_SFEI	83	18
2004-11	Integrated	NAPRIVLWR	02/Nov/2004	NSG_SFEI	86	5						
2004-11	Integrated	NAPRIVUP	02/Nov/2004				NSG_SFEI	0.17	0.07	SG_SFEI	84	9
2004-11	Integrated	PETRIVLWR	02/Nov/2004	NSG_SFEI	85	8						
2004-11	Integrated	PETRIVUP	02/Nov/2004				NSG_SFEI	0.17	0.03	NSG_SFEI	95	5
2004-11	Integrated	SANLORCRKLWR	03/Nov/2004	NSG_SFEI	88	8						
2004-11	Integrated	SANLORCRKUP	03/Nov/2004				NSG_SFEI	0.12	0.04	SL_SFEI	56	24
2004-11	Integrated	SANMATCRKLWR	04/Nov/2004	SL_SFEI	37	14						
2004-11	Integrated	SANMATCRKUP	04/Nov/2004				NSG_SFEI	0.18	0.09	SL_SFEI	19	24
2004-11	Integrated	SUICRKLWR	03/Nov/2004	NSG_SFEI	85	9						
2004-11	Integrated	SUICRKUP	03/Nov/2004				NSG_SFEI	0.18	0.06	NSL_SFEI	71	28

Year-Month	Sample Type Code	StationCode	SampleDate	*Eohaustorius estuarius* Survival (%) n=5 MSD threshold Nov. = 76% MSD threshold Apr. = 81%			*Hyalella azteca* Growth (weight mg/ind) n=8			*Hyalella azteca* Survival (%) n=8 MSD threshold (default) = 80%		
				Qualifier	Result	StDev	Qualifier	Result	StDev	Qualifier	Result	StDev
2005-04	CNEG	CONTROL	29/Apr/2005	X	100	0						
2005-04	CNEG	CONTROL	27/May/2005				X	0.27	0.06	X	84	14
2005-04	Integrated	COYCRKLWR	18/Apr/2005	SG_SFEI	86	3						
2005-04	Integrated	COYCRKUP	18/Apr/2005				NSG_SFEI	0.22	0.07	SL_SFEI	66	14
2005-04	Integrated	NAPRIVLWR	19/Apr/2005	NSG_SFEI	98	5						
2005-04	Integrated	NAPRIVUP	19/Apr/2005				NSG_SFEI	0.33	0.1	NSG_SFEI	83	14
2005-04	Integrated	PETRIVLWR	20/Apr/2005	NSG_SFEI	85	9						
2005-04	Integrated	PETRIVUP	20/Apr/2005				NSG_SFEI	0.34	0.06	NSG_SFEI	78	15
2005-04	Integrated	SANLORCRKLWR	20/Apr/2005	NSG_SFEI	81	18						
2005-04	Integrated	SANLORCRKUP	20/Apr/2005				SG_SFEI	0.39	0.07	NSG_SFEI	86	9
2005-04	Integrated	SANMATCRKLWR	18/Apr/2005	SL_SFEI	33	12						
2005-04	Integrated	SANMATCRKUP	18/Apr/2005				NSG_SFEI	0.63	0.15	SL_SFEI	4	5
2005-04	Integrated	SUICRKLWR	19/Apr/2005	NSG_SFEI	84	18						
2005-04	Integrated	SUICRKUP	19/Apr/2005				NSG_SFEI	0.33	0.09	NSG_SFEI	88	15

APPENDIX D. FIELD SAMPLE - LABORATORY REPORT OF SEDIMENT TOXICITY TESTS (SEE CHAPTER 1)

A011738

Report of Sediment Toxicity Test Results

PRISM Episodic Toxicity

By the
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Department of Environmental Toxicology

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Submitted to:
The San Francisco Estuary Institute

November 2005

Introduction

Sediments were collected from upstream and downstream stations from six tributaries of San Francisco Bay as part of the PRISM Episodic Toxicity project. Sediments were collected in November 2004 and April 2005. This report presents the data obtained from these toxicity tests, including:

- The mean percent survival of the amphipods *Eohaustorius estuarius* after exposure to solid-phase sediments for 10 days,
- The mean percent survival of the amphipods *Hyalella azteca* after exposure to solid-phase sediments for 10 days,
- The point estimate (LC50) values for organism reference toxicant tests,

Methods

Sample Handling

Sediment samples were collected from November 1-4, 2004 and April 18-20, 2005, under the supervision of Applied Marine Sciences (AMS), and were stored on ice in the dark at AMS prior to delivery (see attached copy of chain of custody form). Samples were transferred in coolers with ice, arriving at the Marine Pollution Studies Laboratory (MPSL) on November 9, 2004 and April 22, 2005. The first round of amphipod tests with *Eohaustorius estuarius* and *Hyalella azteca* were initiated on November 12, 2004. For the second round, *E. estuarius* tests were initiated on April 29, 2005, and *H. azteca* tests were initiated on May 27, 2005. All tests were initiated within the 14-day holding time specified in the MPSL Quality Assurance Project Plan for these tests except for the second round *H. azteca* tests. These samples were held for 39 days prior to testing.

Solid-phase samples were prepared as described in the amphipod protocols (US EPA 1994 and US EPA 2000). Sediment was re-homogenized in the sample jar with a polypropylene spoon, and then

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distributed to replicate test beakers. Overlying water was added to the test containers, and sediment and overlying water were allowed to equilibrate overnight before the amphipods were added.

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Controls and Measurement of Physical/Chemical Parameters

Positive control reference toxicant tests were conducted for all species using cadmium chloride dilutions to bracket the LC50 values for each species. The negative control for the *E. estuarius* solid-phase test consisted of five laboratory replicates of home sediment, which was clean well-sorted fine-grained sand collected at the same place and time as the test amphipods. The negative controls for the *H. azteca* tests consisted of eight laboratory replicates of formulated sediment. Formulated sediment was created using equal parts Salinas River, California reference site sediment and clean, kiln-dried sand (#60, RMC Pacific Materials, Monterey, CA, USA). The sediment was amended with 0.75% organic peat moss (Uni-Gro, Chino, CA, USA). One kilogram (dry weight) of formulated sediment was prepared by combining 500g reference sediment, 500g sand, and 7.5g peat with 350 mL well water.

Water quality parameters of dissolved oxygen, pH, conductivity, and salinity were measured using a Hach SensIon selective ion meter with appropriate electrodes; and ammonia and sulfide were measured spectrophotometrically. Temperature was measured using a continuously recording thermograph and thermometer.

Ammonia was measured in overlying water and interstitial water in the solid-phase *E. estuarius* test, and hydrogen sulfide was measured in the interstitial water only. These compounds can be toxic to test organisms at concentrations found in some test sediments, and their concentrations must be quantified to determine whether they may be responsible for observed toxicity. It is difficult to measure the exact concentrations to which the free-burrowing infaunal amphipods are exposed during the test. Measurement of overlying water may underestimate exposure, and measurement of interstitial water may overestimate exposure, because the mobile amphipods may avoid sulfide-rich deeper layers and may emerge from the sediment or seek refuge in very shallow oxidized sediment layers. Both interstitial and overlying measurements are given in this report to indicate the likely range of exposure concentrations.

Interstitial water was extracted via centrifugation of 50-mL sediment samples collected from extra replicate test beakers on day 0 and day 10 of the test. Sulfide samples were preserved with zinc acetate immediately after centrifugation, and interstitial pH and ammonia samples were measured within one hour of centrifugation.

The detection limit for total ammonia is 0.1 mg/L and the detection limit for total sulfide is 0.25 mg/L. Unionized ammonia and hydrogen sulfide concentrations vary depending on pH. With a pH range of 7.5 to 8.5 the unionized ammonia concentration will range from 0.7 to 6.2% of total ammonia and the hydrogen sulfide concentration will range from 2.0 to 16.6% of total sulfide.

Data Analysis

Toxicity testing data from each sample were compared to laboratory controls using separate-variance t-tests. There was no field replication, and variance among the five laboratory replicates was used as the variance component in the t-tests. The separate-variance t-test is similar to a simple Student's t-test, with degrees of freedom adjusted to account for any heterogeneity of variance between samples. The t-test was employed to simply indicate whether differences between test samples and controls were statistically significant at the given alpha level (0.05). The alpha level used in this analysis is different from the one used for the San Francisco Regional

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Monitoring Program (0.01). An alpha level of 0.05 is standard for the State Water Resources Control Board's Surface Water Ambient Monitoring Program.

Additional statistical methods were applied to determine sample toxicity, because a t-test can often detect small differences between samples when there is low variance among laboratory replicates. Such small differences may not be biologically significant. Many sediment assessment studies using amphipods have established a criterion of 80% of the control value; samples with amphipod survival above this value are not considered toxic regardless of t-test results (Schimmel *et al.* 1994, US EPA/ACOE 1991). This 80% Minimum Significant Difference (MSD) criterion was created using data from sediment tests using *Ampelisca abdita*. We have produced a similar MSD using data from San Francisco Regional Monitoring Program *E. estuarius* tests (Phillips *et al.* 2001). This analysis indicates that the *E. estuarius* test is capable of identifying statistically significant differences in 90% of cases where the difference between the treatment and the control is 18.8%. We currently do not have a MSD value for *H. azteca*, so the default threshold of 80% was used. *Hyalella azteca* survival was compared directly to a default 80% threshold, but the growth data was normalized to the control data before being compared to the 80% threshold.

In order to evaluate whether samples were significantly more toxic than samples collected from reference areas in San Francisco Bay, the data were compared to tolerance limits developed using a "reference envelope" approach (Smith 1995). These tolerance limits were adopted from previous studies in San Francisco Bay (Hunt *et al.* 1998). Samples producing survival less than the tolerance limits are expected (with 95% confidence) to be more toxic than the most toxic 10% of reference site samples. The tolerance limit was 69.5% of the control value for *E. estuarius* in homogenized sediment (with $p = 10$ and $\alpha = 0.05$; Hunt *et al.* 1998).

Results and Discussion

Toxicity Tests

E. estuarius survival in control home sediments from November 2004 and April 2005 was 95 ± 6% and 95 ± 6%, respectively. *E. estuarius* were healthy and not negatively affected by laboratory conditions or handling. In both sampling periods, Lower San Mateo Creek sediment produced *E. estuarius* survival significantly less than that observed in the controls, as indicated by t-tests ($\alpha = 0.01$) and MSD (Table 1). Survival values for Lower San Mateo Creek were also significantly less than expected of the most toxic 10% of reference site samples.

H. azteca survival in control home sediments from November 2004 and April 2005 was 98 ± 5% and 84 ± 14%, respectively. *H. azteca* were also healthy and not negatively affected by laboratory conditions or handling. In both sampling periods, Upper San Mateo Creek sediment produced *H. azteca* survival significantly less than that observed in the controls, as indicated by t-tests ($\alpha = 0.01$) and an 80% threshold (Table 2). Additionally, Upper San Lorenzo Creek was significantly toxic in November 2004 and Upper Coyote Creek was significantly toxic in April 2005 (Table 2). There were no significant reductions in *H. azteca* growth in either sampling period.

Water Quality Measurements of Test Sediments and Elutriates

Dissolved oxygen, pH and salinity measurements were all within acceptable ranges for *E. estuarius* and *H. azteca* except for some salinity and hydrogen sulfide concentrations for *E. estuarius* (Tables

3 and 4). Application limits have not been established for hydrogen sulfide in the US EPA protocol because of the assumed ability of amphipods to emerge from sediments and escape into overlying water where H_2S is rapidly oxidized. Knezovich *et al.* (1995) lists the water only Lowest Observed Effect Concentration (LOEC) for *E. estuarius* at 0.114 mg/L H_2S. Several *E. estuarius* samples exceeded this hydrogen sulfide concentration (Table 3), but there was no significant toxicity in these samples. Measurements of total ammonia and unionized ammonia were all below the application limit established in the US EPA amphipod protocol for *E. estuarius* (0.8 mg/L, US EPA 1994), and were below the *E. estuarius* unionized ammonia 96-hour LC50 of 2.490 mg/L (Kohn *et al.* 1994).

Reference Toxicant Tests

Amphipod cadmium responses, measured as the LC50s, were within the limits of the control chart (Figures 1 and 2), indicating that test organisms responded to the toxicant in a manner consistent with previous tests.

Quality Assurance

Water quality parameters measured during tests were within specified ranges, with the following exception. Salinity outside of the quality assurance range occurred in several *E. estuarius* samples. Although these samples were 1-2 parts per thousand above the recommended salinity range for the test, the salinity was well within the tolerance range of the organisms. Temperature was within ± 2°C for all tests.

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Table 1. Means and standard deviations of percent survival for E. estuarius. Shaded areas indicate sample mean was significantly different than control mean based on separate variance t-test (1-tailed, alpha = 0.01), and the difference between the mean control response and the mean sample response was greater than the 90th percentile minimum significant difference (MSD). Bold numbers indicate sample mean was less than that expected at San Francisco Bay reference sites, based on "reference envelope" analysis (69.5% surviva, p = 10%, alpha = 0.05; Smith 1995; Hunt *et al.* 1998).

	November 2004		April 2005	
Station	Mean	SD	Mean	SD
Coyote Lower	82	10	86	3
Napa Lower	86	5	98	5
Petaluma Lower	85	8	85	9
San Lorenzo Lower	88	8	81	18
San Mateo Lower	37	14	33	12
Suisun Lower	85	9	84	18
Control	95	6	100	0

Table 2. Means and standard deviations of percent survival and growth (mg/individual) for *H. azteca*. Shaded areas indicate sample mean was significantly different than control mean based on separate variance t-test (1-tailed, alpha = 0.01), and the difference between the mean control response and the mean sample response was greater than the 90th percentile minimum significant difference (MSD).

	November 2004				April 2005			
	Survival		Growth		Survival		Growth	
Station	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Coyote Upper	83	18	0.126	0.047	66	14	0.218	0.074
Napa Upper	84	9	0.172	0.068	83	14	0.330	0.100
Petaluma Upper	95	5	0.168	0.033	78	15	0.342	0.057
San Lorenzo Upper	56	24	0.115	0.043	86	9	0.392	0.070
San Mateo Upper	19	24	0.180	0.091	4	5	0.633	0.153
Suisun Upper	71	28	0.178	0.059	88	15	0.333	0.091
Control	98	5	0.143	0.026	84	14	0.272	0.062

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Table 3. Physical/chemical measurements of test solutions in the *E. estuarius* toxicity test. Measurements were taken at the beginning and end of each test (indicated by Day). ND indicates measurements below detection limit. NA indicates that sample was not analyzed. Shaded boxes indicate measurements outside of quality control range, as discussed above.

		Overlying					Interstitial					
Site	Day	pH	DO	Sal	Total Amm	Un-ion Amm	pH	Sal	Total Amm	Un-ion Amm	Total S2-	H2S
		unit	mg/L	‰	mg/L	mg/L	unit	‰	mg/L	mg/L	mg/L	mg/L
Coyote Lower	0	8.00	8.30	19.4	0.5	0.012	7.57	11	4.4	0.039	0.0344	0.0062
Napa Lower	0	7.94	8.25	20.7	0.4	0.008	7.46	16	3.8	0.026	0.0651	0.0143
Petaluma Lower	0	7.86	8.19	21.1	0.9	0.015	7.6	20	4.7	0.045	ND	ND
San Lorenzo Lower	0	7.92	7.92	19.5	0.7	0.014	7.22	13	5.7	0.023	0.1265	0.0416
San Mateo Lower	0	7.90	8.11	21.5	0.1	0.002	7.09	22	3.5	0.010	0.0098	0.0039
Suisun Lower	0	7.69	7.64	20.1	0.2	0.002	7.1	12	2.6	0.008	ND	ND
HOME	0	7.90	8.28	21.1	ND	ND	NA	NA	NA	NA	NA	NA
Coyote Lower	10	8.06	8.54	20.5	0.3	0.008	7.23	19.4	6.9	0.028	0.0344	0.0111
Napa Lower	10	7.97	8.20	22	0.4	0.009	7.16	21.1	2.9	0.010	0.0467	0.0168
Petaluma Lower	10	7.84	8.08	23.4	0.2	0.003	7.22	18.4	3.7	0.015	0.0098	0.0032
San Lorenzo Lower	10	8.44	8.13	20.6	7.2	0.447	6.88	19.9	13.7	0.025	0.0283	0.0146
San Mateo Lower	10	7.98	8.17	23.5	1.4	0.031	6.84	23.5	5.4	0.009	ND	ND
Suisun Lower	10	7.86	8.56	20.5	0.7	0.012	6.9	19.2	2.8	0.005	ND	ND
HOME	10	7.96	8.18	25.6	0.5	0.011	NA	NA	NA	NA	NA	NA
Coyote Lower	0	7.62	7.53	18.8	ND	ND	7.19	7.4	2.4	0.009	0.2033	0.0700
Napa Lower	0	7.59	6.46	16.3	1.3	0.012	6.79	5.8	8.2	0.012	0.6194	0.3522
Petaluma Lower	0	7.42	8.29	19.4	ND	ND	6.79	15	ND	ND	0.4367	0.2489
San Lorenzo Lower	0	7.65	8.07	19	ND	ND	6.84	6	9.6	0.016	0.5737	0.3099
San Mateo Lower	0	7.55	7.97	18.8	0.2	0.002	6.98	17.4	ND	ND	0.2794	0.1285
Suisun Lower	0	7.62	7.73	17.1	0.9	0.009	6.76	7.4	1.9	0.003	0.1627	0.0953
HOME	0	7.74	8.29	20	0	0.000	NA	NA	NA	NA	NA	NA
Coyote Lower	10	7.92	8.20	19.9	ND	ND	7.35	16	5.6	0.030	0.2541	0.0677
Napa Lower	10	7.91	8.12	17.4	0.3	0.006	6.81	12	14.2	0.022	0.2896	0.1614
Petaluma Lower	10	7.81	7.89	20.1	ND	ND	6.88	18	2.8	0.005	0.3200	0.1655
San Lorenzo Lower	10	8.06	8.00	18.8	4	0.107	7.24	16	15	0.062	0.2236	0.0713
San Mateo Lower	10	7.81	5.00	20.6	3.6	0.055	7.38	18	10.2	0.058	0.2642	0.0669
Suisun Lower	10	7.75	8.29	17.7	ND	ND	6.78	15	3.3	0.005	0.1779	0.1022
HOME	10	7.92	8.27	22.9	ND	ND	NA	NA	NA	NA	NA	NA

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Table 4. Physical/chemical measurements of test solutions in the *H. azteca* toxicity test. Measurements were taken at the beginning and end of each test (indicated by Day). ND indicates measurements below detection limit. NA indicates that sample was not analyzed.

Site	Day	Overlying pH	DO	Cond	Total Amm	Un-ion Amm
		unit	mg/L	uS/cm	mg/L	mg/L
Coyote Upper	0	8.22	7.21	869	0	0.000
Napa Upper	0	8.3	7.75	1488	0.3	0.031
Petaluma Upper	0	8.24	7.77	1807	0.4	0.036
San Lorenzo Upper	0	8.12	7.00	688	ND	ND
San Mateo Upper	0	8.07	6.48	713	0.4	0.025
Suisun Upper	0	8.14	6.18	862	ND	ND
HOME	0	8.17	6.71	1098	0.3	0.023
Coyote Upper	10	8.09	6.13	837	0.3	0.020
Napa Upper	10	7.76	5.60	675	1	0.032
Petaluma Upper	10	7.84	5.79	710	1.8	0.068
San Lorenzo Upper	10	8.38	5.51	720	1.3	0.156
San Mateo Upper	10	8.22	5.05	690	1.9	0.164
Suisun Upper	10	7.74	5.60	678	2.2	0.067
HOME	10	7.94	6.31	660	2.1	0.099
Coyote Upper	0	7.94	7.17	790	0.7	0.033
Napa Upper	0	7.71	5.29	788	1.1	0.031
Petaluma Upper	0	7.68	6.59	880	1.2	0.032
San Lorenzo Upper	0	7.59	2.34	813	0.2	0.004
San Mateo Upper	0	7.36	2.31	856	3.8	0.049
Suisun Upper	0	7.67	6.62	736	0.9	0.023
HOME	0	7.4	2.48	1161	2.8	0.039
Coyote Upper	10	8.36	5.12	839	1.2	0.138
Napa Upper	10	8.55	4.84	843	1.8	0.302
Petaluma Upper	10	7.89	3.75	873	2.6	0.110
San Lorenzo Upper	10	8.47	5.27	890	1	0.144
San Mateo Upper	10	7.84	4.23	870	3.7	0.140
Suisun Upper	10	7.98	4.93	822	2.3	0.119
HOME	10	8.42	5.54	862	5.9	0.768

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Figure 1. Plot of the LC50 values for E. estuarius reference toxicant tests conducted at MPSL.

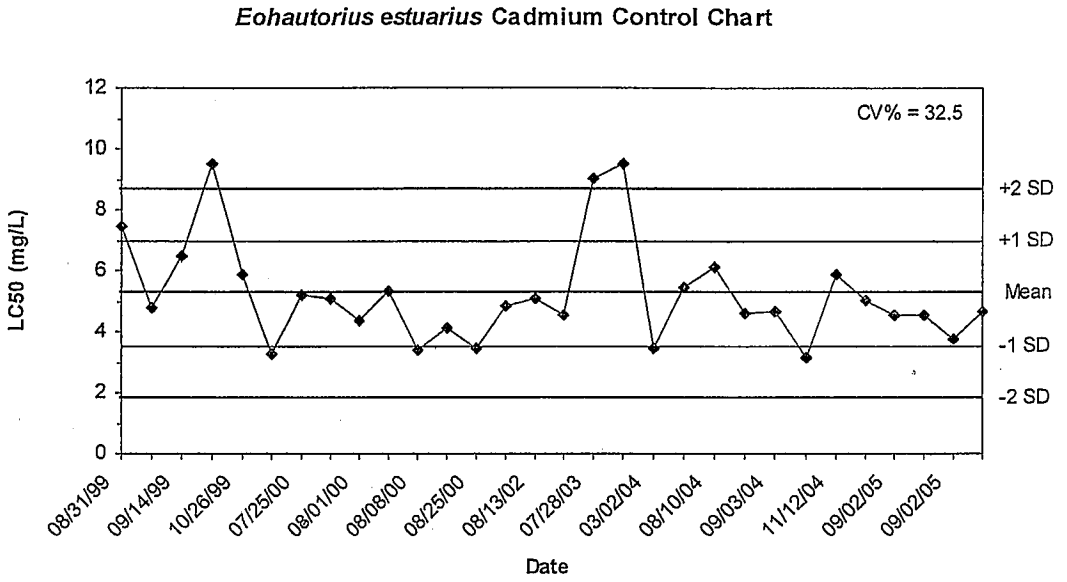
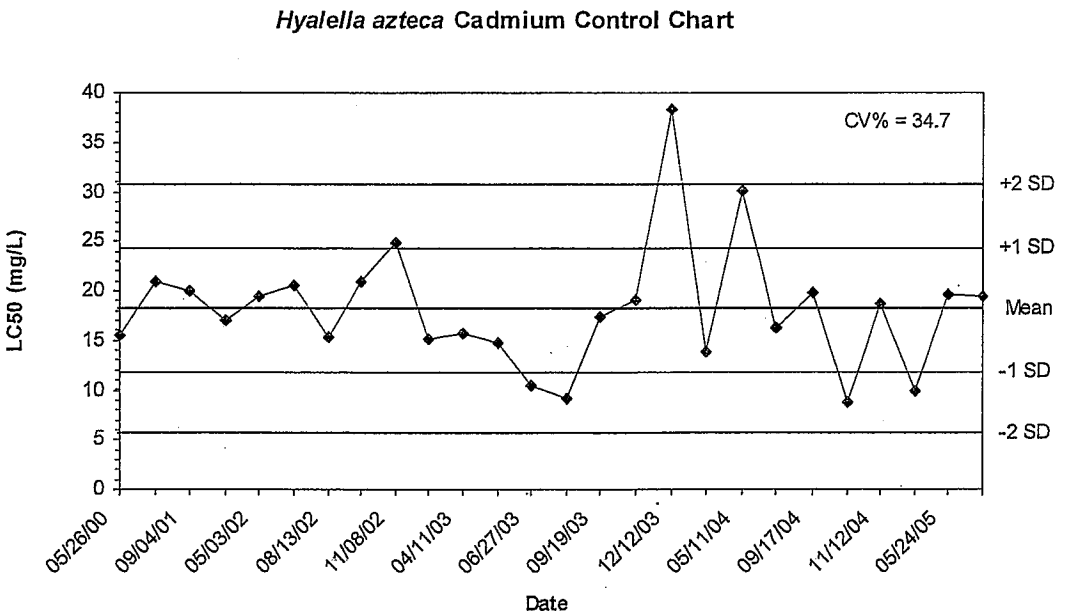


Figure 2. Plot of the EC50 values for *M. galloprovincialis* reference toxicant tests conducted at MPSL.



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APPENDIX E. PYRETHROID WORKSHOP AGENDAS AND MEETING NOTES

A011749

Development of water and sediment TIE methods for pyrethroid pesticides

SWRCB PRISM Projects

Workshop Agenda
March 28, 2005

Item	Time
Introductions and workshop goals (Sarah Lowe SFEI)	10:00 – 10:15
Overview of sediment TIE methods for Prism project (Anderson/Phillips)	10:15 – 10:45
Overview of sediment TIE methods (Weston)	10:45 – 11:15
Overview of water TIE methods for Prism project (Miller)	11:15 – 11:45
Overview of pyrethroid analytical methods development for Prism (Oros)	11:45 - 12:15
Working Lunch Break	12:15 – 12:30
Overview of pyrethroid analytical methods development (Crane/Mekebri)	12:30 – 13:00
Overview of pyrethroid analytical methods development (Kuivila)	13:00 – 13:30
Discussion of sediment and water column TIE methodology needs and...	13:30 –
merging of toxicology and analytical chemistry to support TIEs for pyrethroids	15:30
Identification of data/methodology gaps for Region 5 grants (Larson/group)	15:30 – 15:45
adjourn	

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PRISM Workgroup Meeting Notes, March 28, 2005

Summary of current pyrethroid TIE projects (presented by meeting participants) and list of chemistry and toxicity information gaps

Meeting participants: Brian Anderson, Sarah Lowe; Jeff Miller; Daniel Oros; Abdu Mekebri; Dave Crane; Don Weston; Erin Amweg; Bryn Phillips; Jeff Miller; Kathy Kuivila; Kelly Moran; Karen Larsen; Stephanie Fong

I. Toxicity TIE projects and related work

Who is doing what?

1. MPSL: Sediment TIE development (focus on *Hyalella*)
   - LC50s for several pyrethroids for freshwater and estuarine species
   - Spiked sediment – bifenthrin, cypermethrin, bifenthrin/chlorpyrifos
   - All current TIE techniques – carboxylesterase, Piperonyl butoxide (PBO),
   - HPLC fractionation
   - Synergism of mixtures

2. Weston (UCB): Sediment TIE development (focus on *Hyalella*)
   - LC50s for six pyrethroids for freshwater species
   - Temperature effects
   - Piperonyl butoxide (PBO) potentiation
   - Esterase?

3. Miller (Aqua Science)
   - HPLC of 6 pyrethroids
   - Antibodies
   - Esterase
   - ELISAs
   - Pyrethroid losses on container walls

II. Chemistry Data Gaps

1. Detection Limits
   - Lowest possible (saltwater is lower than freshwater) - LC50s of marine species are generally lower than freshwater species. Need to identify test species and target MDLs less than their LC50s.

2. Water

   What measurements should be reported?
   - Dissolved concentration
   - Total concentration

- Colloidal concentration

3. Sediment

   What measurements should be reported?
   - Pore water concentration
   - Pore water with dissolved organic matter (DOM)
   - Sediment concentration

4. Field Sampling

   How should field sampling be conducted?

   What materials are best for sampling?
   - Containers (amber, glass bottles)
   - Storage (4°C for water and ≤0°C for sediments (except SedTox = 4°C)
   - Holding times (degradation)
   - Collection procedures
   - Isomer procedures

Chemical Methods (Not a data gap and included here for information purposes)

Laboratory	Extraction Method	Analysis Method
CDFG		GC-ECD
CDFG		GC/MS-MS
AXYS		GC/HR-MS
AXYS		LC/MS-MS
Aqua Science		HPLC

III. Toxicity, Sediment TIE, and Water TIE Data Gaps

1. Sublethal toxicity/chronic toxicity

2. Isomer toxicity

3. Mixtures
   - Additivity of pyrethroids
   - Synergism of mixtures

4. Temperature
   Do our laboratory methods represent real world conditions?
   (Some pyrethroids seem to be more toxic at lower temperatures, which may not be captured in the laboratory method.)

5. Sensitivity especially to marine organisms

6. Field Sampling procedures
   - Collection procedures – Ag. Waiver monitoring study is investigating one type of container for water toxicity sampling.
   - Storage
   - Holding times (degradation)

IV. New compounds on the horizon & more information (from Kelly Moran)

List of pesticides that have been put on the "threat list" for urban surface waters and wastewater discharges, based on a literature review, toxicity data, pesticide use patterns, and sales and use data for California. This list is specific to urban areas:

(a) Pyrethroids--of greatest interest for urban surface water quality are bifenthrin, cyfluthrin (including beta-cyfluthrin), cypermethrin, deltamethrin, esfenvalerate, lambda-cyhalothrin, and permethrin. (Note: Based on recent commercial retail product changes, tralomethrin may join this list, so I suggest trying to include it too when possible).
(b) Carbaryl
(c) Malathion
(d) Polyhexamethylenebiguanide (PHMB)
(e) Fipronil

This list is in the recommendations section of a soon-to-be-released report Kelly Moran is doing on urban pesticide use in California. It should be out in mid-April (2005).

At the meeting I neglected to mention that folks might find the annual series of reports I'm doing for the Urban Pesticide Pollution Prevention Project (UP3 Project) to be interesting. They include a report on regulatory affairs (EPA and DPR actions and coming actions and water quality agency participation in them), a report on research and monitoring information from the literature (including reports from the gray literature) that could inform California water quality agencies in their action plans to prevent pesticide-related surface water toxicity, and a report on urban pesticide use trends for pesticides that are the greatest threats to urban surface waters (including POTW discharges). All these reports are on the UP3 Project web site (www.UP3Project.org --quickest access is on the "documents" page, which you can link to from the upper toolbar).

PYRETHROIDS WORKSHOP

"Facing Up to the Challenges in Pyrethroid Methods Development and Field Monitoring"

SFEI, 7770 Pardee Lane, 2nd Floor, Oakland, CA

May 11, 2006, 9:00 am-4:30 pm

PROGRAM

8:00 Sign-in and Refreshments

8:55 Welcome (Daniel Oros, SFEI)

Toxicology Studies (Session Chair: Sarah Lowe, SFEI)

9:00 Brian Anderson, UC Davis
Recent Advances in Sediment TIEs Emphasizing Pyrethroid Pesticides

9:45 Inge Werner, UC Davis
Effects of Pyrethroids on Early Life Stages of Chinook Salmon

10:30 Break (15 min)

10:45 Don Weston, UC Berkeley
An Overview of Sediment Toxicity and Pyrethroid Pesticides Throughout the Central Valley

11:30 Group discussion on toxicology topics of concern (Lead by Session Chair)

12:00 Lunch (Catered Lunch, Courtesy of RMP)

Chemistry Studies (Session Chair: Daniel Oros, SFEI)

12:30 Jay Gan, UC Riverside
Water and Sediment Analysis: Issues and Challenges

1:15 Million Woudneh, AXYS
Analysis of Pyrethroids, Pyrethrins and Piperonyl Butoxide in Surface Water and Sediments by HRGC/HRMS

2:00 Break (10 min)

2:10 Abdou Mekebri and Dave Crane, CDFG
Analysis of Pyrethroids at Environmentally Relevant Levels

2:55 Michelle Hladik, US Geological Survey
Sample Processing and Analysis of Pyrethroids in Water and Suspended Sediments

3:40 Break (5 min)

3:45 Kelly Moran, TDC Environmental
Update on Pesticide Information Use in Water Quality and Regulatory Programs

4:30 Meeting Wrap-Up

PYRETHROIDS WORKSHOP MEETING SUMMARY

"Facing Up to the Challenges in Pyrethroid Methods Development and Field Monitoring"
SFEI, 7770 Pardee Lane, 2nd Floor, Oakland, CA
May 11, 2006, 9:00 am-4:30 pm

This meeting was supported by two PRISM Grants #04-135-55-20 and #04-134-55-20, and the Regional Monitoring Program for Water Quality in San Francisco Bay – Episodic Toxicity Program (RMP-EpTox).

The Goal of the meeting was to provide the opportunity for toxicologists and chemists, who are investigating pyrethroid detection and effects in the environment, to get together and discuss findings, methods, and processes.

Last year many participants of this meeting met to outline pyrethroid work being conducted by PRISM grantees and others so as to identify information needs in both chemical methods development and Toxicology. To that end, this meeting was a forum to get together again and share research findings.

Toxicology Studies (Session Chairs: Sarah Lowe, SFEI; Brian Anderson UC Davis)

Presentations:

Brian Anderson, UC Davis
Recent Advances in Sediment TIEs Emphasizing Pyrethroid Pesticides

Inge Werner, UC Davis
Effects of Pyrethroids on Early Life Stages of Chinook Salmon

Don Weston, UC Berkeley
An Overview of Sediment Toxicity and Pyrethroid Pesticides Throughout the Central Valley (Presentation not available)

Major points:

1. Toxicity Identification Evaluations useful for determining toxicity caused by pyrethroid pesticides have come a long way towards becoming standardized.
2. Current considerations:
3. Sensitive detection limits are necessary in chemical analyses of sediment, porewater, and TIE fractions.

4. Type of columns, solvents, and flow rates used to extract and elute pyrethroids from sediment and porewater continues to be subject of continuing research in developing TIE methods. Discussion between toxicologists and chemists was helpful to investigate alternative methods. Continued discussion between disciplines is essential to fine-tune the methods.

5. Studies suggest that it is important chemistry labs have a comprehensive analyte list which includes the 13 pyrethroid pesticides now in use.

6. PBO is a strong synergist which inhibits in vivo pesticide metabolism, and is found periodically in ambient samples. This chemical should be included in chemical analyses where pyrethroid toxicity is of concern.

7. Sub-lethal, behavioral and biochemical effects (cytokine production) from pulses of pyrethroid exposure indicate immune system response in fish even 2 months after a short-term pyrethroid exposure.

8. Swimming performance appears to be another sensitive measure of pyrethroid exposure effects (Debra Denton dissertation).

Chemistry Studies (Session Chair: Daniel Oros, SFEI)

Presentations:

Jay Gan, UC Riverside

Water and Sediment Analysis: Issues and Challenges

Million Woudneh, AXYS

Analysis of Pyrethroids, Pyrethrins and Piperonyl Butoxide in Surface Water and Sediments by HRGC/HRMS

Abdou Mekebri and Dave Crane, CDFG

Analysis of Pyrethroids at Environmentally Relevant Levels

- Liquid-liquid extraction was the best method when compared to SPE or SPME
- GC-ECD is sensitive with GC-MS confirmation yields good detection and sensitivity

Michelle Hladik, US Geological Survey

Sample Processing and Analysis of Pyrethroids in Water and Suspended Sediments

Major points:

1. Partitioning of pyrethroids in the environment and factors influencing bioavailability: pyrethoids in the dissolved fraction may be tightly bound to dissolved organic matter (DOM) and possibly biologically unavailable. Further investigation on partitioning is warranted.
2. Lower detection limits: Need to get lower limits as the toxicologists are finding that organisms are extremely sensitive to some pyrethroids.
3. Several methods have been developed to identify pyrethroids in ambient samples.
4. False identification of compounds is a concern.
5. Identification of enantiomers/isomers is important as some are more toxic than others (also see above #3).

Regulatory Update on Emerging Contaminants (specifically pesticides)

Presentations:

Kelly Moran, TDC Environmental

Update on Pesticide Information Use in Water Quality and Regulatory Programs

Debra Denton, EPA-Region 9

Update EPA's Information usage and needs

(Presentation not available)

Major points:

1. Anyone monitoring current use pesticides in surface water should send their data to DPR for entry in the DPR database. DPR is looking for good quality monitoring results for surface water or sediment. Putting your data in their database will help all of us working to manage pesticides & water quality issues with understanding the problems from pesticides (and identifying the non-problems). There is some information on DPR's web site at

http://www.cdpr.ca.gov/docs/sw/surfdata.htm The database is managed by Keith Starner at DPR--his contact information is on the web site. It is best to call him before sending your data, as he can talk with you about how it would be easiest for you and for him to transfer the data. He prefers electronic data submittals. The SWAMP format works well for him.

2. There is still a need to identify how urban uses of pyrethroids (Urban sprays around buildings to control ants, lawn/garden use, pre-construction termiticide use, etc.) links to the presence of pyrethroids in urban creeks.
3. Many urban use pesticides are not being monitored in the environment. The UP3 Project web site has a list of pesticides that are of concern for urban surface water quality. Ones where monitoring is particularly lacking are fipronil & degradates and the biocide polyhexamethylene biguanadine (PHMB), which is very toxic to rainbow trout.
4. The Urban Pesticide Pollution Prevention (UP3) website is a helpful resource for publications and to find out what's being used locally (http://www.up3project.org/up3_index.shtml). Please send Kelly Moran any publication citations or white papers that relate to urban pesticide usage or related topics.
5. EPA is using DPR data and GIS tools to assist in targeted site evaluations.

Data Gaps Identified by the Group:

1. More LC50s are needed to establish the sensitivity of estuarine organisms to pyrethroids; EC50 data for both fresh water and estuarine organisms is needed.
2. Characterize the influence of ambient temperatures on pyrethroid toxicity. Laboratory tests of field samples are conducted at standard temperature limits (~23C). Some pyrethroids are more toxic at lower temperatures. Lower ambient temperatures may result in greater in situ toxicity than would be observed in laboratory tests.
3. Product signatures – it is important to identify specific chemicals (enantiomers/isomers) that are causing observed toxicity as specific compounds may be traced back to a probable source.
4. Sublethal effects are extremely important to evaluating long-term ecological health of the ecosystem. Specific biochemical measures have been developed to the point where they can clearly indicate organismal suppression of the immune system making the organism susceptible to effects of mixtures which individually may not be clearly linked to a toxic effect but synergistically may be affecting the ecological integrity of a study site. (This seems like several data-gaps...)
5. Identify and articulate the best solvents/mechanisms for getting the TIE fractions to the chemistry laboratory so that there is minimal loss/dilution of sample: solvents, containers, holding times. It would be good to have a spiking study to quantify individual losses of the different pyrethroids by various methods.
6. Hydrographic data should be characterized in order to target the most likely locations for potential toxicity or presence of contaminants.
7. Source identification: connecting specific urban uses Urban structural pest control (above ground), lawn/garden use, construction use, etc.) to pyrethroid levels in creeks.
8. Water column toxicity: characterize duration in ambient samples.
   There are a few studies:
   Ag Monitoring in Central Valley (monthly, limited data)
   DPR-Stormwater studies
9. Pesticide identification in urban creeks: new and emerging pesticides and other contaminants are not being adequately characterized in urban creeks.

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Aquatic Toxicity Due to Residential Use of Pyrethroid Insecticides

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Pyrethroids are the active ingredients in most insecticides available to consumers for residential use in the United States. Yet despite their dominance in the marketplace, there has been no attempt to analyze for most of these compounds in watercourses draining residential areas. Roseville, California was selected as a typical suburban development, and several creeks that drain subdivisions of single-family homes were examined. Nearly all creek sediments collected caused toxicity in laboratory exposures to an aquatic species, the amphipod *Hyalella azteca*, and about half the samples caused nearly complete mortality. This same species was also found as a resident in the system, but its presence was limited to areas where residential influence was least. The pyrethroid bifenthrin is implicated as the primary cause of the toxicity, with additional contributions to toxicity from the pyrethroids cyfluthrin and cypermethrin. The dominant sources of these pyrethroids are structural pest control by professional applicators and/or homeowner use of insecticides, particularly lawn care products. The suburbs of Roseville are unlikely to be unique, and similar sediment quality degradation is likely in other suburban areas, particularly in dry regions where landscape irrigation can dominate seasonal flow in some water bodies.

Introduction

Pyrethroid insecticides now fill most of the residential needs previously met by organophosphates. Use of organophosphates was drastically curtailed in the United States by the recent withdrawal of nearly all products for residential use that contain chlorpyrifos or diazinon. The vast majority of insecticides sold for consumer use now contain pyrethroids, and they are widely used around homes by professional pest control applicators as well. Agricultural use of pyrethroids has resulted in residues in runoff (*1*), with resulting contamination of creeks receiving return flow from irrigated fields (*2*). Similarly, the pyrethroid bifenthrin has been found in runoff from a commercial nursery (*3*, *4*). Landscape irrigation or stormwater runoff could play similar roles in transporting residentially used pyrethroids into urban water bodies. However, there is no monitoring for most pyrethroids in urban environments. The U.S. Geological Survey's National Water-Quality Assessment (NAWQA) Program, the largest effort to monitor urban drainages, monitors sediments for permethrin, only one of many residential use pyrethroids and the one with the lowest aquatic toxicity (*5*). Given the minimal monitoring that has been done for these pesticides with widespread use, there is a need to determine the following: (1) if residential use of pyrethroids results in residues in nearby aquatic systems; (2) if concentrations reach levels that cause mortality in sediment toxicity tests; and (3) if the presence of pyrethroids is a factor controlling the distribution of resident aquatic invertebrates.

Materials and Methods

Study Area. The area surrounding Sacramento, California has experienced rapid population growth, and within the past few years, thousands of homes have been built on land that was historically open grassland. Roseville is one of many such suburban communities surrounding Sacramento. The western portion of Roseville is characterized by numerous contiguous subdivisions of single-family homes, most of which are less than 10 years old. There is no industry in the area and only minimal commercial development and agriculture. The area was selected as a candidate for a case study on residential pesticide use because of the few pesticide sources other than residential application, and the fact that historical data had indicated the presence of *Hyalella azteca* (Arthropoda: Crustacea) in streams in the area, a species of particular interest in this study.

The main watercourse west of Roseville is Pleasant Grove Creek, a slow-moving stream 2–4 m wide and 0.5–1 m deep in most reaches. Kaseberg Creek and the South Branch of Pleasant Grove Creek (hereafter referred to as the South Branch) are the main tributaries (Figure 1). Precipitation of typically 40–60 cm/yr occurs primarily from November through March. During the summer, the primary source of water to the system is runoff from residences from over-irrigation of landscapes and lawns. Many stormwater drains from the housing subdivisions discharge to Pleasant Grove Creek, and particularly its tributaries, along much of their lengths.

Sampling Procedures. Sampling sites were established at 3–6 locations along the mainstem of each of the three creeks, and in 2–3 secondary tributaries entering each creek. These smaller tributaries originate at the outfall of storm drains serving the residential areas, and carry water from the outfalls to the main creeks.

Pyrethroids are rapidly adsorbed to soil particles, so sediments would expected to be the main repository for these compounds (*4*). Bottom sediments were collected from most sampling sites in September 2004, with the remainder of the sites sampled in either the preceding or following month. There were rain events between each of these sampling occasions, though 1–3 sites were resampled before and after each rain. No appreciable change in toxicity or pyrethroid concentrations was observed, and results from these few sites with multiple samples are sometimes averaged in the data presented.

All sites were sampled from the bank or by wading into the creek, using a steel scoop to skim the upper 1 cm of the sediment column. Approximately 3 L of sediment was collected at each site, placed in pre-cleaned glass jars, and held on ice until return to the laboratory. All sediments were

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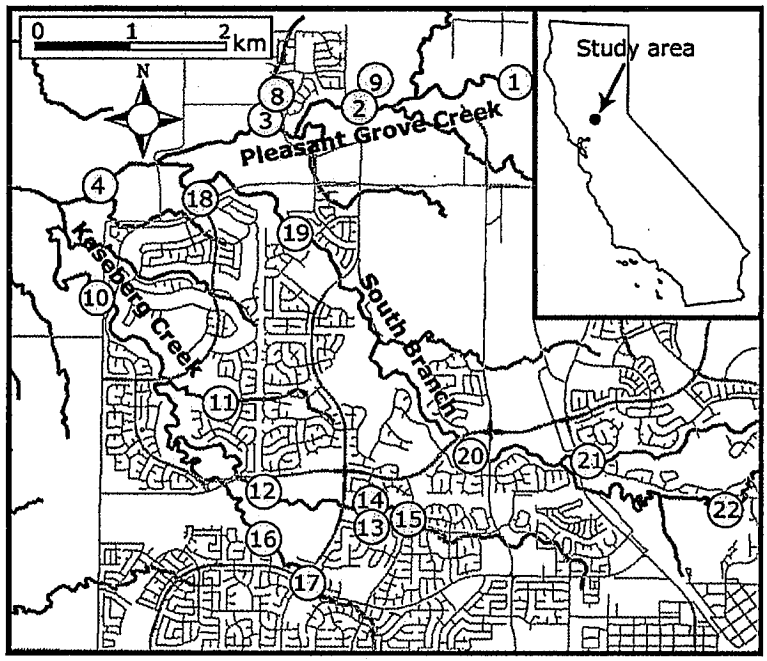

FIGURE 1. Map of study area with sampling sites shown. Inset map shows location of study area within California. Areas of housing development can be inferred from density of roads. Water flow in all creeks shown is from east to west. Stations 5, 6, and 7 are in Pleasant Grove Creek off the left side of the map, approximately 7, 10, and 13 km downstream of station 4, respectively. They are not shown because doing so would substantially reduce the detail visible in the map.

homogenized in the laboratory by hand mixing, then held at 4 °C (toxicity samples) or −20 °C (chemistry samples).

A physical habitat assessment was conducted at each site to document any heterogeneity among sites that could affect availability of *H. azteca* habitat. Physical habitat assessments consisted of collection of the standardized Habitat Assessment Field Data Sheet (*6*) for low-gradient wadeable streams. Site habitat data included estimates of epifaunal substrate/available cover, pool substrate characterization, pool variability, sediment deposition, channel alteration, channel sinuousity, bank stability, vegetation protection, and riparian vegetative zone width. Data are not presented, though the assessment documented comparable habitat throughout the study area. Water quality measurements were taken for dissolved oxygen, temperature, pH, and specific conductivity.

Field sampling for resident *H. azteca* was conducted using a low-gradient modification of the California Stream Bioassessment Procedure (*7*). All of the sample sites were low gradient (slope <0.2) and did not contain riffle habitat. Each sampling site consisted of a relatively homogeneous 100-m sampling reach. The reach was divided into three equal segments and each segment was sampled by approximately 20 jabs followed by a sweeping motion using a 0.5-mm mesh D-frame kick net. Sampling included aquatic macrophytes and overhanging riparian vegetation along the banks, as well as scraping along the surface of the bottom sediments. The sample from each segment was preserved with 10% formalin and later transferred to 70% ethanol. Laboratory processing included enumeration of only the *H. azteca* in each sample.

Analytical Methods. Chemical analytes included seven pyrethroids, 20 organochlorine pesticides or their degradation products, and one organophosphate (chlorpyrifos). Individual pyrethroid isomers were quantified, though they are summed in all data presented. Analysis followed the methods described by You et al. (*8*), differing only in quantification of 3 additional pyrethroid analytes. Briefly, sediment samples were sonicated with a solution of acetone and methylene chloride and the extracts were cleaned by column chromatography with deactivated Florisil. Analysis was performed on an Agilent 6890 series gas chromatograph with an Agilent 7683 autosampler, an electron capture detector, and two columns, an HP-5MS and a DB-608 (Agilent Technologies, Palo Alto, CA). Qualitative identity was established using a retention window of 1% with confirmation on a second column, and calibration was based on area using external standards at concentrations ranging from 10 to 100 μg/L diluted from stock solutions. Analytical grade standards were used throughout the study. The pyrethroids were purchased from Chem Service (West Chester, PA). Organochlorines, organophosphates, and surrogate standards were purchased from Supelco (Bellefonte, PA). Detection limits for the individual pyrethroids ranged from 0.1 to 0.6 ng/g, though a consistent reporting limit of 1.0 ng/g was used for all analytes. Recovery of pyrethroids from fortified samples analyzed blind ranged from 61 to 105%.

Two samples (sites 13 and 15) were also analyzed by a second laboratory for quality assurance purposes. This second laboratory extracted the sediments using pressurized fluid extraction (Dionex 200 Accelerated Solvent Extractor, Dionex, Sunnyvale, CA). Gel permeation chromatography followed by Florisil column chromatography were used for extract cleanup. Analysis was done with an Agilent 6890plus gas chromatograph with autosampler, equipped with two ^{63}Ni micro-electron capture detectors and dual 60-m capillary columns (DB-5 and DB-17MS, Agilent Technologies). Positively identified pyrethroids were confirmed using gas chromatography with mass spectrometry-ion trap detection (GC/MS-ITD) when possible. A Varian GC/MS-ITD, Saturn 2000 (Varian, Palo Alto, CA) was used with a 30-m DB-5MS column (Agilent Technologies). The GC/MS-ITD was used in select ion storage (SIS) and/or MS−MS mode. All concentration data presented were derived from analyses by the primary laboratory, rather than the second laboratory that was used primarily for confirmation of analyte identity by GC/MS. However, results from the second lab confirmed both the identity and quantification of analytes as reported herein.

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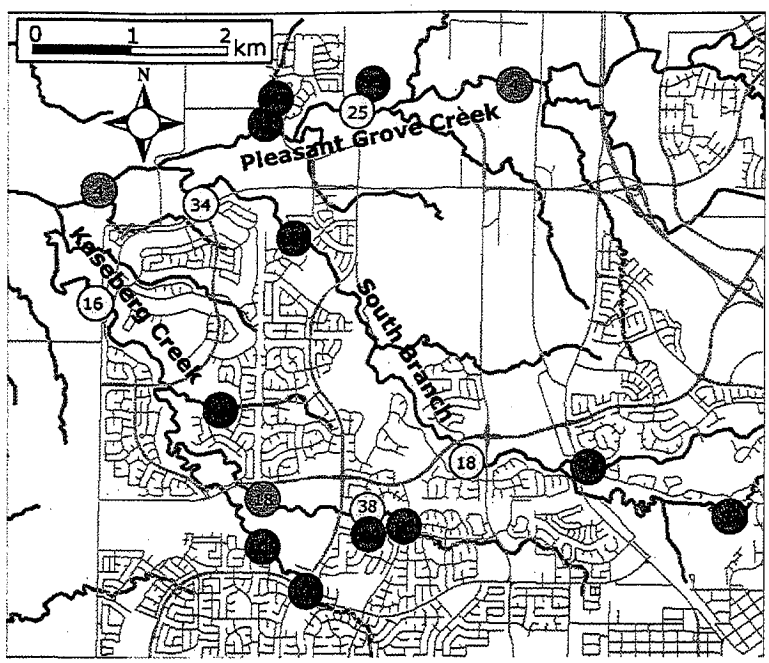

FIGURE 2. Distribution of sediment toxicity among the study sites. The numerical values at each site indicate the percent mortality of *H. azteca* in 10-d toxicity tests. Results are also illustrated by color coding (red = high toxicity with >70% mortality; yellow = moderate toxicity with mortality significantly greater than control but <70%; green = nontoxic with mortality not significantly different than control). Two stations (sites 5 and 6) not shown, but located on Pleasant Grove Creek 7 and 10 km, respectively, further downstream of station 4 were also nontoxic.

Total organic carbon was determined on a CE-440 elemental analyzer from Exeter Analytical (Chelmsford, MA), following acid vapor treatment to remove inorganic carbon.

Toxicity Testing. Toxicity testing was performed using 7–10-d old *H. azteca*, following standard methods (*9*). Testing was done in 400-mL beakers containing about 75 mL of sediment, with eight replicate beakers per sample. Test protocols included use of moderately hard water reconstituted by addition of salts to Milli-Q purified water (Millipore, Billerica, MA), a temperature of 23 °C, a 16:8-h light/dark cycle, and daily feeding with YCT (yeast, cerophyll, trout chow). Two volume additions of water were supplied daily to each testing chamber by an automatic water delivery system. This rate of water renewal was sufficient to keep dissolved oxygen levels high (5–7 mg/L) in most instances. However, three sediments required gentle aeration. Sediment from site 8 was aerated for the full test duration. Sediments from sites 21 and 22 received aeration beginning on day 5 when dissolved oxygen had declined to about 3 mg/L. After a 10-d exposure period, the amphipods were recovered, survival rate was determined, and biomass was measured after drying at 70 °C to determine growth.

All test batches included control sediment containing 1.87% organic carbon, collected from the South Fork of the American River in Placer County, CA near Folsom Lake. Sediment from this location was one of three sediments that had previously been amended with pyrethroids to determine the LC_{50} values used herein (American River sediment of Amweg et al. (*10*)).

Toxicity data were analyzed using ToxCalc Version 5.0 (Tidepool Scientific Software, McKinleyville, CA). Dunnett's Multiple Comparison test was used to identify stations with significantly greater mortality than the control. Arcsin squareroot transformation was used when necessary to meet assumptions of normality and homogeneity of variance. If these assumptions were not met even after transformation, comparison to control was done using Steel's test.

Results and Discussion

Toxicity Testing. Sediments throughout Pleasant Grove Creek and its tributaries were tested for acute toxicity to the amphipod, *H. azteca*, a species widely used for freshwater sediment testing. Sediment from 9 of the 21 sites caused total or nearly total (>90%) mortality of *H. azteca* in a 10-d exposure (Figure 2). Sediments from the smaller secondary tributaries, all of which originate at storm drain outfalls and carry runoff to the three creeks, were particularly toxic with mortalities ranging from 34 to 100% (mean = 90%). Growth data are provided in the Supporting Information (Table S1), but are not discussed herein as they do not substantially alter the results gained from the mortality endpoint alone.

Sediments from most of the mainstem of Pleasant Grove Creek showed no toxicity (~4% mortality). However, sediments were acutely toxic (25–72% mortality) in Pleasant Grove Creek at the confluence with two tributaries that drain housing developments to the north. Sediments collected within these two tributaries caused total or nearly total mortality.

Sediments throughout most of Kaseberg Creek showed mortality rates greater than the control, and mortality rates tended to increase from its confluence with Pleasant Grove Creek (16% mortality) to the most upstream sites (93 and 100% mortality). Similarly, every site in the South Branch showed significant mortality (18–100%).

Sediment Chemistry. To help identify the cause of the observed toxicity, sediments were analyzed for 28 pesticides including one organophosphate (chlorpyrifos), 20 organochlorines, and 7 pyrethroids. The concentrations of chlorpyrifos and the organochlorines were below levels associated with toxicity to *H. azteca* (*2*). Those results are presented in the Supporting Information (Table S2) but not discussed here. All seven of the pyrethroid analytes were detected in sediments from at least some sites, but esfenvalerate and lambda-cyhalothrin were found infrequently and at low concentrations (Table 1).

A011761

TABLE 1. Pyrethroid Concentrations in Creek Sediments (ng/g Dry Weight)[a] (Sites with a and b Designations Indicate Two Samples Taken at the Same Location Approximately One Month Apart)

sampling site	Compound[b] bif	cyfl	cyper	delta	esf	lam	perm
Pleasant Grove Creek							
mainstem							
1	3.3	u	u	u	u	u	14
2	9.0	u	u	u	u	u	24
3a	17	5.2	2.4	5.1	u	u	17
3b	14	3.5	2.6	2.8	u	2.5	11
4	1.7	u	u	u	u	u	8.2
5	1.5	u	u	u	u	u	3.1
6	1.2	u	u	u	u	u	2.1
tributaries							
9	40	8.3	14	2.0	u	1.6	19
8	77	70	18	5.1	u	2.0	22
South Branch							
mainstem							
21	36	27	23	8.7	2.5	3.4	57
20	5.8	u	u	u	u	u	7.4
19a	146	11	8.0	4.9	u	1.6	54
19b	78	12	3.7	3.1	1.6	1.6	29
tributaries							
22	74	48	40	u	u	3.4	154
18	11	u	4.0	u	u	u	u
Kaseberg Creek							
mainstem							
17	340	161	64	46	u	9.3	188
15	201	96	30	17	5.8	12	117
14	30	6.5	u	1.8	u	1.3	22
12	13	u	u	u	u	1.2	u
10a	6.1	u	u	1.6	u	1.6	u
10b	7.4	3.1	1.3	u	u	1.2	4.5
tributaries							
13	413	167	736	5.7	u	13	225
16	217	90	36	11	5.8	3.5	100
11	437	169	38	15	5.3	8.7	335

[a] u indicates concentration below reporting limit (<1 ng/g). [b] bif = bifenthrin, cyfl = cyfluthrin, cyper = cypermethrin, delta = deltamethrin, esf = esfenvalerate, lam = lambda-cyhalothrin, perm = permethrin.

Pleasant Grove Creek generally had no detectable pyrethroids except for small quantities of permethrin and bifenthrin. However, an exception was the region around stations 2 and 3, the only portion of Pleasant Grove Creek within the study area where there is housing immediately adjacent to the creek. This region contained moderate concentrations of bifenthrin (9–15 ng/g), probably from two small tributaries draining the developed area to the north. Sediments in the two tributaries (stations 8 and 9) contained 40–77 ng/g bifenthrin and up to 70 ng/g cyfluthrin.

Kaseberg Creek and the South Branch, both of which pass through extensive housing developments, contained far higher concentrations of pyrethroids than Pleasant Grove Creek, which borders the northern fringe of the developed area. Secondary tributaries of Kaseberg Creek had the highest concentrations of pyrethroids, particularly bifenthrin, cyfluthrin, cypermethrin, and permethrin. Contamination in the Kaseburg Creek mainstem was less severe, with the exception of the most upstream sites (stations 15, 17).

The extent of pyrethroid contamination in these suburban sediments is remarkable, particularly in comparison to the lesser levels of contamination for some of the same compounds reported in water bodies affected by agriculture. Bifenthrin concentrations in the secondary tributaries reached 437 ng/g, about 15 times greater than the highest bifenthrin concentration reported from about 70 samples from creeks and drains in areas of intensive agriculture in California (*2*). Peak concentrations of permethrin and lambda-cyhalothrin were comparable in the suburban and agricultural areas. These comparisons, however, may be distorted by the fact that samples with the highest concentrations in the current study were often collected near the point of storm drain inputs, whereas agriculture-related samples have been farther from individual outfalls.

The data suggest that sediment contamination was localized near storm drain outfalls and at points where the secondary tributaries enter the main creeks. For example, station 14 in Kaseberg Creek contained 62 ng/g total pyrethroids, far less than at a site only 0.2 km upstream (station 13, 1560 ng/g) or another site 0.5 km upstream (station 15, 479 ng/g). The fact that Pleasant Grove Creek is relatively unaffected despite the widespread contamination in Kaseberg Creek and the South Branch also suggests minimal transport of contaminated sediments, probably due to the low current speeds in the creeks. Overall, it appears that any given outfall affects sediment quality for a distance of tens to hundreds of meters downstream. However, given the numerous outfalls scattered throughout the system, the result is a patchwork of highly contaminated reaches.

Pyrethroid concentrations were used to calculate toxicity units (TU) in the sediments as follows:

$$TU = \frac{\text{Actual concentration (organic carbon normalized)}}{\text{Reported } \textit{H. azteca}\ LC_{50} \text{ concentration (organic carbon normalized)}}$$

LC_{50} concentrations for a 10-d exposure of *H. azteca* to pyrethroid-contaminated sediments have been determined for 3 sediments (*10*). The LC_{50} values used in the TU analysis are the means from these 3 sediments: bifenthrin = 0.52 μg/g organic carbon (oc), cyfluthrin = 1.08 μg/g oc, cypermethrin = 0.38 μg/g oc, deltamethrin = 0.79 μg/g oc, esfenvalerate = 1.54 μg/g oc, lambda-cyhalothrin = 0.45 μg/g oc, and permethrin = 10.83 μg/g oc. All pyrethroids are extremely hydrophobic, thus, LC_{50} values are more consistent and the TU analysis is improved by expressing concentrations normalized to sediment organic carbon (*10*).

When the pyrethroid concentrations are expressed as TUs, it is apparent that nearly all of the sites had concentrations that would be expected to be acutely toxic (Figure 3). All sites but one (station 20) in Kaseberg Creek and the South Branch had at least 1 TU, indicating that *H. azteca* would be expected to show high mortality in sediment toxicity tests due to pyrethroids nearly anywhere in either creek. The tributaries of Kaseberg Creek are particularly noteworthy because their sediments had 14–41 times the acutely lethal concentrations of pyrethroids.

Pleasant Grove Creek was the only creek where TU analysis suggests pyrethroids concentrations were low enough to allow survival of *H. azteca*. Sediments in its two small northern tributaries (stations 8 and 9) had 7–13 TU, and Pleasant Grove Creek had 2–3 TU in the region where these tributaries enter. However, the remainder of Pleasant Grove Creek was well below 1 TU.

When the pyrethroid concentration data are weighted by toxicity of the individual compounds, as in the TU analysis, it is apparent that most of the expected toxicity is attributable to bifenthrin. Bifenthrin alone comprised an average of 70% of the TUs among all sites. While bifenthrin is the dominant contributor to the toxicity, it is not the sole contributor. Other pyrethroids, particularly cyfluthrin and cypermethrin, were found in some locations at concentrations expected to be toxic to *H. azteca*. Of the 16 sites with one or more TU, 11 sites would still have more than 1 TU if bifenthrin were excluded from the analysis.

Permethrin was commonly found in creek sediments, having the highest or second highest concentration of all

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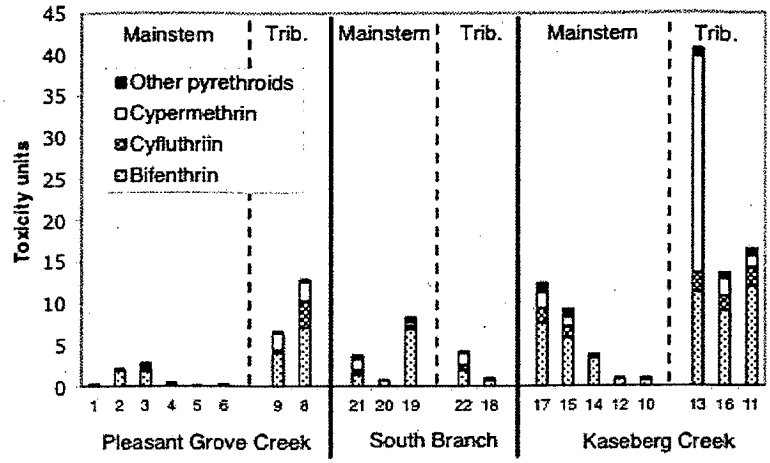

FIGURE 3. ***H. azteca*** **TUs in the sediments at each sampling site, and the contribution of the various pyrethroids to the total TU. At one TU, data in the literature (*10*), suggests that the concentration of pyrethroids would be sufficient to cause 50% mortality to *H. azteca* in 10-d sediment toxicity tests.**

pyrethroid analytes in over $^3/_4$ of the samples. However, it contributed little to the pyrethroid TUs. It is among the least toxic of the pyrethroids to *H. azteca* (*10*) and to aquatic life in general (*5*).

The TU analysis identifies sites where *H. azteca* mortality would be expected based on chemical concentrations and previously reported toxicity thresholds. It was a good predictor of the actual toxicity testing results (Figure 4a) with the correlation between pyrethroid TUs and observed *H. azteca* mortality being highly significant ($p < 0.001$; Spearman rank correlation). At sites with less than 1 TU, little mortality would be expected, and little was observed. At all sites with more than 4 TUs there was, as would be expected, little or no survival. Between 1 and 4 TUs there was some divergence between expected and observed mortality. Mortality of 50% would be expected at 1 TU, but only 15–30% mortality was observed. This discrepancy is not unusual since pyrethroid sediment LC_{50} values can vary somewhat among sediments even after adjustment for organic carbon content (*10, 11*).

Resident Macroinvertebrates. *H. azteca* is resident in the Pleasant Grove Creek system, and its distribution was studied to determine if patterns were correlated with pyrethroid concentrations and toxicity test results. Populations were present at all sites in Pleasant Grove Creek, although densities were reduced at the mouths of the two northern tributaries and sampling sites nearest to and downstream of the South Branch and Kaseberg Creek tributaries (Table S3). The species was completely absent from both the South Branch and Kaseberg Creek.

The abundance of resident *H. azteca* was inversely correlated with pyrethroid TUs (Figure 4b; $p < 0.05$; Spearman rank correlation). Sediments containing more than 1 TU of pyrethroids had few or no resident *H. azteca*. Densities were variable at sites having less than 1 TU, presumably due to factors other than pyrethroid concentrations. The distribution of resident *H. azteca* was consistent with the patterns of sediment pyrethroid concentrations and toxicity test results, but the patterns were confounded by other habitat factors, for example, the low dissolved oxygen concentrations in some regions of the system. The low input of water in the summer results in low current speeds, and with the accumulation of decaying riparian vegetation in the bottom of the creeks, dissolved oxygen levels can be low (measured at 1.0–7.6 mg/L in Pleasant Grove Creek, 3.6–7.8 mg/L in the South Branch, and 0.5–4.5 mg/L in Kaseberg Creek).

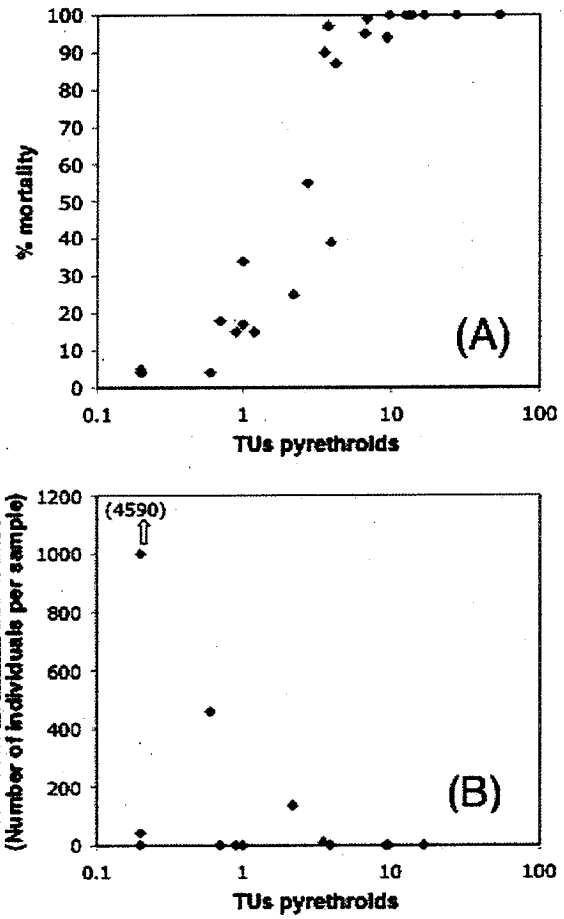

FIGURE 4. Relationship between the number of TUs of pyrethroids in creek sediments and the biological measures: (A) the toxicity to *H. azteca* in 10-d laboratory exposures to the sediments; (B) the density of resident *H. azteca* in Pleasant Grove Creek, South Branch, and Kaseberg Creek. When tested by Spearman rank correlation, both relationships were significant ($p < 0.001$ and $p < 0.05$ for (A) and (B), respectively).

Identifying the Source of pyrethroids. The strong relationship between pyrethroid TUs and observed sediment toxicity, and the fact that *H. azteca* mortality appeared when

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TABLE 2. Reported Pyrethroid Use (kg/year) in Placer County, California in 2003 (Reported Data Include Only Commercial Applications, Not Use by Homeowners)

pyrethroid	agricultural use	structural pest control	landscape maintenance
bifenthrin	0.01	141.4	6.2
cyfluthrin	0	275.1	3.9
cypermethrin	0	3337.9	0.05
deltamethrin	0	32.1	0.83
esfenvalerate	17.8	0.02	0
lambda-cyhalothrin	22.6	2.3	0
permethrin	0	673.5	157.5
other	0	1.2	0

sediment pyrethroid concentrations reached levels at which the literature suggests it should if pyrethroids were the responsible agent (at or slightly below 1 TU; Figure 4a), provide strong evidence implicating pyrethroids as the cause of toxicity. The potential sources of the pyrethroids observed in the creek sediments include the following: (1) agriculture; (2) mosquito control; (3) landscape treatment by professional applicators; (4) structural pest control by professional applicators; and (5) landscape application by homeowners or their gardening services. It is possible to eliminate some of these potential sources using statistics taken from the Pesticide Use Reporting database maintained by the California Department of Pesticide Regulation (www.cdpr.ca.gov). All commercial pesticide applications in California require an entry into the database, including information on product used, active ingredient, amount used, date, and place of application. The database includes all agricultural pesticide use and residential applications by licensed pest control firms, but it does not include products purchased from retail stores and used by homeowners or gardening services they may employ.

It is unlikely that the pyrethroids observed were of agricultural origin. There is very little agriculture in the watershed studied or in the county as a whole. In Placer County in 2003 only 1% of the reported pyrethroid use was agricultural (Table 2). Bifenthrin appeared most widespread of all the pyrethroids in Pleasant Grove Creek and its tributaries and made the greatest contribution to the toxicity, but county-wide agricultural use of bifenthrin was only 0.01 kg compared to 147.6 kg of reported nonagricultural use.

Mosquito control spraying can also be eliminated as a source of the contamination observed. The Placer County Mosquito Abatement District controls adult mosquitoes using Scourge, a product containing the pyrethroid resmethrin and the synergist piperonyl butoxide (J. Scott, Placer County Mosquito Abatement District, personal communication). Thus, none of the seven pyrethroid analytes in this study could have originated from mosquito spraying. Two sediment samples (sites 13 and 15) were analyzed specifically for resmethrin with no detectable residues found (GC/MS-ITD screening, 10 ng/g detection limit).

Landscape treatment by professional applicators may have contributed to permethrin in the creeks, as permethrin is the primary compound used for this purpose. However, landscape treatment was unlikely to have been the major bifenthrin source. Reported landscape use of bifenthrin by professional applicators was very low, with only 6.2 kg used county-wide in 2003.

In 2003, 4463.5 kg of pyrethroids was used by professional applicators in Placer County for structural pest control (i.e., in or around the exterior perimeter of homes and other structures). Cypermethrin comprised 75% of the total, followed by permethrin (15%), cyfluthrin (6%), and bifenthrin (3%). The cypermethrin and permethrin products used have substantial below-ground use as termiticides where they would be less prone to runoff, though the product labeling does permit above-ground application as well. Reported structural pest control use of bifenthrin and cyfluthrin were primarily in products intended for above-ground treatment (bifenthrin = Talstar CA granular insecticide, Talstar lawn and tree flowable insecticide; cyfluthrin = Tempo 20 WP, Prescription Treatment brand Cy-Kick CS). Twice as much cyfluthrin was used as bifenthrin for structural pest control, but cyfluthrin concentrations in creek sediments were much lower than bifenthrin. The dominance of bifenthrin in the creeks is not consistent with structural pest control as its dominant source, however, differences in environmental persistence among the pyrethroids may confound this comparison. Bifenthrin half-life in sediments is about a year (*12*), but sediment persistence data on most other pyrethroids are lacking. Thus, it is uncertain if the dominance of bifenthrin in the sediments reflects greater input or greater persistence. Structural pest control could be a significant source for many of the pyrethroids (bifenthrin, cyfluthrin, cypermethrin, and permethrin), but it is not possible with available data to determine its relative magnitude, particularly for the bifenthrin that appears to be the major contributor to toxicity.

An alternative potential source of bifenthrin to the Pleasant Grove Creek system is landscape use by homeowners or their gardening services. Retail pesticide sales data are not publicly available, so it is not possible to quantify usage as was done for the other potential sources. However, the majority of bifenthrin-containing products available in retail outlets are granular products that are broadcast onto lawns using a spreader. Consumer surveys in California have found that about half of retail pesticide purchases are made at large home supply stores (*13*). In a shelf survey of a Home Depot store in the Roseville area, six insecticide products intended for lawn application were found, three of which contained bifenthrin as the active ingredient. One of these three products (Scott's Turf Builder with SummerGuard) is a mixture of bifenthrin and fertilizer; the other two (Ortho Basic Solutions Lawn and Garden Insect Killer, Ortho Bug-B-Gon Max Insect Killer for Lawns) are intended solely for use as insecticides for control of pests such as ants, mole crickets, ticks, and fleas. The remaining three available lawn products contained lambda-cyhalothrin (Spectracide Triazide Soil and Turf Insect Killer (granular)), esfenvalerate (Ortho Bug-B-Gon Max Lawn and Garden Insect Killer (liquid)), or permethrin (Ortho Basic Solutions Lawn and Garden Insect Killer (liquid)).

Using the bifenthrin-containing Ortho Bug-B-Gon Max Insect Killer for Lawns product as an example, if the product were applied to a 100-m^2 lawn at the recommended application rate (738 g product/100 m^2, containing 0.115% bifenthrin), off-site transport of a hypothetical 1% of the applied amount would equate to 8.5 mg of bifenthrin. This amount of bifenthrin would have to be dispersed in over 0.8 metric tons of sediment (dry weight) before the concentration would decrease below the *H. azteca* 10-d LC_{50} (*10*; assuming 2% oc), and even further dilution would be necessary to reach nontoxic concentrations. If the bifenthrin were in the dissolved phase, dilution with at least 2.2 million L of water would be required to reduce the concentration below that acutely lethal to sensitive aquatic species (*5*; given a 5th percentile LC_{50} of all aquatic species tested of <3.8 ng/L). These values used for lawn area and off-site transport are hypothetical, but they illustrate it is plausible that even a very small amount of product carried by irrigation runoff from the lawn to which it was applied could adversely affect sensitive aquatic life in nearby creeks.

This study documented the presence of pyrethroids in the sediments of creeks within a residential neighborhood, and it is possible to identify likely sources, though further work will be necessary to determine their relative magnitudes.

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The compounds of greatest concern are bifenthrin, and secondarily, cyfluthrin and cypermethrin, and their potential sources appear to be limited to structural applications by professional pest control applicators and homeowner use of insecticides, particularly lawn care products. The question arises as to whether these results are unique to Roseville, California or representative of suburban systems in general. Factors such as high-density housing, the cultural emphasis on intensive lawn and landscape care, and efficient storm drain systems that carry irrigation runoff directly to nearby creeks all undoubtedly play a role. However, none of these factors are unique to Roseville, but are typical of countless suburban communities across the United States.

One factor that may exacerbate conditions in the study area is the low rainfall from May through October. During this period, much of the water and suspended sediment entering suburban creeks consists of runoff from landscape irrigation. This situation exists in much of California and other relatively dry regions in the western U.S., and suggests that degradation of sediment quality in suburban watersheds may be more severe in these areas. Other urban and suburban creeks in several additional California cities are under study, and acutely toxic concentrations of bifenthrin have been found in creeks in many of these communities as well (D. Weston, unpublished data). These results indicate that monitoring for pyrethroids in urban and suburban streams is overdue, and that the public, regulators, and scientific community should give greater consideration to the potential effects of residential use of pyrethroid pesticides on aquatic systems.

Acknowledgments

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Supporting Information Available

Mortality and growth data for the toxicity tests (Table S1), chemistry data for analytes other than pyrethroids (Table S2), and abundance data for resident *H. azteca* (Table S3). This material is available free of charge via the Internet at http://pubs.acs.org.

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SUPPORTING INFORMATION

Weston, D.P., Holmes, R.W., You, J., Lydy, M.J. – Aquatic toxicity due to residential use of pyrethroid insecticides.

4 pages (3 tables)

A011766

TABLE S1. Results of 10-d H. azteca sediment toxicity tests. Sites with a and b designations indicate two samples taken at the same location approximately one month apart. Asterisks indicates significant difference from control by Dunnett's test. "nd" indicates growth not determinable because of low survival.

Sampling site	Mortality (%) (Mean±st. dev.)	Biomass after 10 d (% of control)
Pleasant Grove Creek		
Mainstem		
1	4±5	199
2	25±8*	46*
3a	55±40*	69*
3b	90±12*	nd
4	4±8	182
5	4±7	143
6	4±5	131
Tributaries		
9	95±11*	nd
8	100±0*	nd
South Branch		
Mainstem		
21	98±5*	nd
20	18±10*	86
19a	99±4*	nd
19b	100±0*	nd
Tributaries		
22	87±14*	nd
18	34±15*	69*
Kaseberg Creek		
Mainstem		
17	100±0*	nd
15	93±12*	nd
14	38±18*	53*
12	18±14	82
10a	16±9*	143
10b	15±5*	124
Tributaries		
13	100±0*	nd
16	100±0*	nd
11	100±0*	nd

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Table S2. Concentrations of organophosphate and organochlorine pesticides or their degradation products in creek sediments (ng/g dry weight). Sites with a and b designations indicate two samples taken at the same location approximately one month apart.[a]

	Compound[b]												
Sampling site	chlor	a-BHC	d-BHC	hept	a-chl	g-chl	diel	endr	endr al	DDE	DDD	DDT	meth
Pleasant Grove Creek													
Mainstem													
1	u	u	u	u	u	u	1.5	u	u	u	u	6.5	u
2	u	u	u	u	u	u	u	u	u	u	u	3.9	u
3a	u	u	u	u	u	u	1.4	u	u	u	u	3.6	u
3b	u	u	u	u	u	u	1.8	u	u	u	u	4.8	u
4	u	u	u	u	u	u	u	u	u	u	u	u	u
5	u	u	u	u	u	u	u	u	u	u	u	1.3	u
6	u	u	u	u	u	u	u	u	u	u	u	2.5	u
Tributaries													
9	u	u	u	u	u	u	u	u	u	1.2	u	3.7	u
8	2.5	2.4	u	u	u	u	u	u	u	u	u	4.5	u
South Branch													
Mainstem													
21	5.0	u	u	u	1.1	2.1	2.1	1.1	u	1.7	1.2	4.2	7.6
20	u	u	u	u	u	u	u	u	u	u	u	2.3	u
19a	u	u	u	u	u	u	1.2	u	u	1.4	u	6.5	u
19b	1.5	u	u	u	u	u	1.5	u	u	1.5	u	3.5	u
Tributaries													
22	7.2	u	u	u	1.3	2.1	1.6	1.1	u	2.6	4.9	22	u
18	u	u	u	u	1.0	1.9	u	u	u	u	u	3.2	u
Kaseberg Creek													
Mainstem													
17	7.4	u	u	1.2	u	7.6	2.2	1.1	u	3.1	4.0	32	u
15	6.4	u	u	u	u	1.9	1.5	u	u	2.0	u	5.0	u
14	u	u	u	u	u	u	u	u	u	u	u	1.9	u
12	u	u	u	u	u	u	u	u	u	u	u	1.4	u
10a	u	u	u	u	u	u	u	u	u	u	u	4.5	u
10b	u	u	u	u	u	u	1.0	u	u	u	u	3.5	u
Tributaries													
13a	16	u	1.1	1.5	u	u	1.1	u	u	1.2	u	15	16
13b	14	u	u	u	u	u	u	u	u	u	u	u	6.7
16	2.1	u	u	u	u	u	1.3	u	u	1.7	u	5.4	u
11	19	u	u	u	u	u	1.5	u	2.5	3.3	u	21	1.7

[a] U indicates concentration below detection limit (<1 ng/g). The following were not detected in any samples: beta-BHC, gamma-BHC, heptachlor epoxide, aldrin, alpha-endosulfan, beta-endosulfan, endosulfan sulfate, endrin ketone.

[b] chlor = chlorpyrifos, a-BHC = alpha-BHC, d-BHC = delta-BHC, hept = heptachlor, a-chl = alpha-chlordane, g-chl = gamma-chlordane, diel = dieldrin, endr = endrin, endr al = endrin aldehyde, meth = methoxychlor.

A01768

Table S3. Abundance of resident H. azteca (mean and range of three replicate samples). Samples for resident amphipods were not collected at all sites sampled for chemistry and toxicity testing. Site 7 was sampled only for resident H. azteca; no other data available.

Sampling site	Indiv./sample (Mean)	Indiv./sample (Range)
Pleasant Grove Creek		
Mainstem		
1	4590	4140-5350
2	137	108-161
3	10	7-13
4	460	198-894
5	42	7-70
6	1	0-2
7	145	118-161
South Branch		
Mainstem		
20	0	0-0
19	0	0-0
Kaseberg Creek		
Mainstem		
15	0	0-0
14	0	0-0
12	0	0-0
10	0	0-0
Tributaries		
11	0	0-0

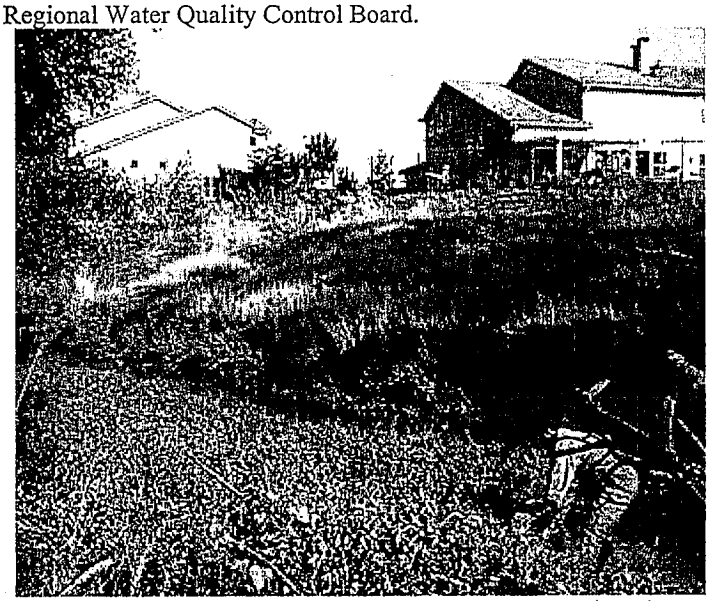
UC Berkeley Press Release

Pyrethroid pesticides found at toxic levels in California urban streams

By Robert Sanders, Media Relations | 25 October 2005

BERKELEY – A group of commonly used pesticides recently found at toxic levels in stream sediments in many agricultural areas around California is also a problem in urban streams, according to a new study by researchers from the University of California, Berkeley, Southern Illinois University and the Central Valley Regional Water Quality Control Board.

Pyrethroid pesticides, widely used on crops like cotton, fruits and lettuce, and the main residential pesticide now that the once-dominant organophosphates, diazinon and chlorpyrifos, have been phased out, were found in three streams in Roseville, Calif., a largely residential community north of Sacramento, at levels toxic to organisms that live in the sediment.



Collecting water and sediments in Pleasant Grove Creek as it flows by a subdivision in Roseville, Calif. *(Photo by Donald Weston/UC Berkeley)*

Though toxicity tests were conducted on tiny, shrimp-like animals called amphipods, a species recommended by the Environmental Protection Agency (EPA) when testing sediment toxicity, the pesticides could be affecting other bottom-dwelling animals as well, according to the researchers.

"Amphipods are a relatively sensitive group of animals, so this study is telling us that pyrethroids at these test sites are reaching levels where they can be lethal to sensitive species," said study leader Donald Weston, adjunct professor of integrative biology at UC Berkeley. Future studies should focus on aquatic insect larvae that commonly live in creeks, such as stoneflies and mayflies, which also tend to be sensitive to pesticides.

Weston and his colleagues reported their findings in the Oct. 19 online issue of *Environmental Science & Technology (ES&T)*, a publication of the American Chemical Society. The article will appear in the Dec. 1 print edition.

The California State Water Resources Control Board funded the project to investigate whether the switch to pyrethroids from organophosphates, which as of 2004 were eliminated for most urban uses, may pose risks to aquatic life, according to state biologist Robert Holmes, one of the authors.

Pyrethroids have been on the market for more than 20 years, and only now are people looking at potentially toxic effects on sediment-dwelling creatures, Weston noted. The new study demonstrates that a potential toxicity problem only recently recognized in agricultural areas is now spreading into urban areas as pyrethroid pesticides have taken over the residential market. Bifenthrin, the

pyrethroid that contributed most to the toxicity measured in the study, is available widely and sometimes mixed with fertilizer to spread as granules over lawns.

"Pesticides are often cheap, but most people don't recognize the environmental costs of using them," Weston said. "It is my feeling that a lot of urban pesticide use may be unnecessary, and the answer lies in changing practices and changing the mentality of pesticide applications in the urban environment."

The findings come at a critical time, when the EPA is beginning the process of re-registration for most pyrethroids. When pyrethroids were first registered in the 1970s and 1980s, data indicated that they bind to sediment and do not stay in the water column. Now, more than 20 years after pyrethroids hit the market, the EPA is asking for studies of sediment toxicity.

"The presumption was that if it binds to sediment, that substance becomes unavailable to organisms and, from a toxicity standpoint, irrelevant. And we're showing that not to be a fair assumption," Weston said. "If binding to sediment was a solution, we wouldn't be worried about DDT, we wouldn't be worried about PCBs, and we wouldn't be worried about a half dozen other organochlorine pesticides now banned."

He noted, however, that having the pesticide bound to the sediment does offer some advantages. As compared to the organophosphates, which are mostly dissolved in the water, having the pyrethroids bound to the sediment may make it easier to minimize their release to creeks, and may mean that toxic levels do not travel as far downstream.

Though pyrethroid pesticides are generally considered safe for fish and other animals that live in the water, until last year there had been little testing of pyrethroid toxicity on insect larvae or shrimp-like amphipods that live in bottom sediments. In the April 8, 2004, online edition of *ES&T*, Weston and colleagues Michael J. Lydy and Jing You of Southern Illinois University in Carbondale reported that some 20 percent of streams in California's Central Valley contained sediments toxic to amphipods, a laboratory standard for sediment toxicity.

In the current follow-up study, Holmes, Weston, Lydy and You sampled three streams in a residential area of Roseville, a rapidly growing community of homes and subdivisions with little agricultural activity that could have confused the picture with respect to pyrethroid sources. Nearly all the creek sediments proved toxic to amphipods, the researchers found.

The main stream, Pleasant Grove Creek, was in pretty good shape, Weston said, with contamination only where tributary streams draining housing subdivisions entered the main creek. He and his team also sampled two of these tributaries - Kaseberg Creek and the south branch of Pleasant Grove Creek, which in the dry summers carry mainly runoff from overwatered residential lawns. Nearly all sediment samples from these tributaries were toxic to amphipods in lab tests and contained pyrethroid concentrations known to kill these crustaceans.

Weston and Holmes chose these creeks in part because they are in an area that harbors natural populations of the amphipod *Hyalella azteca*, the same species as the researchers used in their lab testing. While natural amphipods were found in the main creek where there were low levels of pyrethroids, no wild amphipods were found in areas of the tributaries with high levels of pyrethroids and where they had found the sediments to be toxic in their lab tests. This gives the researchers confidence that their laboratory findings are directly relevant to the organisms in the field.

Weston said that the most toxic of the pyrethroids - all of which are identified by the suffix -thrin - was bifenthrin, which could have gotten into the streams as runoff from homes treated by professional pest-control companies for pest such as ants, or from lawns treated with pesticides or popular fertilizer/pesticide combinations.

"Our work should be of broad public interest," Weston said, "because the source of the toxicity we are finding in the creeks is just residential pesticide use in a typical suburban community. When people apply pesticides to their yards, or hire exterminators to do it, they just assume the pesticides will stay there. I think our work will increase awareness of the possible environmental dangers of pesticide overuse and maybe help people think twice before using pesticides 'just to be safe' when they do not have a clear pest problem."

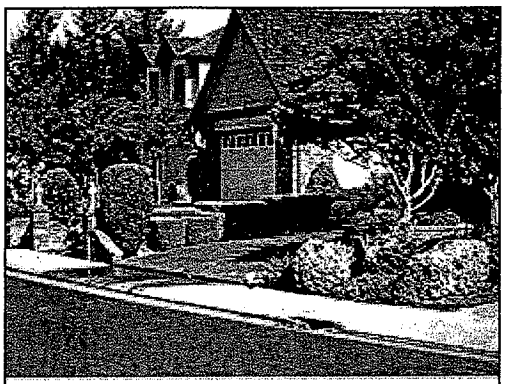
The study was funded by the Surface Water Ambient Monitoring Program (SWAMP) of the California State Water Resources Control Board.

Environmental Science & Technology Online News
http://pubs.acs.org/subscribe/journals/esthag-w/2005/oct/science/pt_pyrethroids.html

Science News –October 26, 2005

Household pesticides are poisoning city creeks

Although safer for humans, pyrethroid insecticides pose unforeseen dangers to the environment.



Erin Amweg

Researchers suspect that pyrethroids bind to small bits of dirt that wash off lawns and into nearby streams.

When Don Weston, an adjunct professor of ecotoxicology at the University of California, Berkeley, checked streams in a suburban neighborhood outside Sacramento, Calif., he found sections devoid of *Hyalella azteca*, a small bottom-dwelling crustacean that the U.S. EPA happens to use to test for toxicity in sediments. In a study recently posted to *ES&T*'s Research ASAP website (es0506354), Weston and his co-workers report that the sediment from these streams contains toxic levels of pyrethroids, a class of insecticides found in household sprays and lawn care products. These findings have caught the attention of EPA, which is now in the process of reregistering these insecticides.

Although they have been on the market for decades, pyrethroids have only dominated the popular garden insecticide market in recent years (see chart). This began after 2000, when EPA reached agreements with pesticide manufacturers to start phasing out many residential uses of organophosphates, a class of insecticides that has troubling health risks for humans. Although substantially safer for humans than organophosphates, pyrethoids were never properly tested to see whether they pose an environmental risk, say experts.

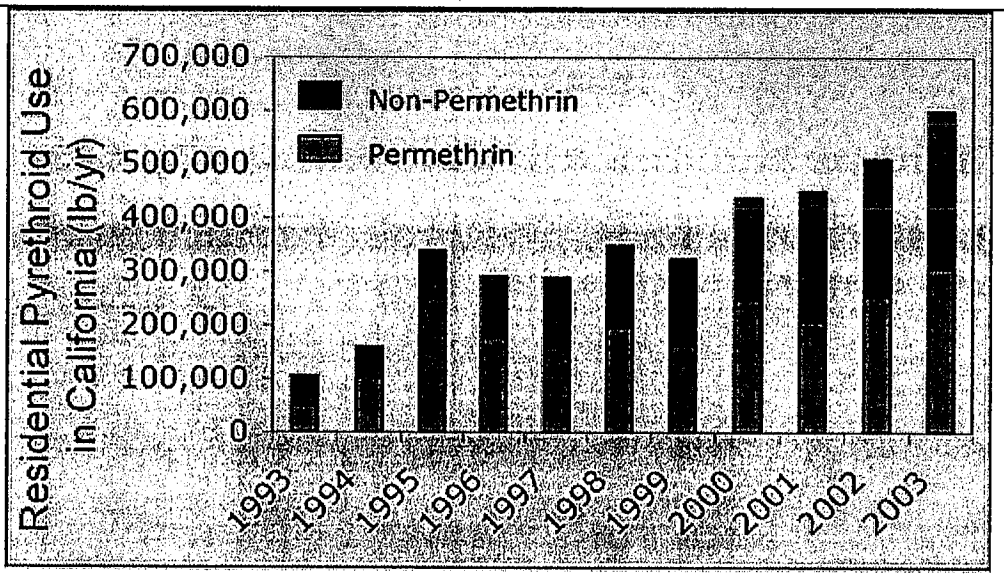


Chart courtesy Of Don Weston
Data Source: California Department Of Pesticide Regulation

Pyrethroid use has increased in recent years as more dangerous insecticides have been banned for residential application. This chart only shows numbers for professional treatments and does not list applications by homeowners. Permethrin is the least toxic member of the pyrethroids.

"These are the products you find on the shelves that end in 'thrin'," says Weston. Although these products are commonly found on the shelves of hardware stores and garden centers, he says, the data on their environmental toxicity are sparse. "These compounds have been around for 20 years, and nowhere in the literature was there any information on what was dangerous to [some] standard testing species," he points out.

Weston says that other than the U.S. Geological Survey, which checks for permethrin as part of its extensive monitoring program for pesticides, his group is the only one that has monitored these compounds in the environment. Westin adds that his group's other studies have found that permethrin is the least toxic compound of the pyrethroid group.

In earlier research, Weston's group discovered high concentrations of pyrethroids in creeks that pass through agricultural land (*Environ. Sci. Technol.* **2004**, *38*, 2752–2759). In the new study, they descended on Roseville, a classic suburban California community that is completely surrounded by houses and receives no water runoff from industry or agriculture.

"We found [pyrethroids] in every one of our samples, not always at toxic levels, and in about half of our samples they caused total or near-total mortality [to *H. azteca*]," Weston says.

To calculate toxicity, Weston exposed the crustaceans to sediments collected from 21 sites around Roseville. After 10 days, samples from 9 sites had killed more than 90% of the test animals. Analysis of these sediments for 28 pesticides, including 7 pyrethroids, found a correlation between *H. azteca* mortality and high levels of pyrethroids. In fact, one of the pyrethroids, bifenthrin, was found at levels about 15 times higher than those reported in areas of California with intensive agriculture.

Reported toxicity data are lacking because companies were never required to submit all possible environmental impacts of pyrethroids to EPA, says Kelly Moran, president of TDC Environmental, a consulting company for many California water-quality agencies. Industry did test these insecticides for

toxicity to fish, but the results are probably not very useful because pyrethroids do not readily dissolve in water, she adds. Instead, they quickly bind to dirt and other surfaces.

EPA is conducting a reregistration for pyrethroid insecticides, as required by the 1996 Food Quality Protection Act, says Bill Jordan with EPA's Office of Pesticide Programs. A manufacturer seeking to register a new pesticide or reregister an existing one is required to demonstrate safety to EPA or meet the statutory safety requirement, Jordan adds.

When Jordan was asked to comment on Weston's paper, press officer Eryn Witcher broke into the interview and steered the discussion away from Weston's findings. However, another EPA official later agreed to speak with *ES&T*. The official refused to be identified because EPA had sent out an email in early October that instructed agency staff not to discuss pyrethroids with the press. The official explained that although pyrethroid insecticides have been sold for decades, EPA did not have sediment toxicity data on this class of compounds until industry submitted the data just last month.

"You've got a compound that is now taking over the market," says the official. "Mammals and birds can quickly break it down, but for fish and invertebrates, it's quite toxic."

Regulatory concern

Given these new data, limits will probably be placed on pyrethroid applications, says the EPA source. The official added that because the compounds bind so tightly to particles, one way to protect waterways would be to prevent erosion in areas that have been sprayed with insecticides. This comment was echoed by Moran, who says that EPA may move to require new labeling on products to reduce the rate or frequency of application.

Another strategy to limit the poisoning of streams would be to require buffer zones around areas where pesticides are sprayed. Weston says that creeks probably become polluted when small particles wash off a lawn that was fertilized with a product containing an insecticide or when heavy rains wash contaminated dirt down a street and into a storm drain that runs directly into a creek.

"Legally, the city of Roseville is responsible to ensure that the water in its creek is not polluted," says Moran. "But they don't have control over what is sold in stores, and they can't prevent the use of pesticides." —PAUL D. THACKER

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Bioavailability

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Sacramento, CA

A011775

Outline

- Why bioavailability?
- Measurement methods
  - Biomimetic polymer fibers
- Bioavailability in surface water
- Bioavailability in sediment
- Future directions

EPA 917-2

Why Bioavailability?

- **Many significant pollutants are highly hydrophobic:**
  - DDT, PCBs, PAHs, chlordane, ..
  - Synthetic pyrethroid insecticides
- **Hydrophobic pollutants adsorb strongly to solid particles and DOM**
- **Adsorbed pollutants are not or less bioavailable**

SALTTOX

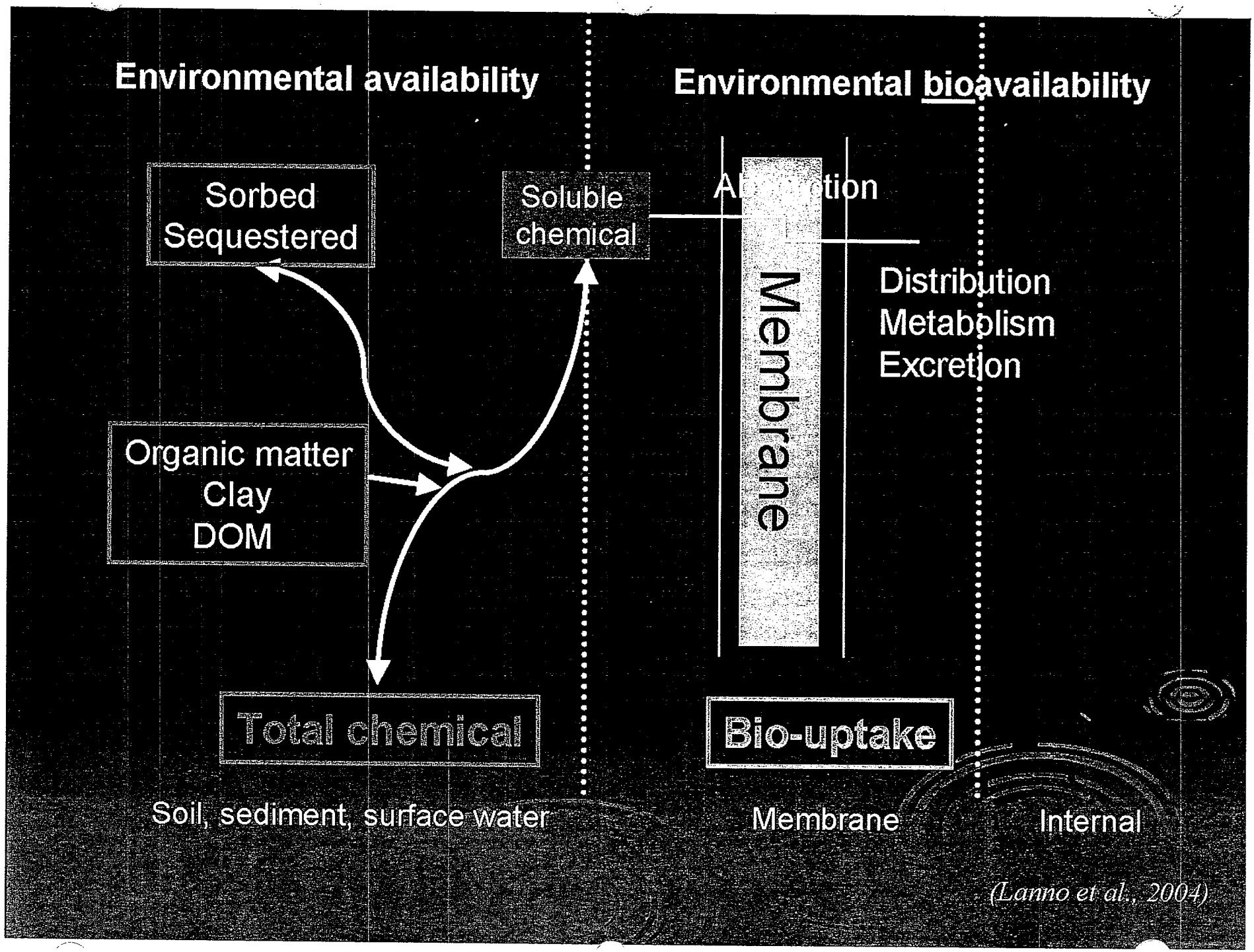
Pyrethroids vs. DDT

Pyrethroids

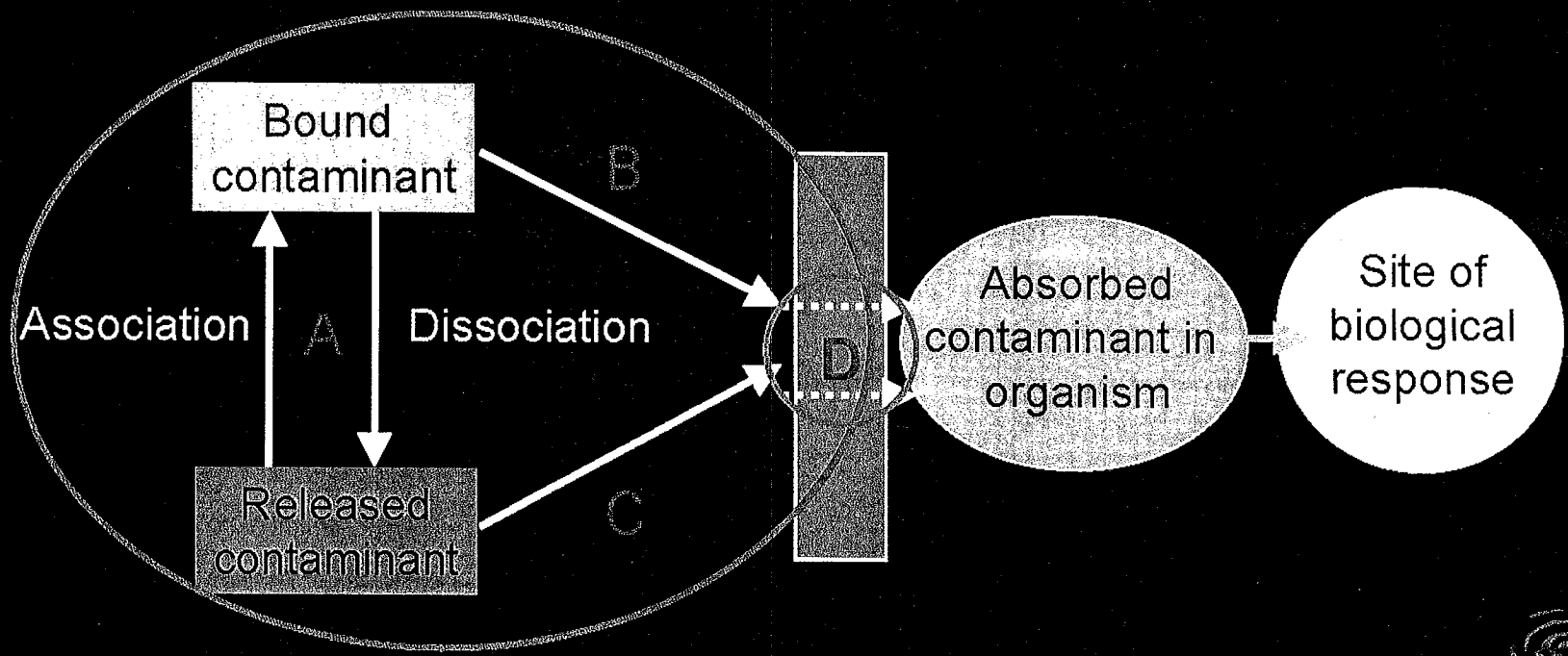
- Nearly insoluble
- Strongly adsorbing
- High aquatic toxicity

DDT likes

- Nearly insoluble
- Strongly adsorbing
- Low aquatic toxicity
- High bioaccumulation potential


Environmental availability
Environmental bioavailability
Sorbed
Sequestered
Soluble
chemical
Absorption
Membrane
Distribution
Metabolism
Excretion
Organic matter
Clay
DOM
Total chemical
Bio-uptake
Soil, sediment, surface water
Membrane
Internal
(Lanno et al., 2004)

Bioavailability vs. Bioaccessibility



Bioavailability: D

Bioaccessibility: A ⇒ D

Ehlers, L.J., and R.G. Luthy, *ES&T*, 2003, 37: 295A-302A

ADA 1781

Detections of Pyrethroids in Sediment
(Central Valley, CA)

Permethrin: 75%

Concentration 0-129 µg/kg

Esfenvalerate: 32%

Concentration 0-30 µg/kg

Bifenthrin: 18%

Concentration 0-21 µg/kg

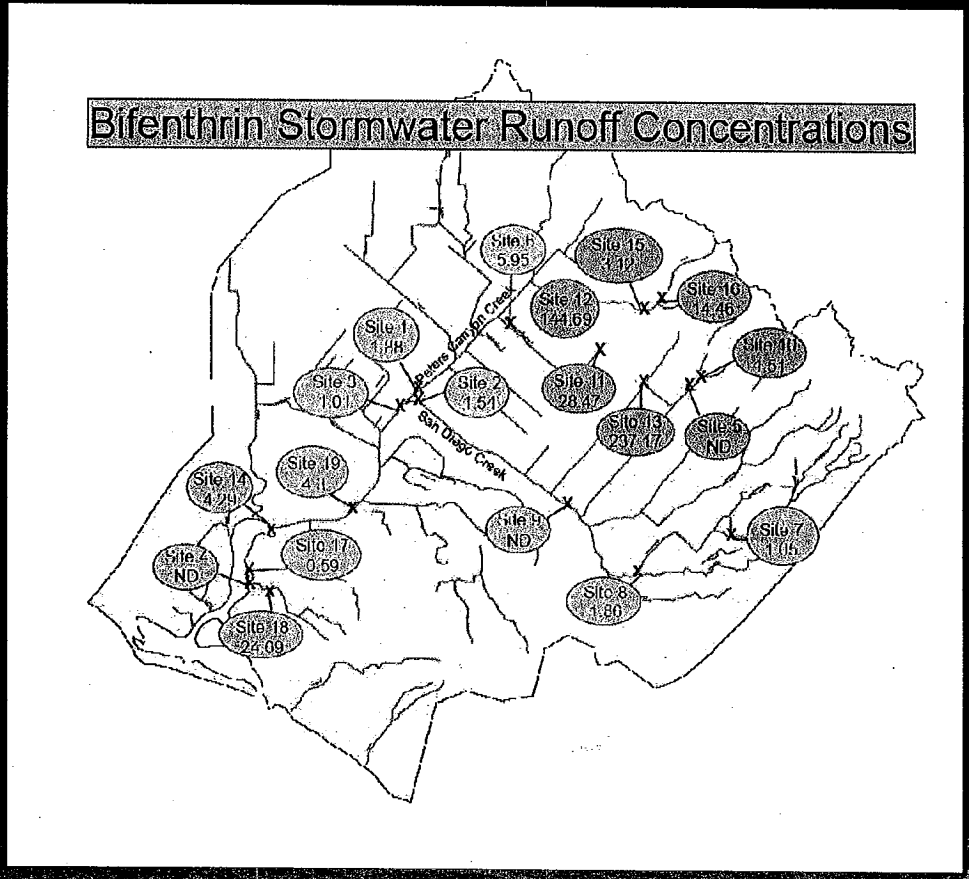
λ-Cyhalothrin: 12%

Concentration 1-8 µg/kg

Source: *Weston et al., 2004, EST, 38: 2752-2759*

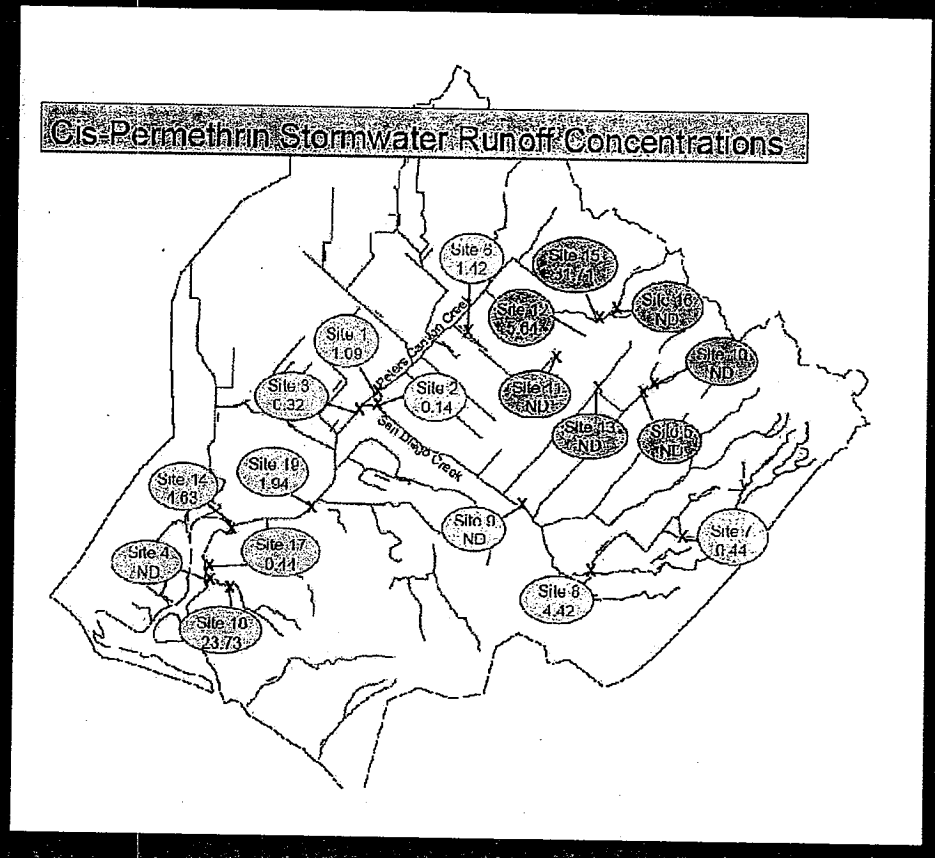
EPA-HQ-OPP-2009-0331-0151

Spring Sediment Samples
(Bifenthrin, µg/kg)



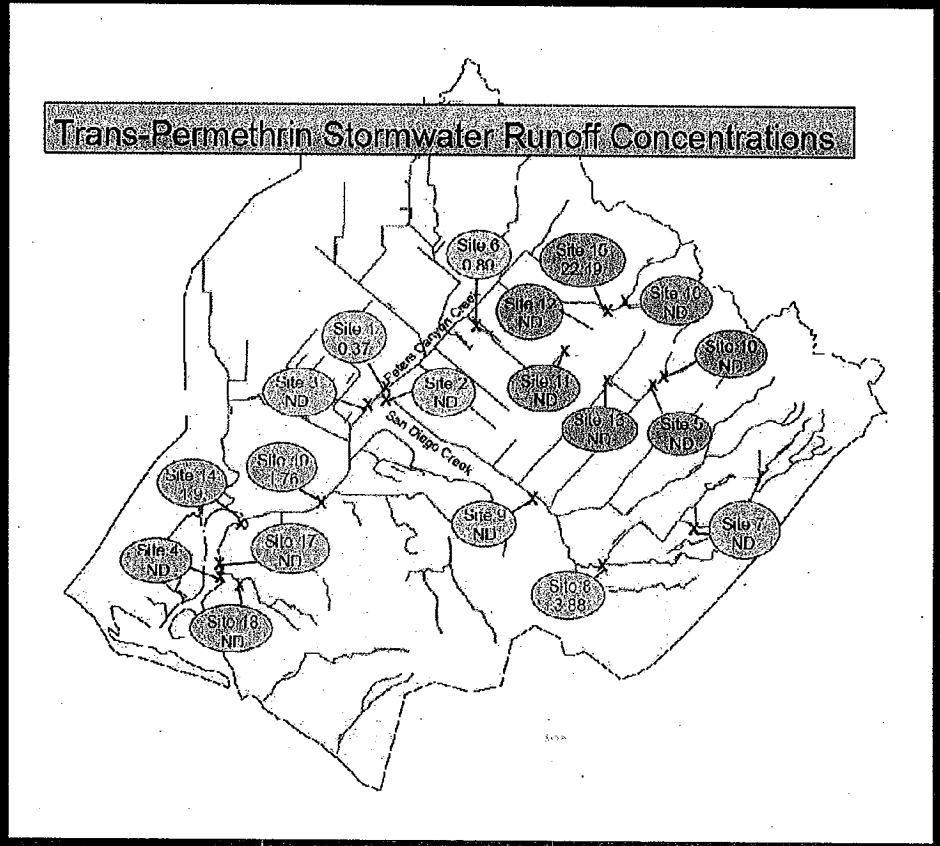
A01 1783

Spring Sediment Samples (*cis*-permethrin, µg/kg)



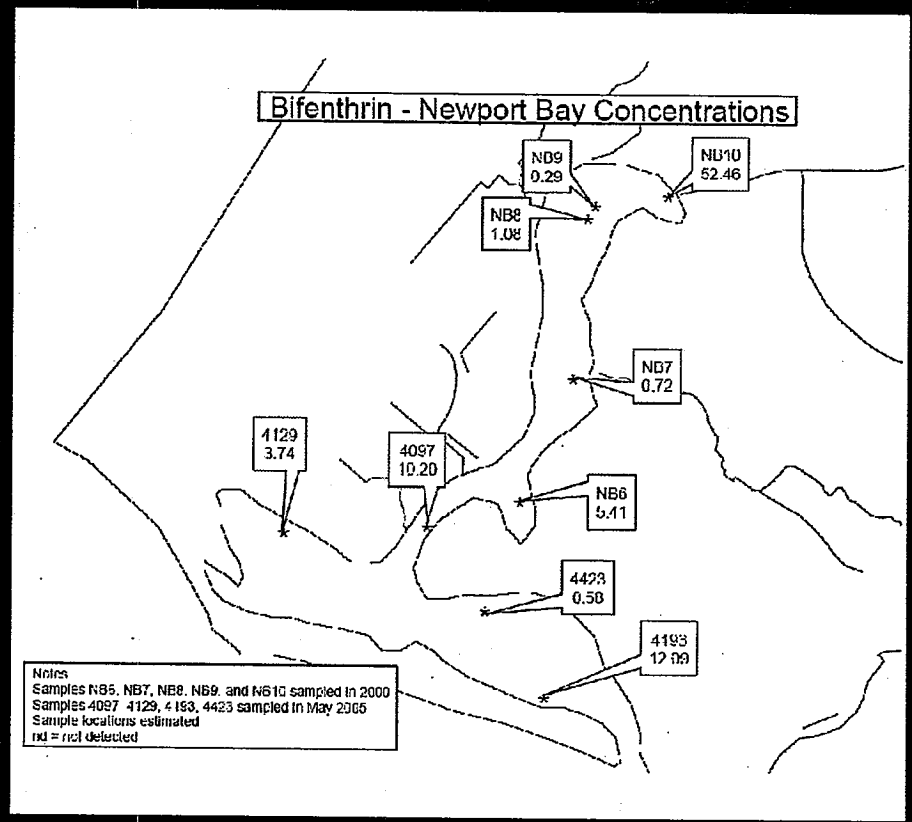
A011781

Spring Sediment Samples (*trans*-permethrin, µg/kg)



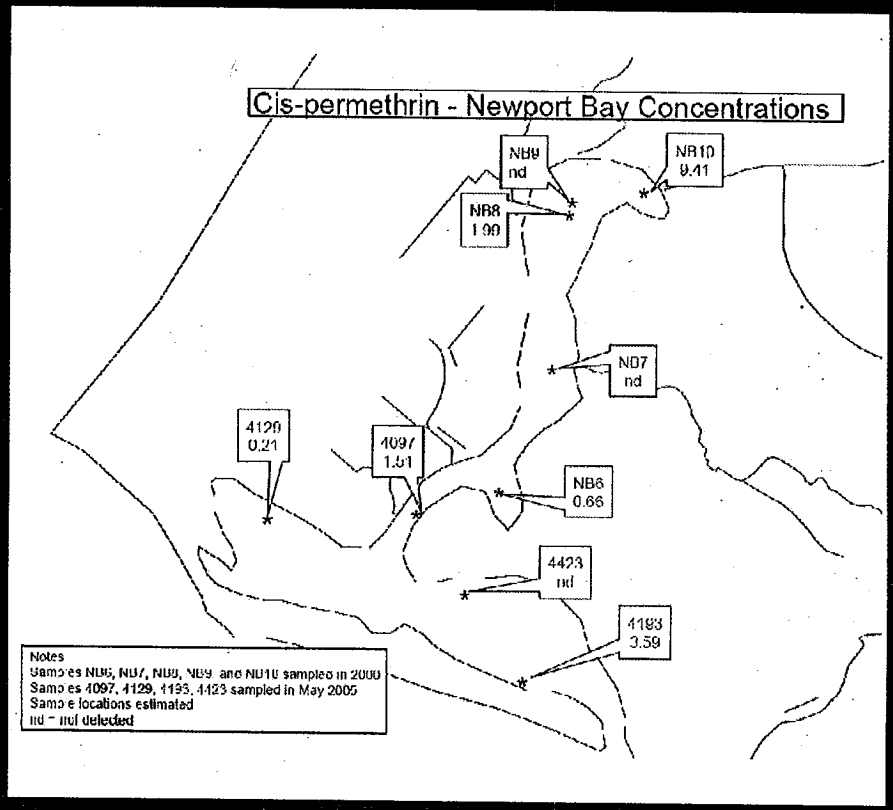
A011785

Newport Bay Sediment (Bifenthrin, µg/kg)



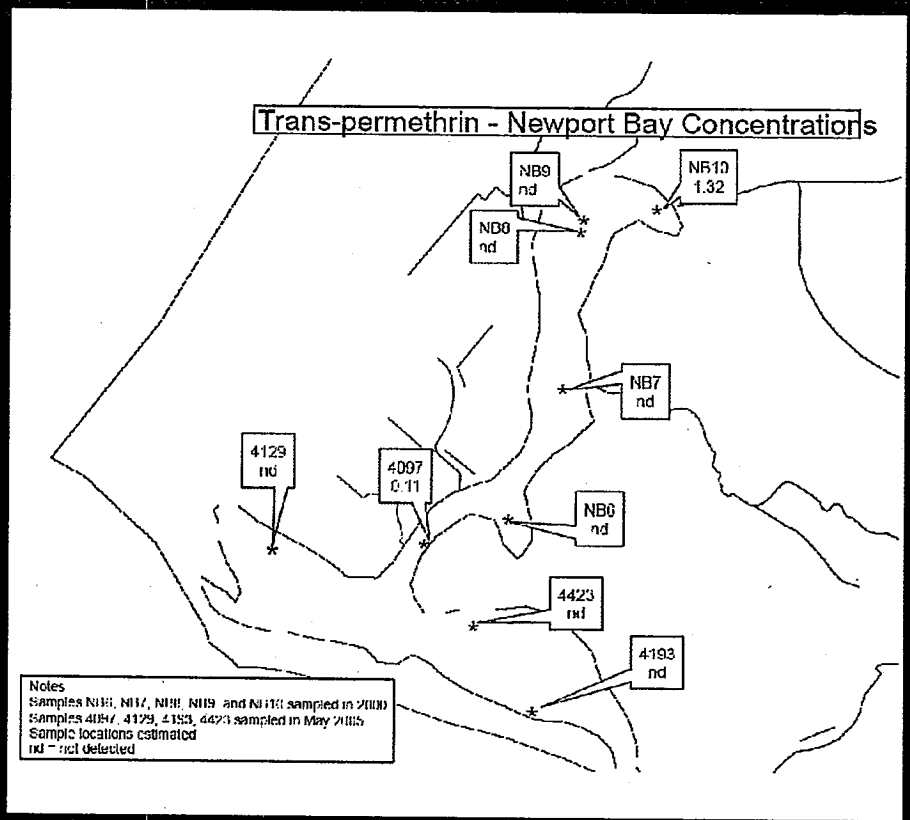
A01 1786

Newport Bay Sediment (*cis*-permethrin, µg/kg)



AQ1167

Newport Bay Sediment (*trans*-Permethrin, µg/kg)

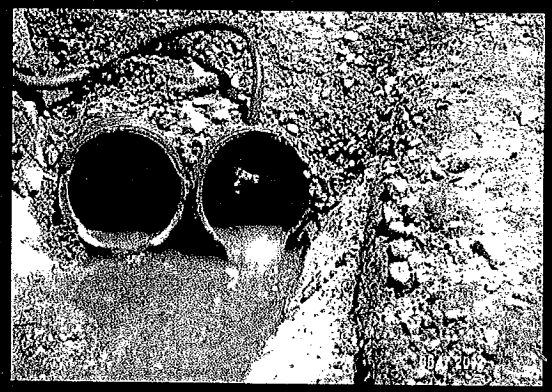


A011788

Phase Partitioning

Water column:

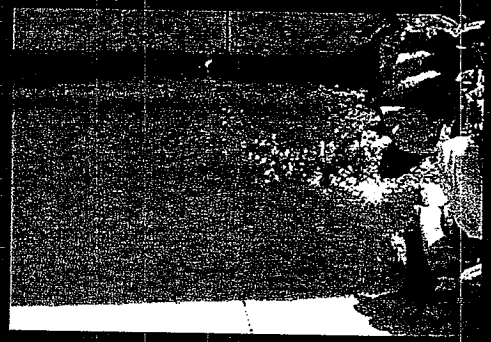
Suspended solids
Dissolved organic matter
Water phase



Sediment:

Solid phase
Dissolved organic matter
Water phase

A01 769



Surface Water

Total chemical

DOC DOC DOC DOC DOC DOC DOC

Adsorbed

DOM

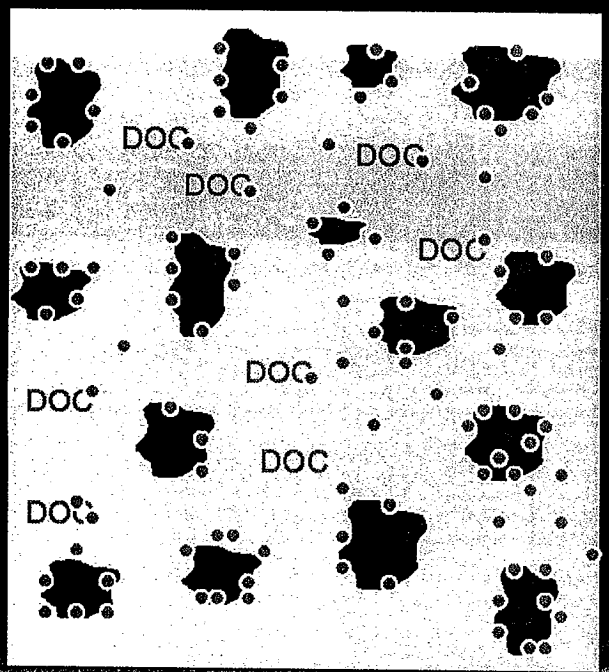
DOM-complexed

Dissolved

Bioavailable chemical

Dissecting C_w

- Overestimation of availability:

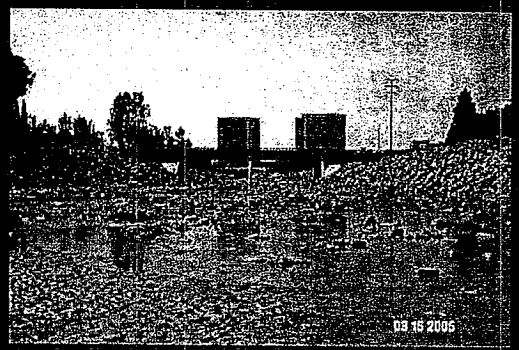


$$C_w = \frac{C_t}{1 + k_{DOM}[DOM] + k_d[SS]}$$

$$C_w = \frac{C_t}{1 + k_{DOM}[DOM]}$$

α → $\alpha = 1$, $\alpha < 1$, $\alpha > 1$

ACL 791



Sediment/Soil

Total chemical

DOC

Adsorbed

DOM

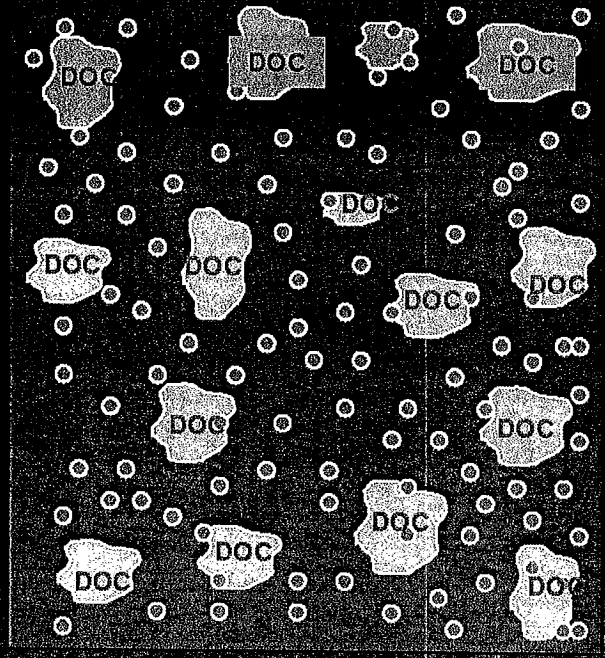
DOM-complex

Dissolved

Bioavailable chemical

Dissecting Pore-water C_w

- Overestimation of availability:



$$C_w = \frac{C_t}{1 + k_{DOM}[DOM] + k_d[S]}$$

$$C_w = \frac{C_t}{1 + k_{DOM}[DOM]}$$

α → $\alpha = 1$, $\alpha < 1$, $\alpha > 1$

AR1793

Implications

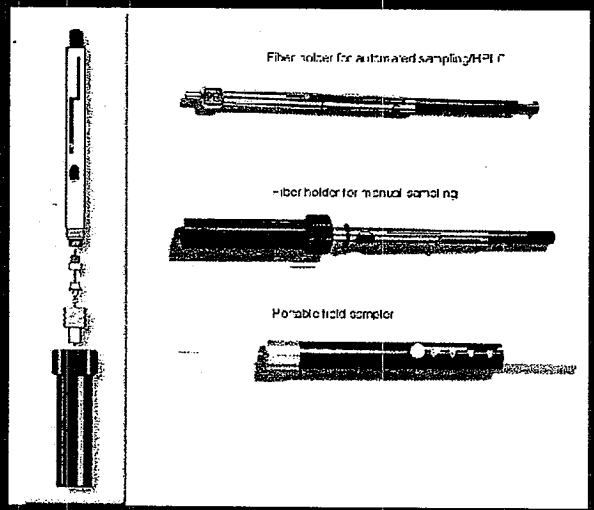
- Total concentration is used in monitoring, regulation, etc
- Aquatic toxicity may be caused only by the dissolved fraction
  - Need "biomimetic" sampling
  - What is not bioavailable? ($\alpha = 1$?)
  - How to predict?

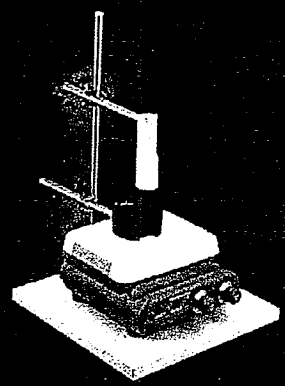
Measuring Bioavailability

- **Conventional:**
  - Dialysis membranes
  - Fluorescence quenching
  - Ultrafiltration
  - Ultracentrifugation
  - Size exclusion chromatography
  - Reverse phase
  - Affinity chromatography
- **Negligible extraction:**
  - Single drop extraction
  - SPMD
  - Empore disk
  - **SPME**

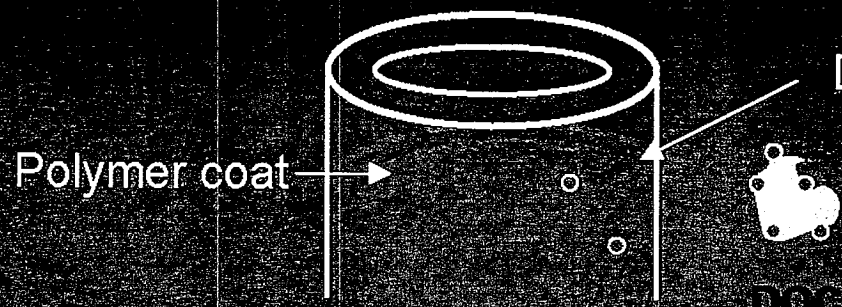
ES&T 795

Solid phase microextraction (SPME)



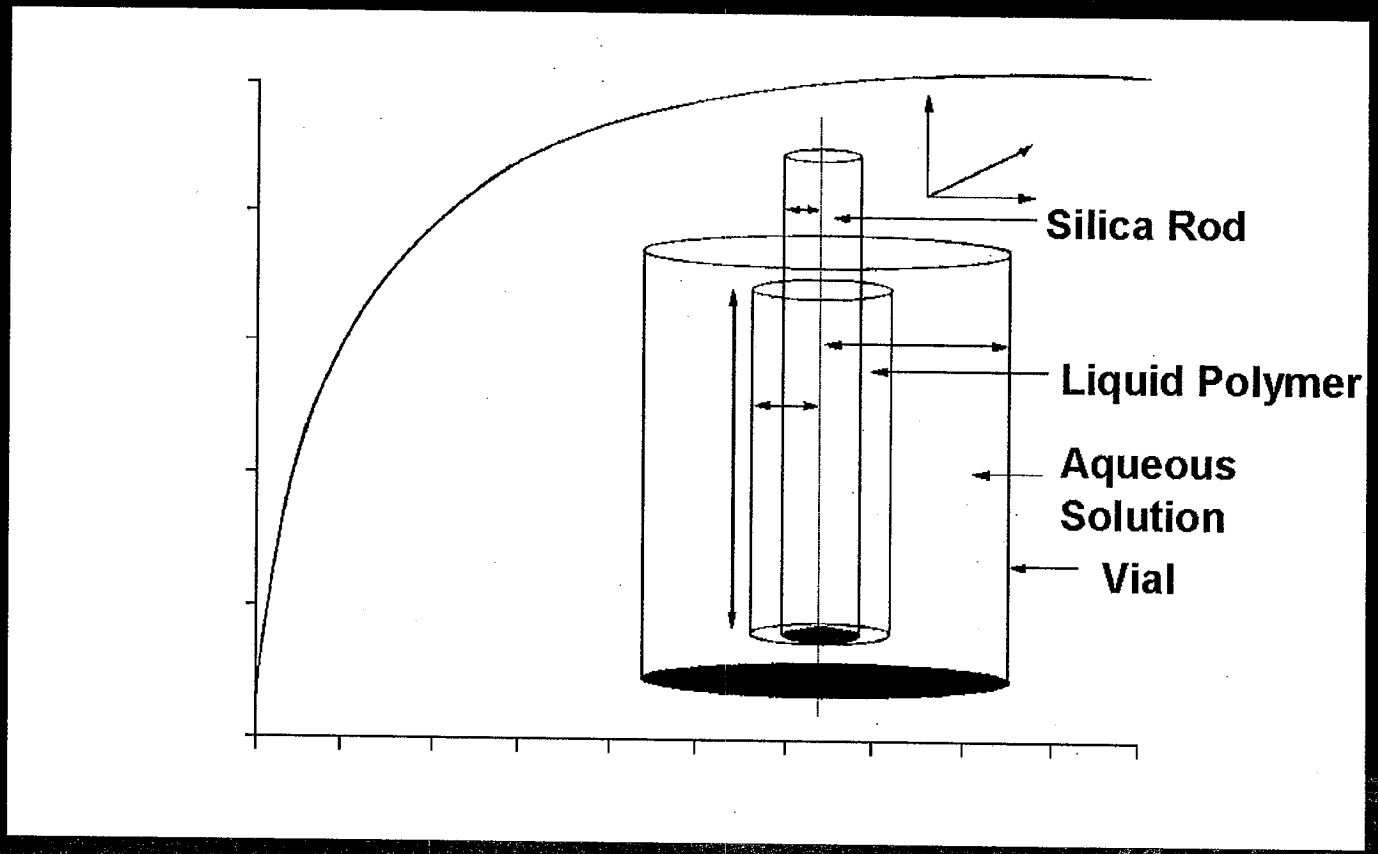


Solid phase microextraction (SPME) detects dissolved concentration C_w



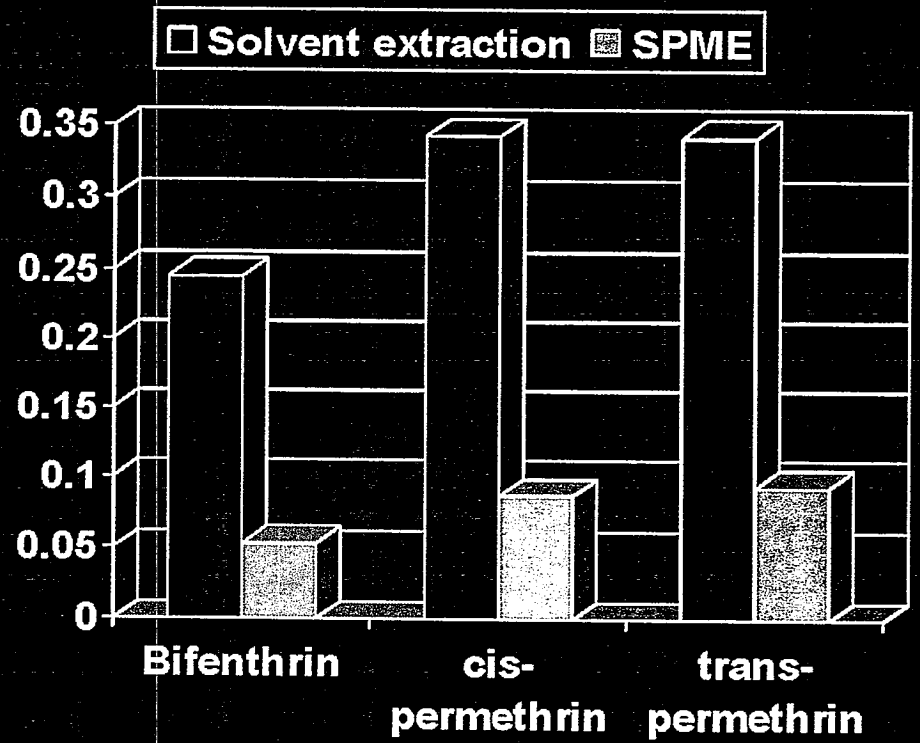
951 1795

Adsorption Mechanism for SPME



A01179?

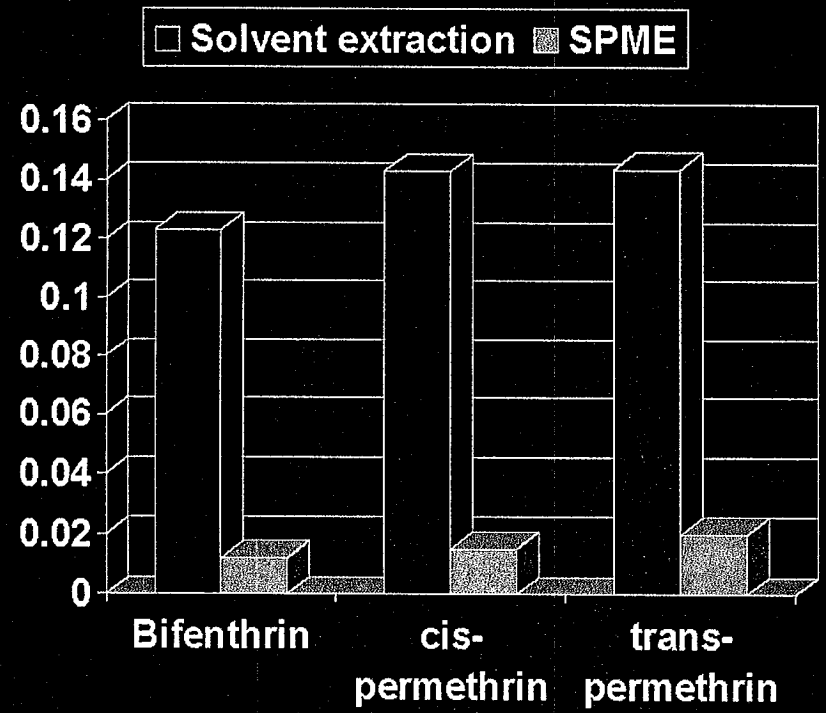
Solvent Extraction vs. SPME (µg/L, ppb)



Runoff inlet

BSI 1758

Solvent Extraction vs. SPME (µg/L, ppb)

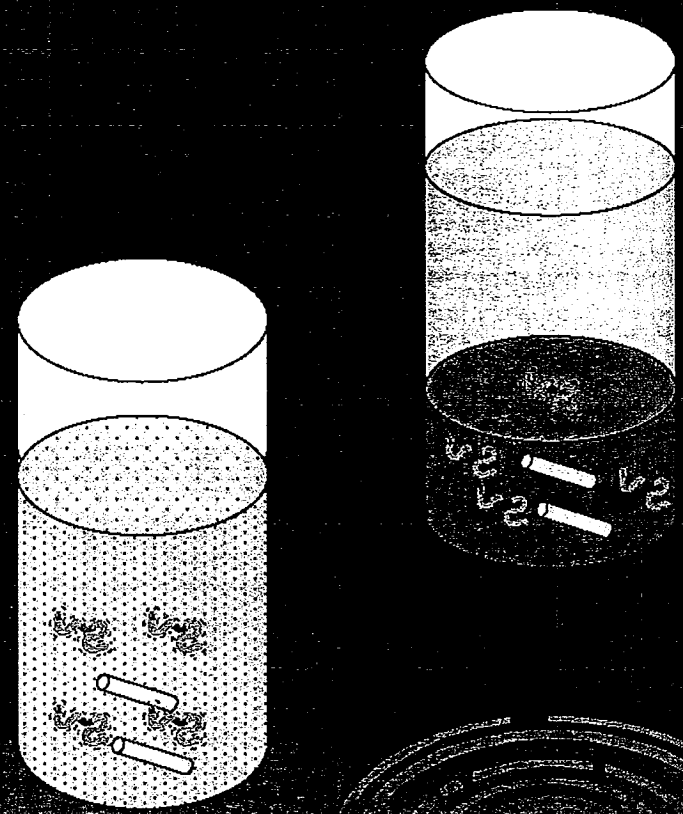


Runoff outlet

"Biomimetic" Fibers

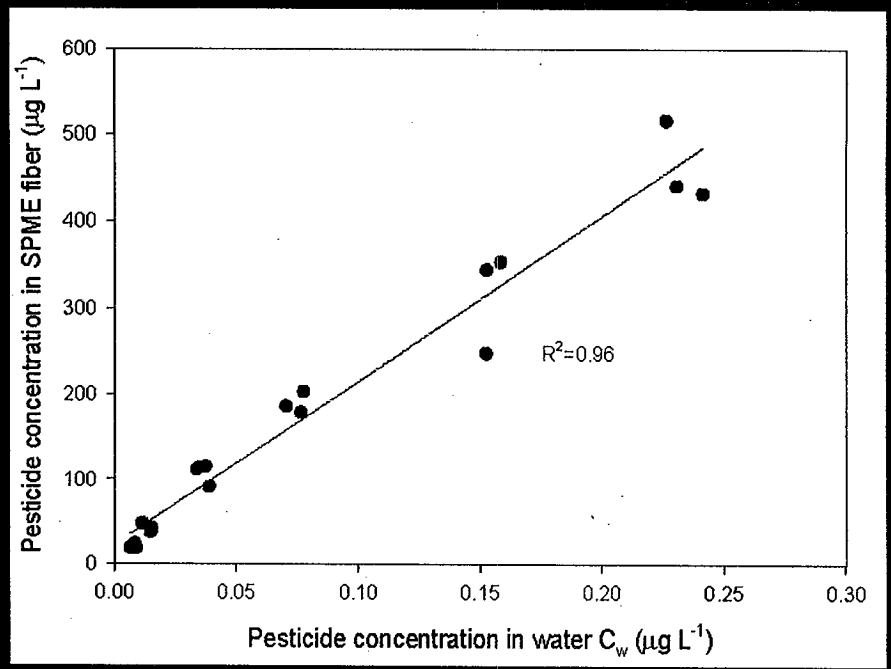
- Polymer-coated fibers
  - Optical fiber companies
- Simultaneous exposure of fiber and organisms in sediment or water
- Measurement of C_f and C_b
- Measurement of LC_{50}
- Correlation

- Advantages:
  - "Negligible" depletion
  - Inexpensive
  - "Real time"
  - Large deployment



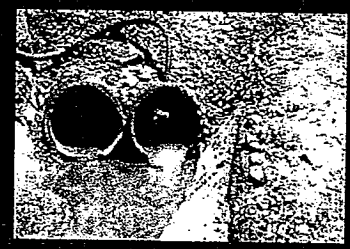
Mayer, P. et al., *EST*, 2000
Leslie, H. et al., *ETC*, 2002

K_{fiber}

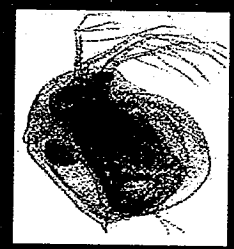


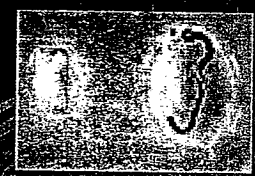
4011801

- Types of surface water:
  - Runoff effluents
  - Water column



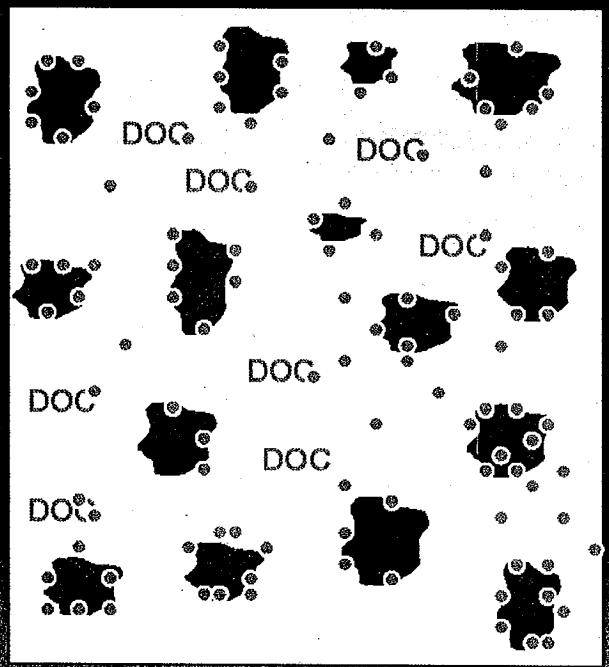
- Study design
  - Bioaccumulation (uptake) (*D. magna*)
  - Acute toxicity (*C. dubia*)





Bioaccumulation

- **Overestimation of availability:**



$$C_{PDMS} = \frac{C_0}{1 + k_{DOC}[DOC]}$$

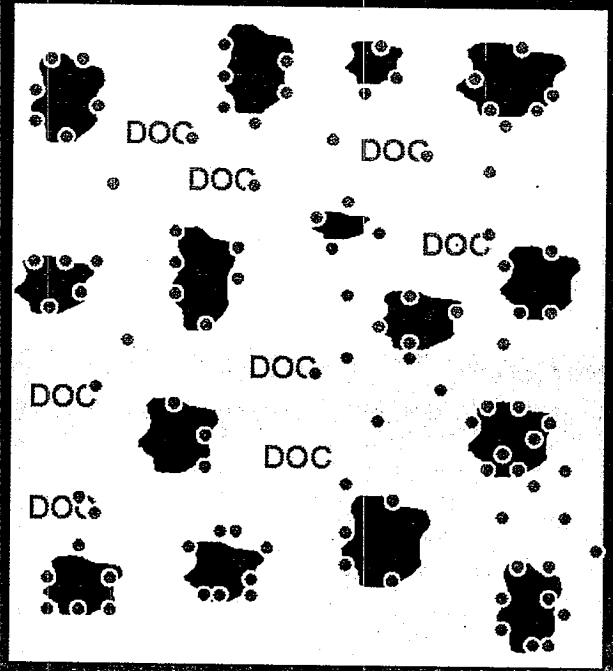
$$BAF = \frac{BAF_{[0]}}{1 + \alpha k_{DOC}[DOC]}$$

α → $\alpha = 1$, $\alpha < 1$, $\alpha > 1$

P01802

Acute Toxicity

- **Overestimation of toxicity:**



$$C_{PDMS} = \frac{C_0}{1 + k_{DOC}[DOC]}$$

$$\frac{1}{LC50} = \frac{1}{LC50_{[0]} \times (1 + \alpha k_{DOC}[DOC])}$$

$$LC50 = LC50_{[0]} \times (1 + \alpha k_{DOC}[DOC])$$

α → $\alpha = 1$, $\alpha < 1$, $\alpha > 1$

Study I

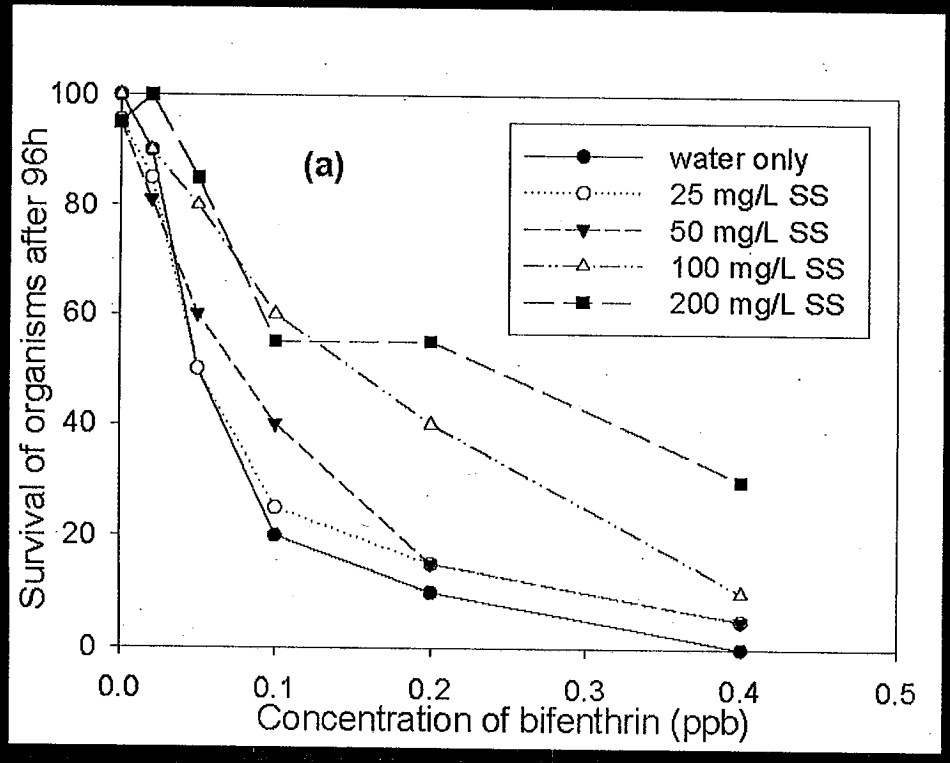
- LC50 in surface water with suspended solids
  - 4 sediments
  - Washed and unwashed
  - Bifenthrin, permethrin, cypermethrin, esfenvalerate
  - *C. dubia* 96-h static tests
  - Supelco SPME at specific time points
  - LC50, C_w

Sediment Properties

Sediment	pH	OM(%)	C-Org(%)
San Diego Creek	7.9	0.87	0.50
Field Furrow	7.7	4.22	2.45
Salinas River	7.9	0.13	0.07
Miles Creek	5.6	2.35	1.36

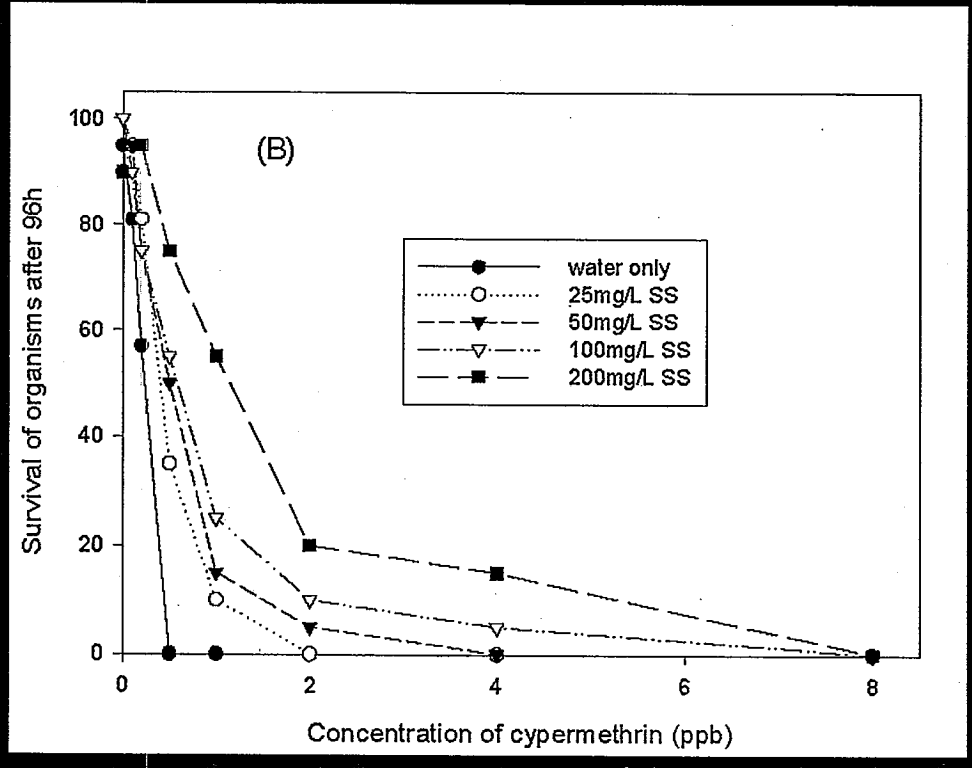
001996

Toxicity Curve
(Bifenthrin-SD Creek Sediment)



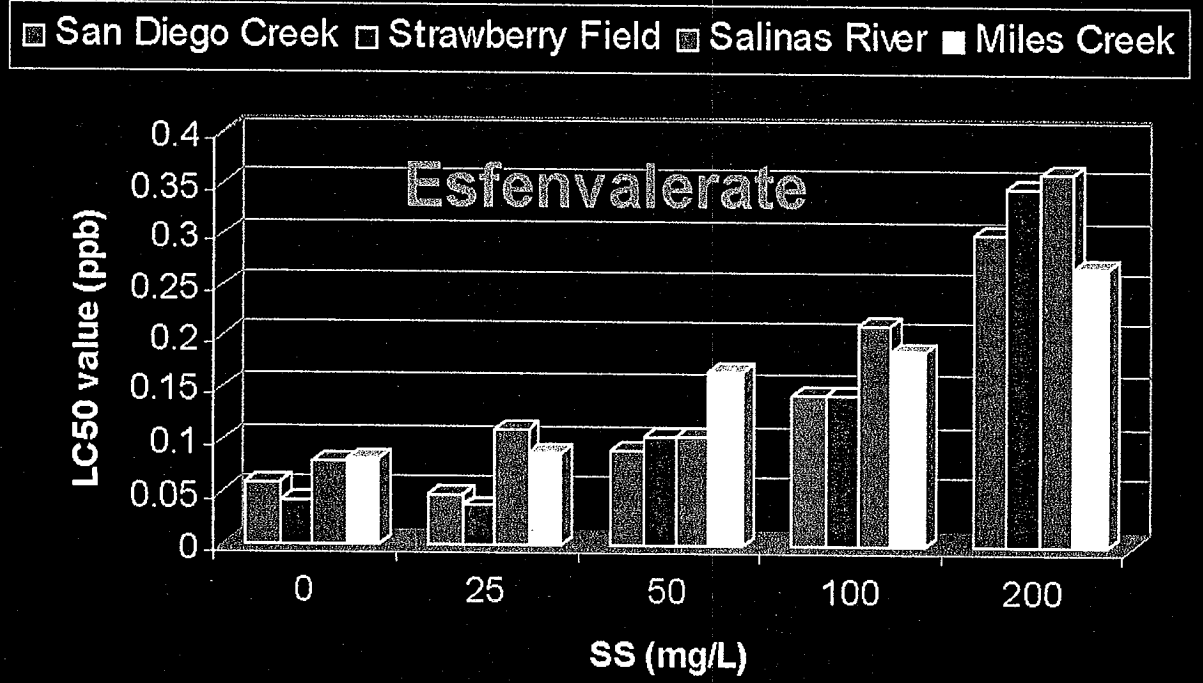
A011897

Toxicity Curve
(Cypermethrin-SD Creek Sediment)

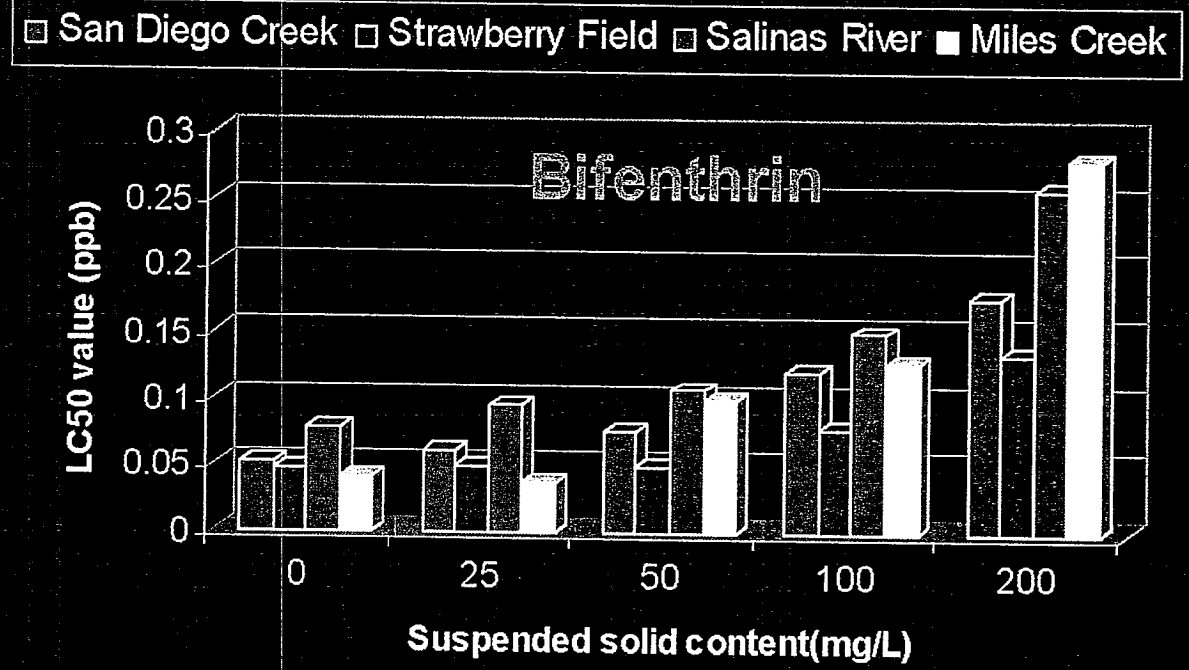


AQL1868

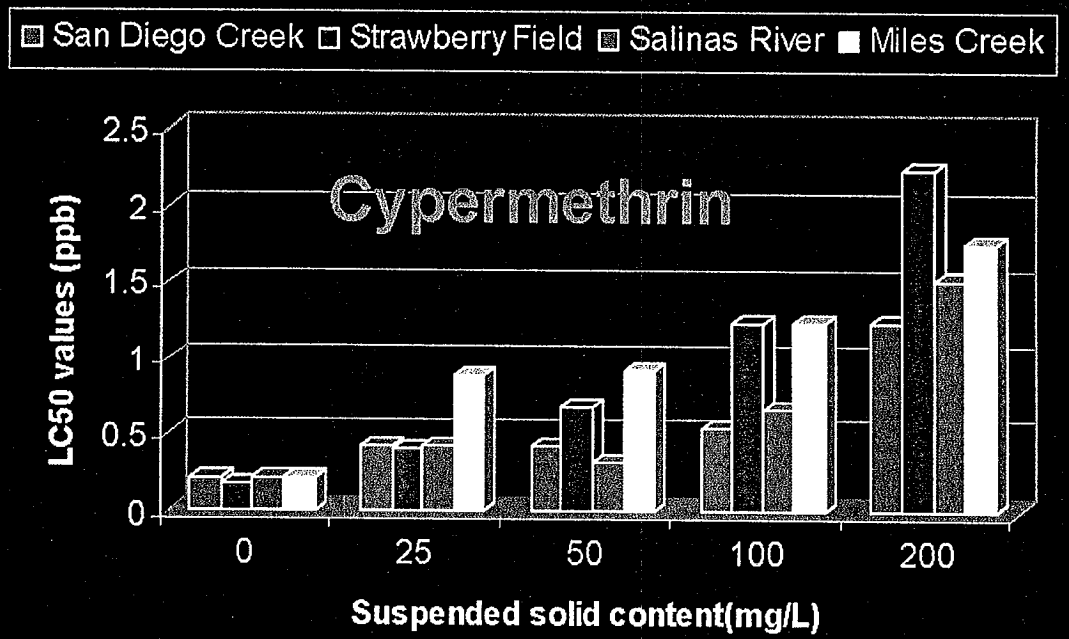
SS Effect on *C.dubia* toxicity



Effect of SS on *C.dubia* Toxicity



SS Effect on *C.dubia* toxicity



Bifenthrin LC50 (ppb)
(San Diego Creek)

SS Mg/L	Unwashed			Washed		
0	0.052±0.017	0.02	0.05	0.052±0.017	0.02	0.05
25	0.060±0.025	0.02	0.05	0.052±0.016	0.02	0.05
50	0.075±0.031	0.02	0.05	0.061±0.021	0.02	0.05
100	0.121±0.060	0.05	0.1	0.110±0.047	0.02	0.05
200	0.176±0.059	0.1	0.2	0.156±0.045	0.05	0.1

P01-1812

Bifenthrin LC50 (ppb)
(Field Furrow)

SS Mg/L	Unwashed			Washed		
	LC50	*NOEC*	*LOEC*	*LC50*		
0	0.048±0.020	0.05	0.1	0.048±0.020	0.05	0.1
25	0.051±0.018	0.05	0.1	0.040±0.011	0.01	0.02
50	0.049±0.015	0.02	0.05	0.048±0.016	0.02	0.05
100	0.077±0.025	0.05	0.1	0.061±0.025	0.05	0.1
200	0.133±0.042	0.1	0	0.113±0.036	0.05	0.1

AQUATIC 3

Bifenthrin LC50 (ppb)
(Salinas River)

SS Mg/L	unwashed			washed		
0	0.079±0.021	0.02	0.05	0.079±0.021	0.02	0.05
25	0.096±0.022	0.02	0.05	0.069±0.020	0.02	0.05
50	0.107±0.030	0.05	0.1	0.081±0.020	0.05	0.1
100	0.150±0.038	0.1	0.2	0.135±0.037	0.05	0.1
200	0.258±0.070	0.1	0.2	0.208±0.064	0.1	0.2

A01-1941

Bifenthrin LC50 (ppb)
(Miles Creek)

SS mg/L	unwashed			washed		
0	0.041±0.014	0.02	0.05	0.041±0.014	0.02	0.05
25	0.037±0.021	0.02	0.05	0.055±0.022	0.05	0.1
50	0.100±0.032	0.02	0.05	0.097±0.031	0.02	0.5
100	0.127±0.038	0.1	0.2	0.133±0.046	0.05	0.1
200	0.281±0.068	0.1	0.2	0.231±0.059	0.1	0.2

AQ1185

cis-Permethrin LC50 (ppb)
(San Diego Creek)

SS (mg/L)	unwashed			washed		
0	0.516±0.101	0.4	0.8	0.516±0.101	0.4	0.8
25	0.610±0.139	0.4	0.8	0.628±0.135	0.4	0.8
50	0.802±0.155	0.4	0.8	0.742±0.155	0.4	0.8
100	1.051±0.225	0.8	1.2	0.921±0.179	0.4	0.8

A21 1216

cis-Permethrin LC50 (ppb)
(Field Furrow)

SS Mg/L	unwashed			washed		
0	0.525±0.102	0.4	0.8	0.525±0.102	0.4	0.8
25	0.651±0.104	0.4	0.8	0.592±0.120	0.4	0.8
50	0.775±0.152	0.4	0.8	0.747±0.161	0.4	0.8
100	0.942±0.183	0.4	0.8	0.883±0.124	0.4	0.8

ABT 1997

cis-Permethrin LC50 (ppb)
(Salinas River)

SS Mg/L	unwashed			washed		
0	0.507±0.085	0.2	0.4	0.507±0.085	0.2	0.4
25	0.596±0.101	0.4	0.8	0.576±0.101	0.2	0.4
50	0.711±0.147	0.4	0.8	0.663±0.135	0.4	0.8
100	0.883±0.188	0.4	0.8	0.830±0.182	0.4	0.8

CDFG 018

cis-Permethrin LC50 (ppb)
(Miles Creek)

SS Mg/L	unwashed			washed		
0	0.494±0.100	0.2	0.4	0.494±0.100	0.2	0.4
25	0.694±0.146	0.4	0.8	0.663±0.130	0.4	0.8
50	0.817±0.168	0.4	0.8	0.782±0.156	0.4	0.8
100	1.041±0.237	0.4	0.8	0.930±0.176	0.4	0.8

Page 1 of 9

Esfenvalerate LC50 (ppb)
(San Diego Creek)

SS (mg/L)	unwashed			washed		
0	0.059±0.027	0.05	0.1	0.059±0.027	0.05	0.1
25	0.049(a)	0.4	>0.4	0.079±0.037	0.05	0.1
50	0.092±0.028	0.02	0.05	0.066±0.028	0.02	0.05
100	0.144±0.075	0.05	0.1	0.104±0.051	0.05	0.1
200	0.302±0.137	0.2	0.4	0.295±0.100	0.2	0.4

CDFG 1626

Esfenvalerate LC50 (ppb)
(Field Furrow)

SS (mg/L)	unwashed			washed		
0	0.043±0.015	0.02	0.05	0.043±0.015	0.02	0.05
25	0.039±0.036	0.02	0.05	0.057±0.020	0.02	0.05
50	0.106±0.049	0.05	0.1	0.075±0.036	0.02	0.05
100	0.145±0.094	0.05	0.1	0.138±0.084	0.05	0.1
200	0.349±0.154	0.2	0.4	0.266±0.128	0.1	0.2

DRAFT 2/21/21

Esfenvalerate LC50 (ppb)
(Salinas River)

SS (mg/L)	unwashed			washed		
0	0.079±0.028	0.05	0.1	0.079±0.028	0.05	0.1
25	0.112±0.049	0.05	0.1	0.102±0.041	0.05	0.1
50	0.105±0.51	0.1	0.2	0.101±0.074	0.05	0.1
100	0.212±0.134	0.1	0.2	0.127±0.059	0.1	0.2
200	0.363±0.160	0.2	0.4	0.266±0.095	0.1	0.2

001822

Esfenvalerate LC50 (ppb)
(Miles Creek)

SS (mg/L)	unwashed			washed		
0	0.083±0.031	0.02	0.05	0.083±0.031	0.02	0.05
25	0.088±0.036	0.05	0.1	0.060±0.028	0.02	0.05
50	0.167±0.091	0.1	0.2	0.090±0.035	0.1	0.2
100	0.187±0.109	0.1	0.2	0.161±0.092	0.1	0.2
200	0.270±0.080	0.1	0.2	0.239±0.132	0.1	0.2

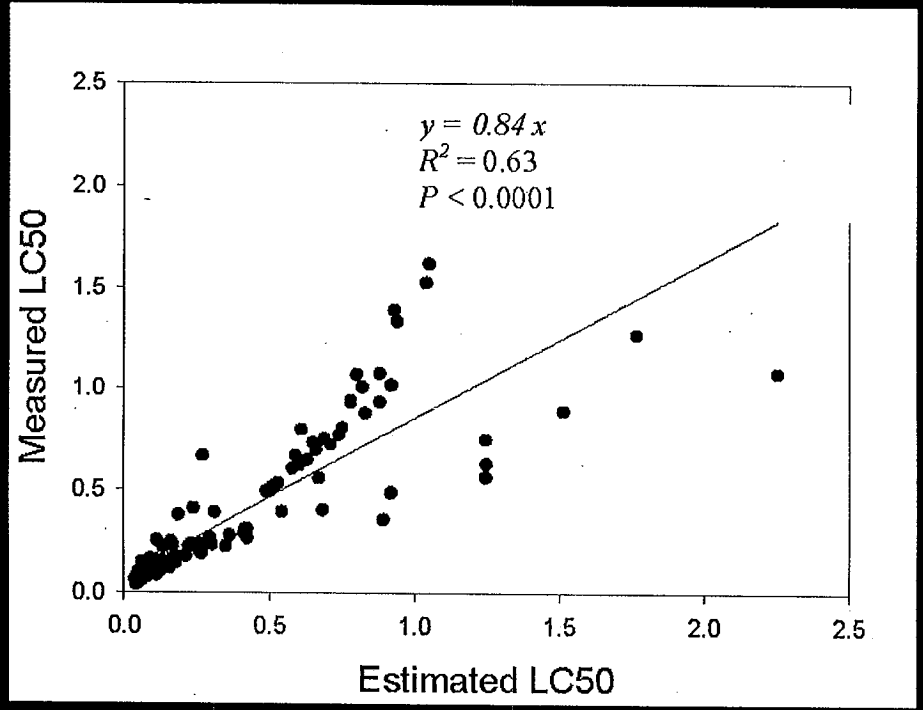
EPA 0223

Bifenthrin Kd
(Unwashed Sediments)

Compound	San Diego Creek ($\times 10^4$)	Field furrow ($\times 10^4$)	Salinas River ($\times 10^4$)	Miles Creek ($\times 10^4$)
Bifenthrin	0.86±0.07	1.54±0.17	0.81±0.38	2.44±0.51
Esfenvalerate	1.62±0.38	2.23±0.84	1.03±0.15	2.53±0.56
cis-Permethrin	2.27±0.73	1.71±0.37	0.61±0.26	1.77±0.49
Cypermethrin	0.96±0.11	2.75±0.73	1.53±0.30	2.90±0.88

EXHIBIT 69

LC50 Prediction
(All combined)



AR91-1825

$\alpha \approx 1$?

- Mean 1.07 ($\pm$0.35) (95% CI)
- 0.28 to 2.39

- Variation likely inherent of biological tests
- $\alpha \approx 1 \Rightarrow$ Adsorbed fraction not available
- $\alpha > 1$:
  - Antagonism?
  - Matrix effect

- Prediction:
  - With a factor of 2 (95% CI)

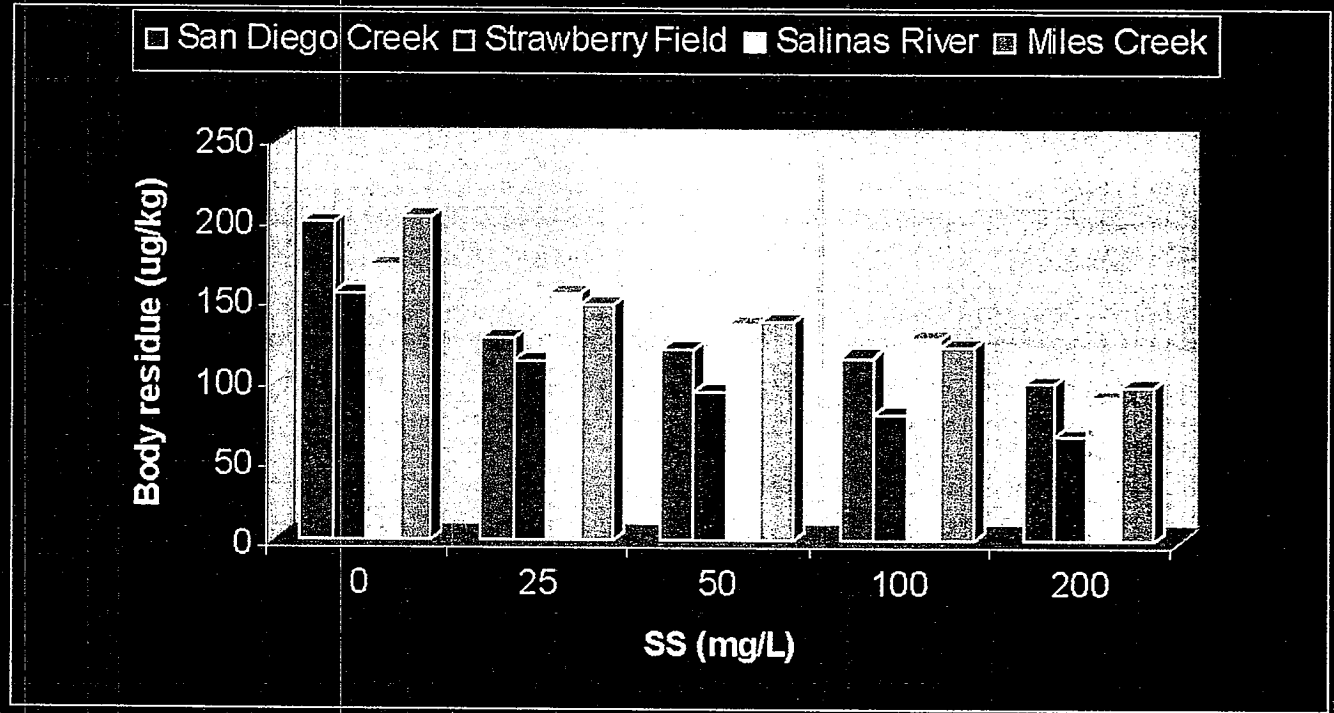
926 T01

Study II

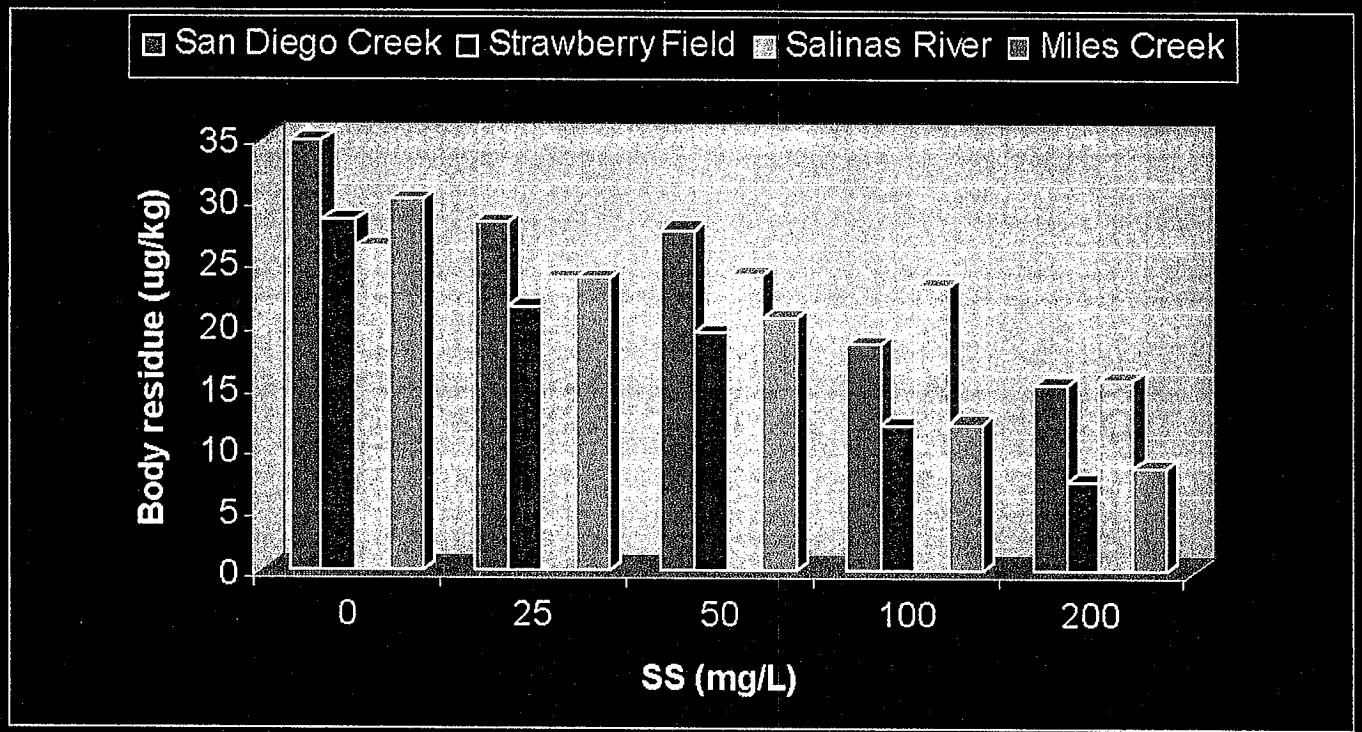
- Bioaccumulation in surface water with suspended solids
  - 4 sediments
  - Washed and unwashed
  - *D. magna* 24-h static tests
  - ^{14}C-permethrin and ^{14}C-bifenthrin
  - Simultaneous PDMS fibers
  - Body residue, C_{PDMS}, BAF

ADR 4627

Bioaccumulation of ^{14}C-Bifenthrin (unwashed sediments)

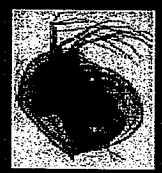


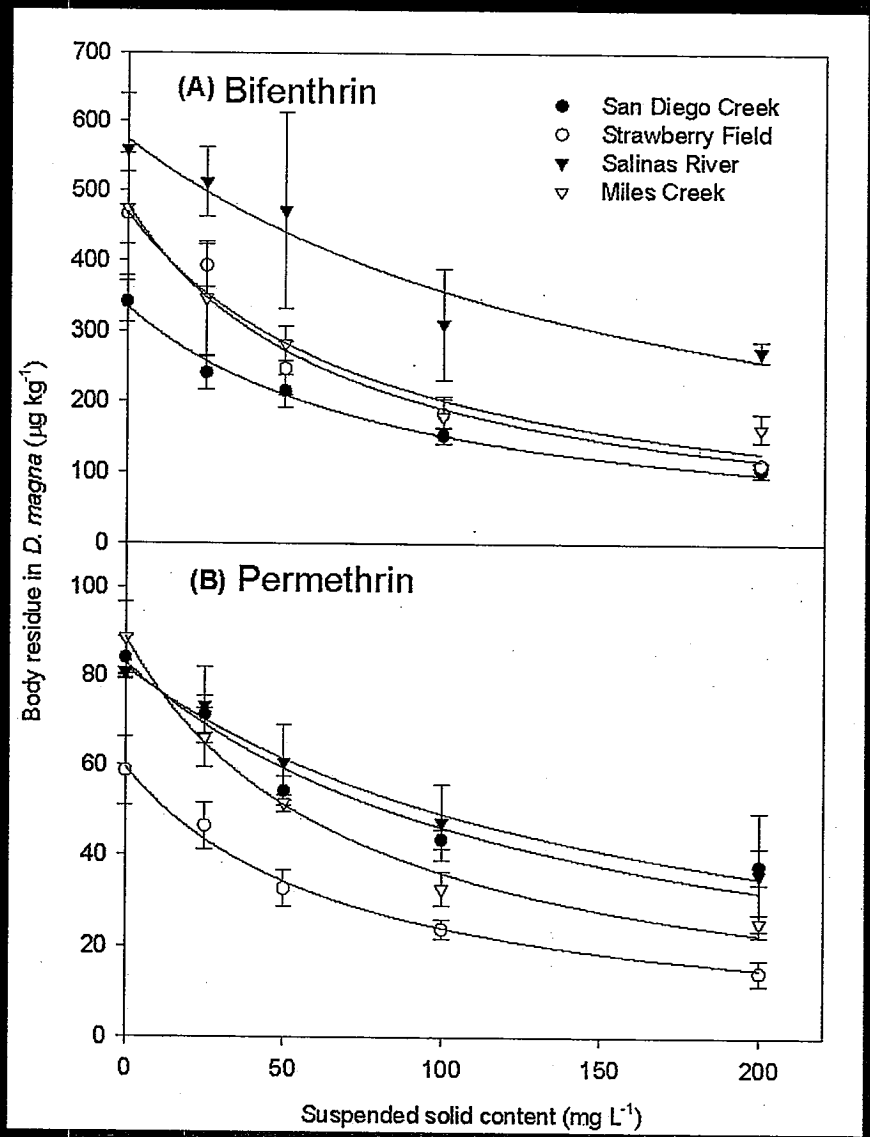
Bioaccumulation of ^{14}C-Permethrin (unwashed sediments)



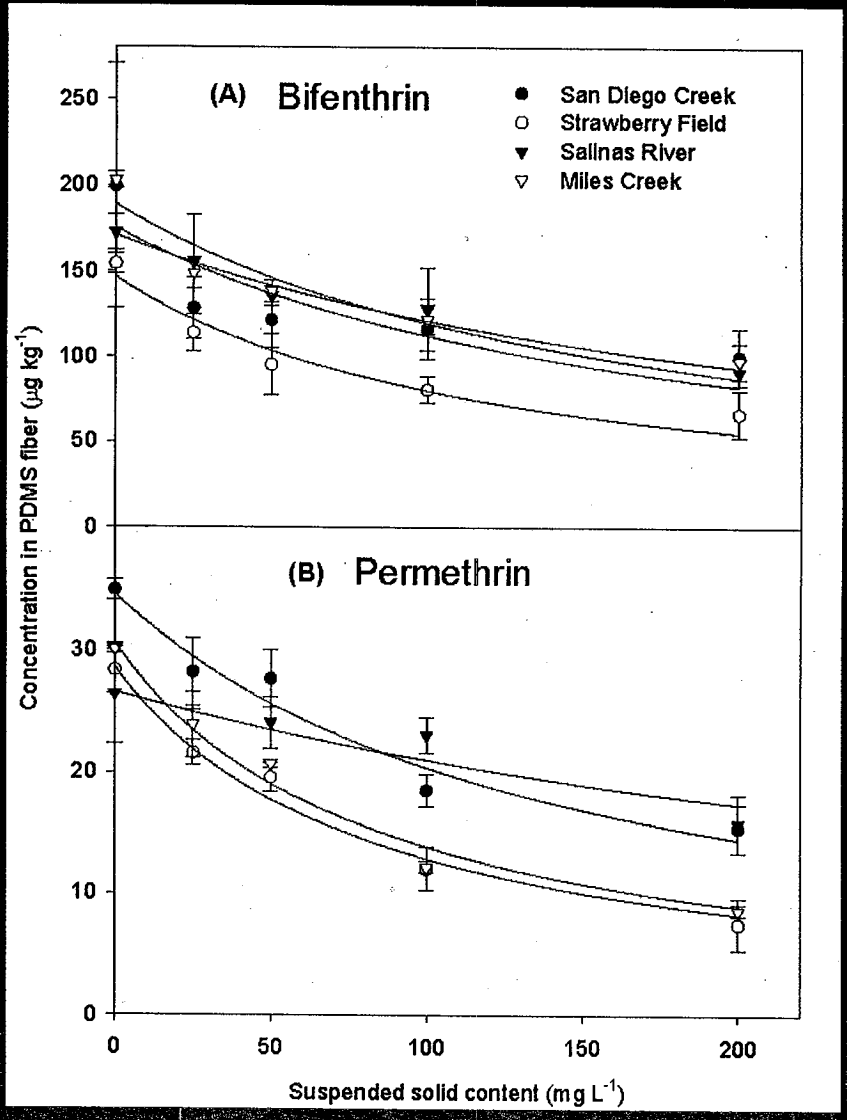
A01829

Bioaccumulation in *D. magna*



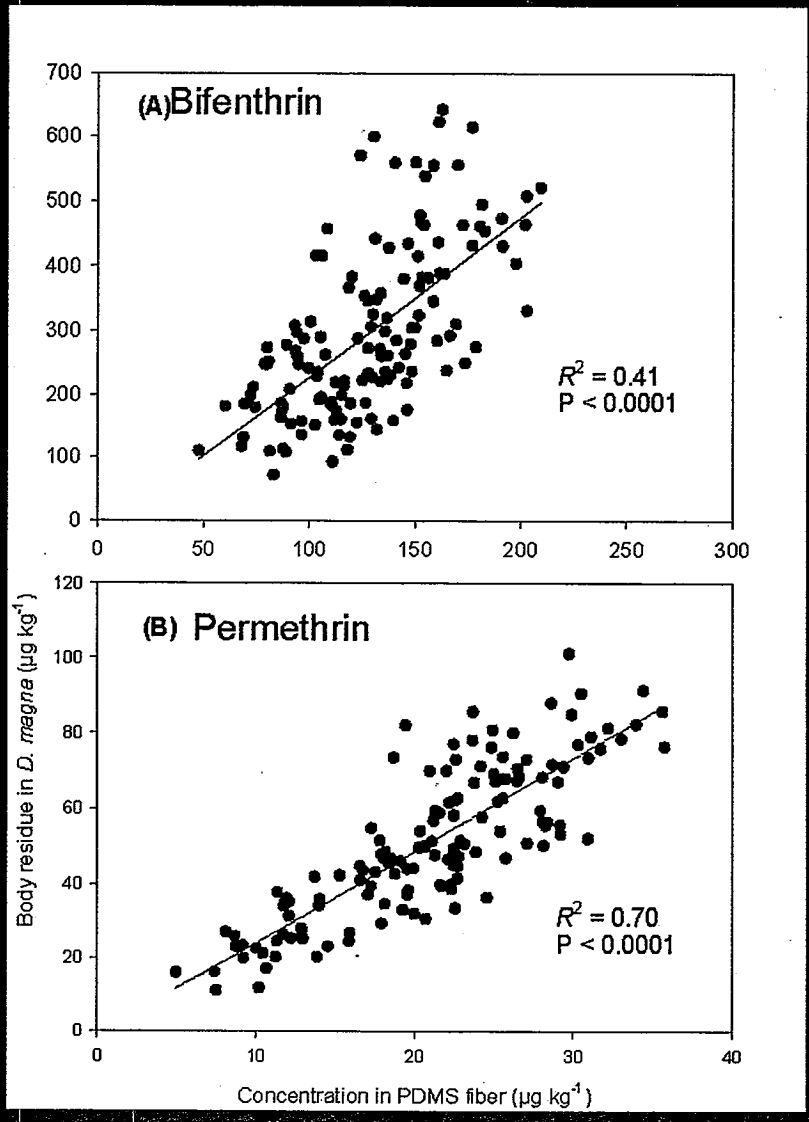


Accumulation in PDMS fibers



A911831

Correlation between *BR* and C_{PDMS}



AQ1 1832

K_d Estimated from BAF and PDMS

Bifenthrin				
Source sediment	Unwashed ($\times 10^3$)		Washed ($\times 10^3$)	
	PDMS	BAF	PDMS	BAF
San Diego Creek	5.7±2.2	12.4±1.2	4.2±1.5	6.5±1.0
Field furrow	7.1±1.5	15.1±2.2	4.0±1.2	9.0±1.8
Salinas River	4.5±1.0	6.1±1.5	1.4±0.5	5.6±1.4
Miles Creek	5.8±0.8	13.1±2.1	7.9±1.1	7.1±1.9

Permethrin				
Source sediment	Unwashed ($\times 10^3$)		Washed ($\times 10^3$)	
	PDMS	BAF	PDMS	BAF
San Diego Creek	7.0±0.8	7.4±1.0	4.9±0.2	4.9±0.8
Field furrow	12.3±1.2	15.0±1.7	9.7±0.8	10.1±1.6
Salinas River	2.7±0.6	5.9±1.2	1.8±0.6	5.5±1.3
Miles Creek	12.2±1.0	14.8±1.4	7.8±0.3	12.5±1.9

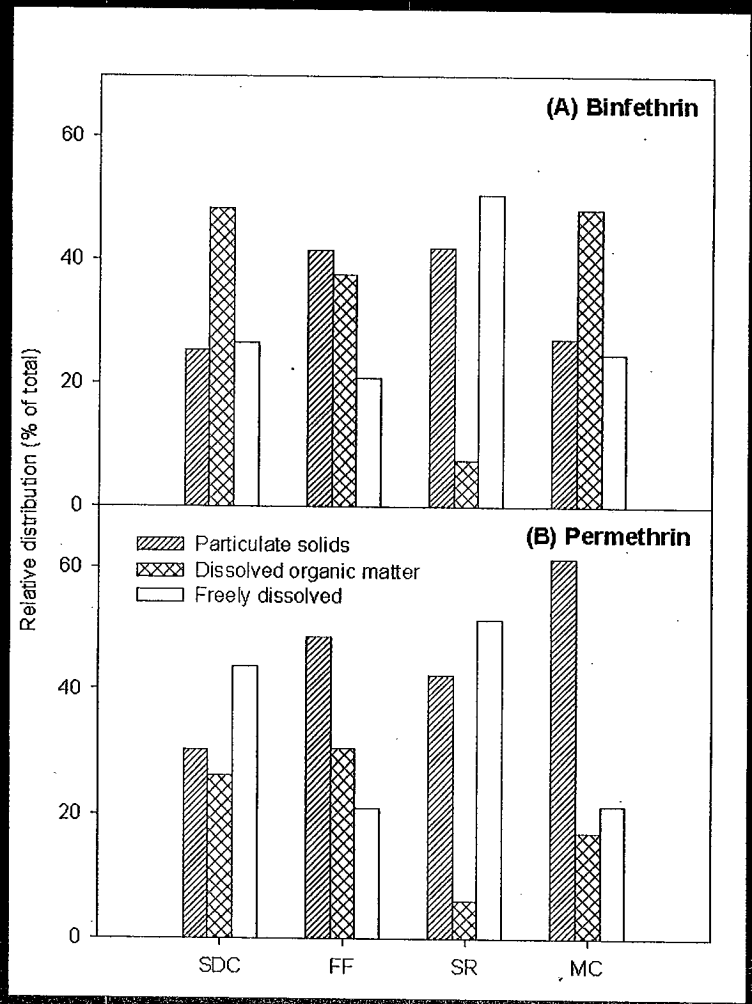
AG1833

Partition Coefficients

Source sediment	Bifenthrin			Permethrin		
	K_P ($\times 10^3$)	K_{DOC} ($\times 10^5$)	K_{POC} ($\times 10^5$)	K_P ($\times 10^3$)	K_{DOC} ($\times 10^5$)	K_{POC} ($\times 10^5$)
SDC	4.28±1.08	1.63±0.22	2.95±0.74	3.96±0.88	0.69±0.18	2.73±0.61
FF	7.92±1.67	1.57±0.36	3.34±0.70	9.23±1.37	1.26±0.30	3.89±0.58
SR	5.16±1.93	0.68±1.38	3.02±1.13	5.15±1.66	0.54±1.20	3.01±0.97
MC	4.75±1.97	2.16±0.51	2.35±0.98	11.60±1.64	0.83±0.42	5.74±0.81

HQ 1831

Relative Phase Distribution



5687 1835 A91

$\alpha \approx 1$?

- $\alpha \approx 1$ (8 of 16)
- $\alpha > 1$ (8 of 16)

- Variation likely inherent of biological tests
- $\alpha \approx 1$ ⇨ Adsorbed fraction not available
- $\alpha > 1$:
  - Antagonistic effect
  - Matrix effect

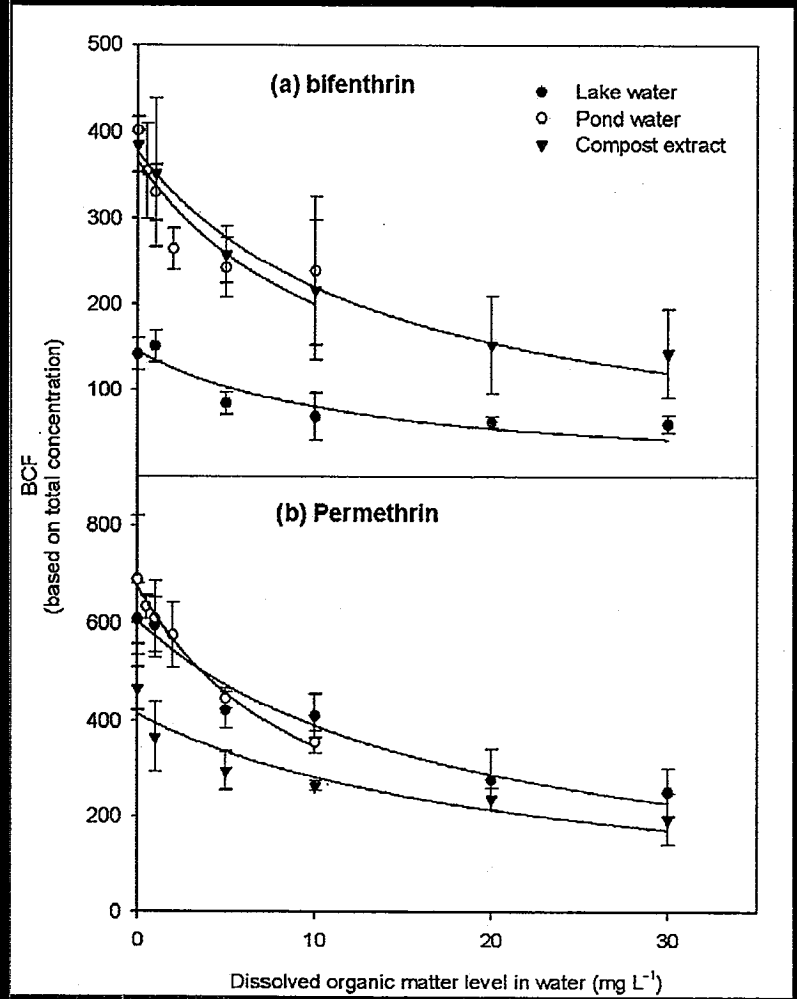
- Prediction:
  - Excellent predictions
  - Bifenthrin: $BR = 2.40\ (\pm 0.24) * C_{PDMS}$
  - Permethrin: $BR = 2.47\ (\pm 0.14) * C_{PDMS}$

9681 TOL

Study III

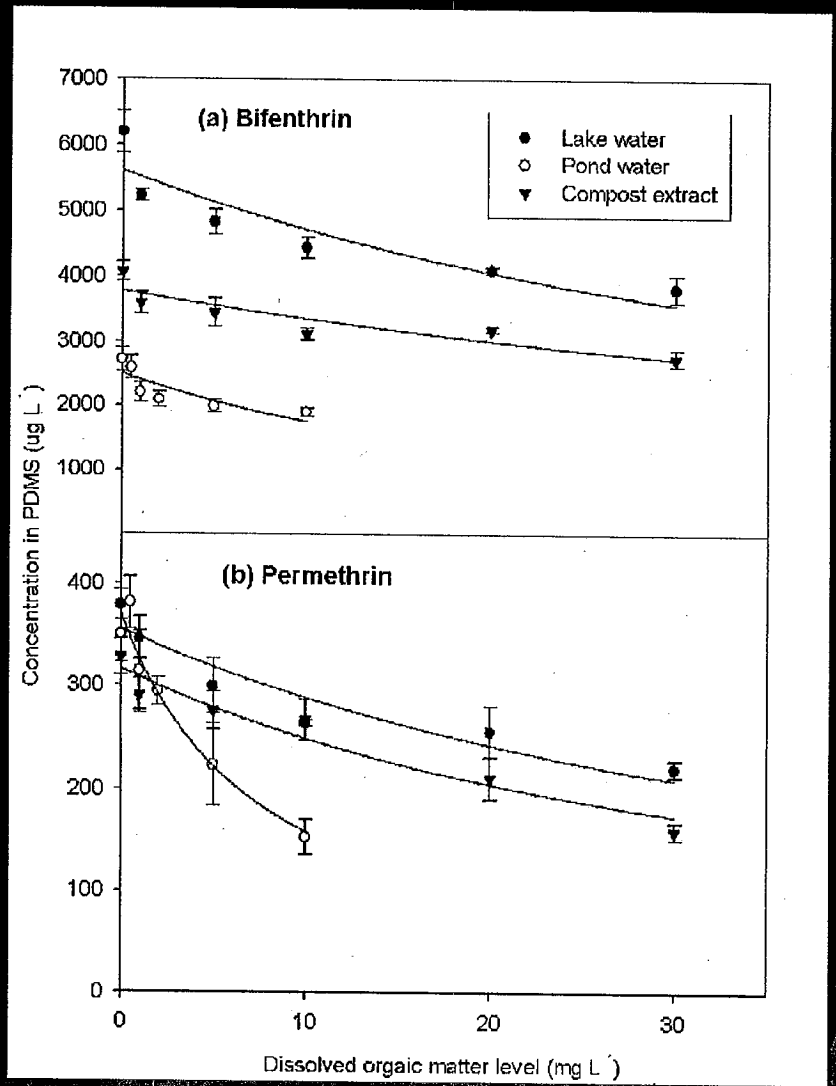
- Bioaccumulation and LC50 in surface water with DOM
  - 3 source waters with DOM
  - Filter through 0.45 µm
  - *D. magna* 24-h tests for bioaccumulation
  - ^{14}C-permethrin and ^{14}C-bifenthrin
  - Simultaneous PDMS fibers
  - Body residue, C_{PDMS}, BAF
  - LC50 for *C. dubia*

Effect of DOM on Bioaccumulation in *D. Magna*



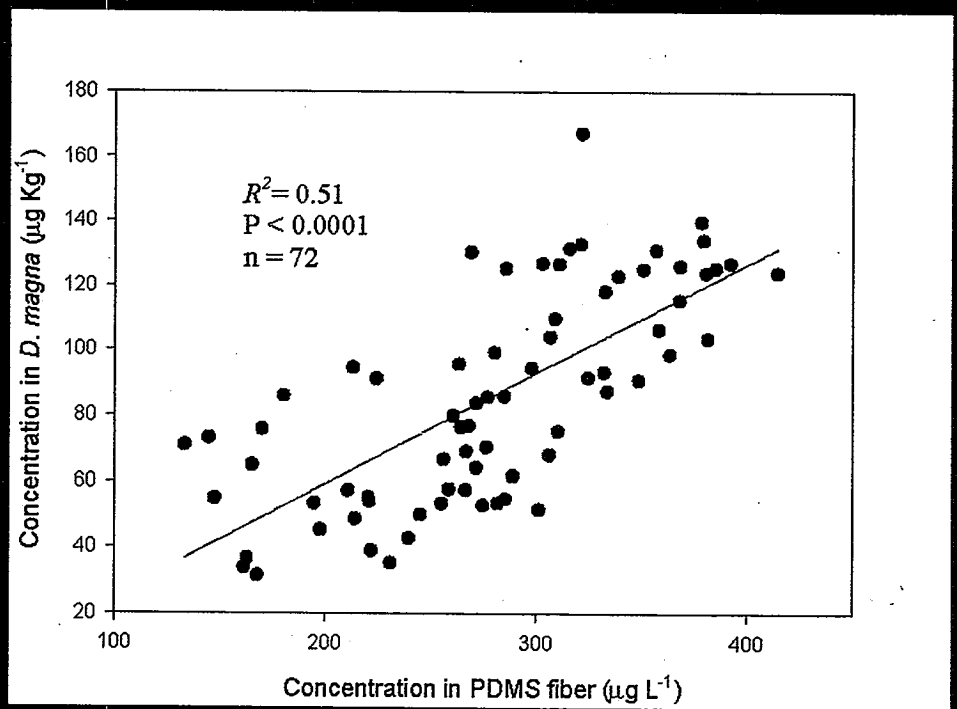
A07 1838

Effect of DOM on Accumulation in PDMS Fibers

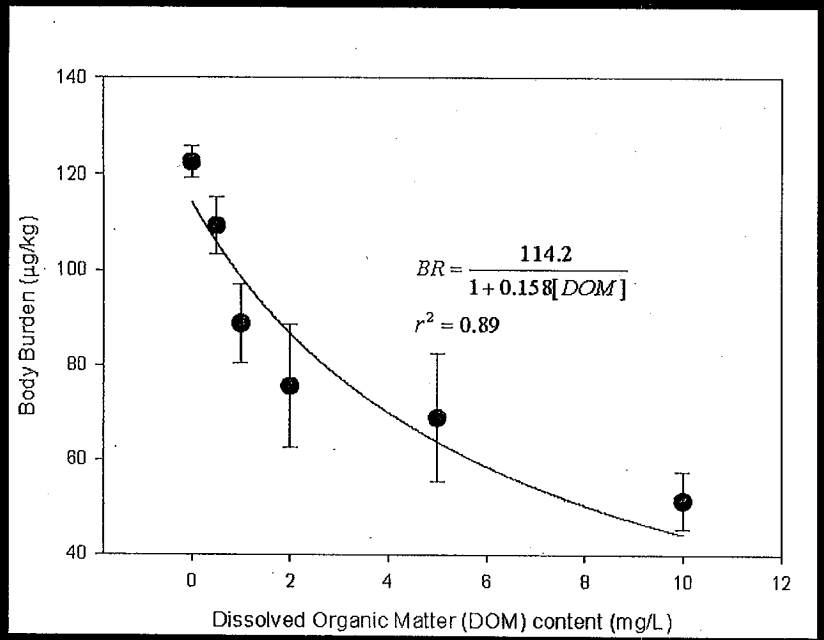


HQ1839

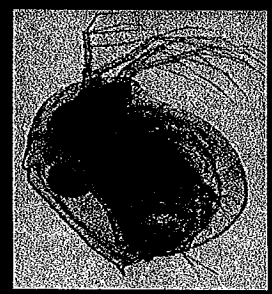
Correlation between *BR* and C_{PDMS} (Permethrin)



Bioavailability vs. DOM level (Permethrin)

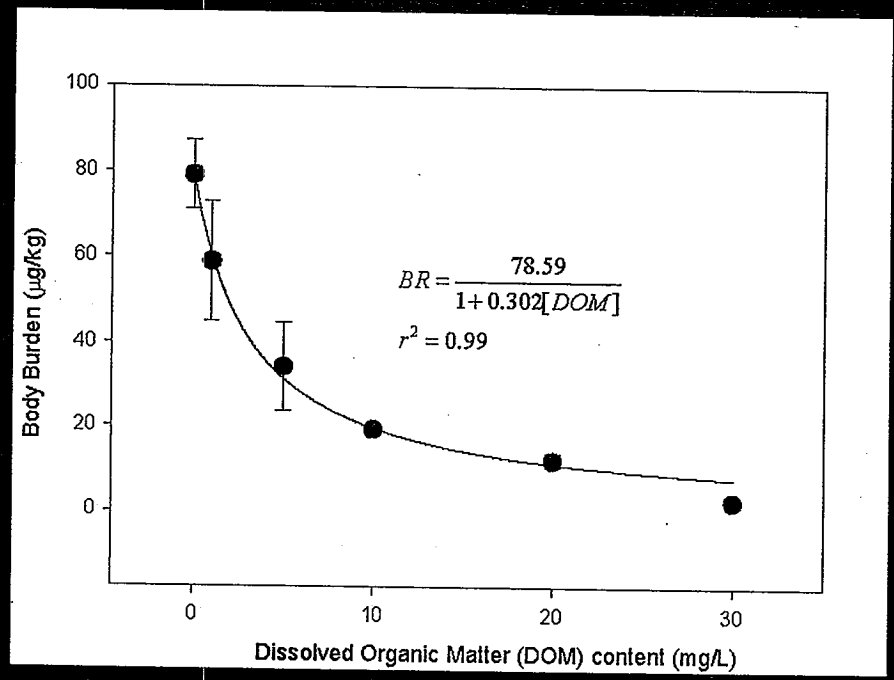


Garden Pond

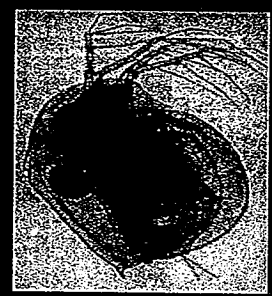


ARCHIVE

Bioavailability vs. DOM level (Permethrin)



Lake Elsinore

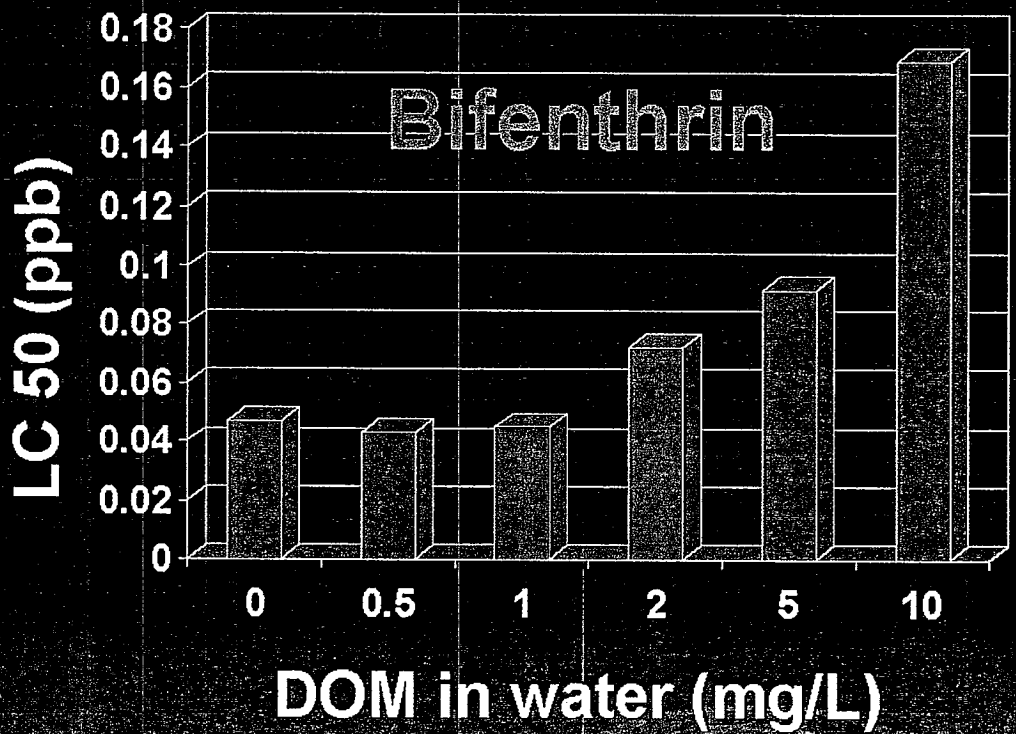


AQ1 1842

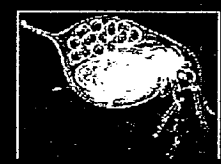
Estimated K_{DOC} Values

DOM source	PDMS ($\times 10^4$)	BCF ($\times 10^4$)	LC50 ($\times 10^4$)
		Bifenthrin	
Lake water	6.54 ± 1.86	8.05 ± 2.72	14.9 ± 1.51
Pond water	9.04 ± 1.96	8.32 ± 3.17	18.2 ± 2.14
Compost extract	4.61 ± 1.86	6.13 ± 0.88	4.1 ± 0.6
		Permethrin	
Lake water	4.74 ± 2.84	5.52 ± 0.89	3.4 ± 0.5
Pond water	11.21 ± 1.38	9.51 ± 0.66	9.2 ± 0.7
Compost extract	3.10 ± 0.69	4.69 ± 1.39	3.1 ± 0.3

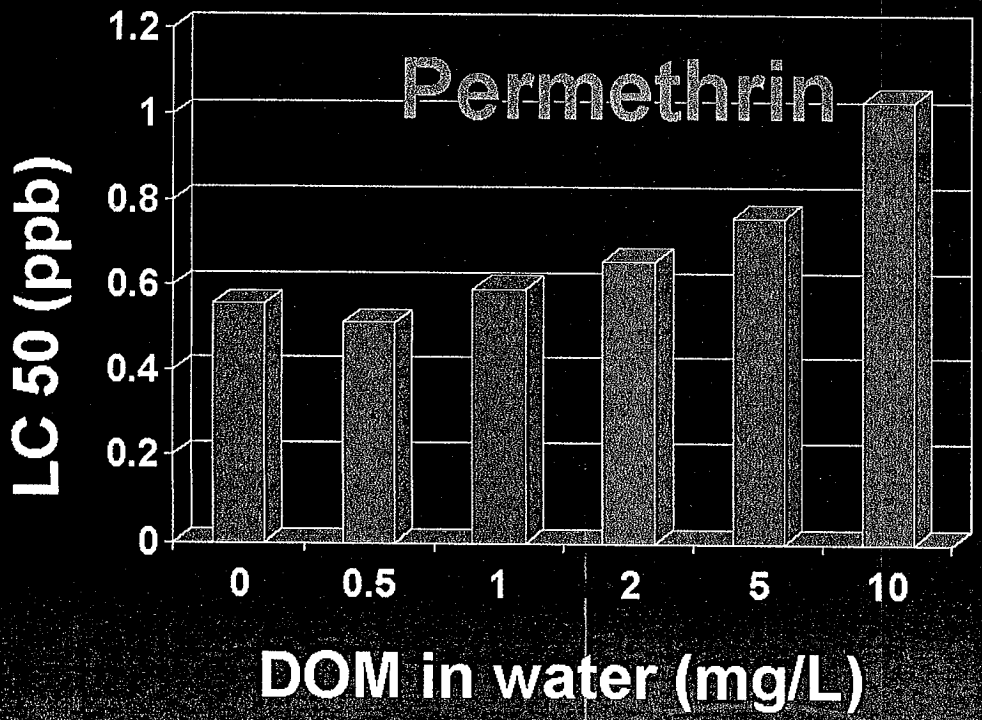
DOM Effect on Toxicity
(*C. dubia* LC50 (ppb))



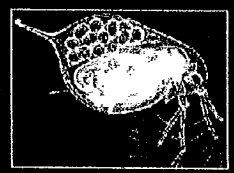
Garden Pond



DOM Effect on Toxicity
(*C. dubia* LC50 (ppb))



Garden Pond



Effect of DOM on LC50 to *C. dubia*

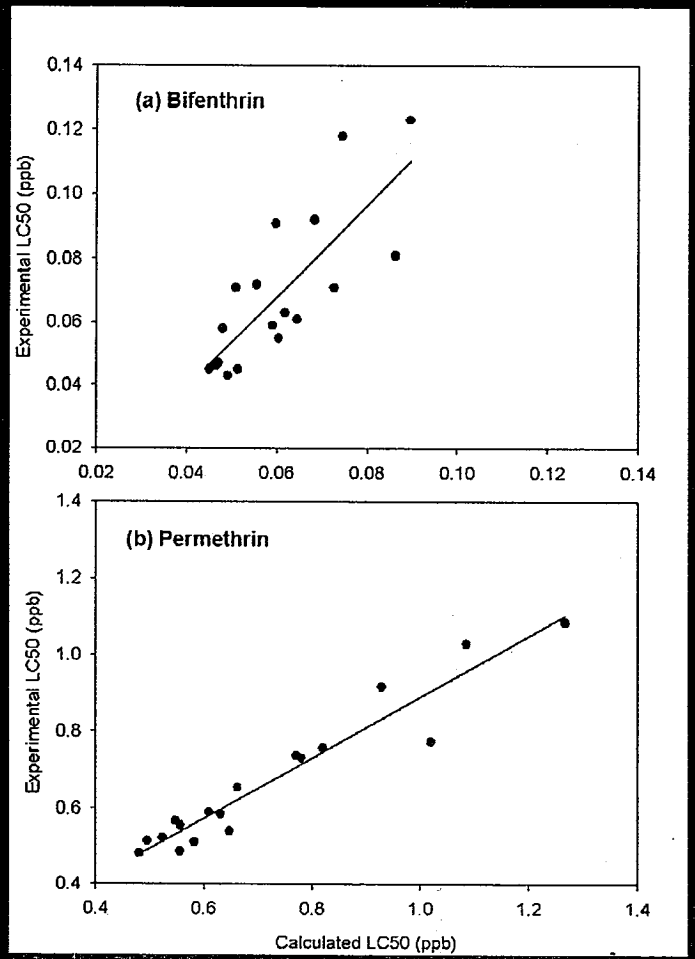
DOC (mg L^{-1})	Bifenthrin	DOC (mg L^{-1})	Permethrin
Lake water			
0	0.045 (0.032-0.059)	0	0.523 (0.384-0.645)
0.5	0.046 (0.030-0.063)	1	0.567 (0.423-0.687)
1	0.058 (0.039-0.077)	5	0.540 (0.434-0.657)
2	0.071 (0.051-0.092)*	10	0.739 (0.568-0.947)
5	0.091 (0.055-0.127)*	20	0.776 (0.626-0.952)*
10	0.118 (0.086-0.153)*	30	1.085 (0.805-1.391)*
Pond water			
0	0.047 (0.033-0.061)	0	0.556 (0.409-0.677)
0.5	0.043 (0.028-0.059)	0.5	0.512 (0.382-0.622)
1	0.045 (0.028-0.064)	1	0.591 (0.478-0.719)
2	0.072 (0.052-0.095)	2	0.656 (0.490-0.813)
5	0.092 (0.066-0.126)*	5	0.760 (0.565-0.954)*
10	0.123 (0.081-0.169)*	10	1.030 (0.808-1.318)*
Compost extract			
0	0.059 (0.045-0.076)	0	0.481 (0.389-0.583)
0.5	0.055 (0.034-0.075)	1	0.515 (0.391-0.629)
1	0.063 (0.044-0.084)	5	0.487 (0.388-0.597)
2	0.061 (0.046-0.079)	10	0.586 (0.423-0.738)
5	0.071 (0.052-0.092)	20	0.734 (0.520-0.903)*
10	0.081 (0.059-0.107)	30	0.919 (0.706-1.190)*

CDN1916

Estimated K_{DOC} Values

DOM source	PDMS ($\times 10^4$)	BCF ($\times 10^4$)	LC50 ($\times 10^4$)
		Bifenthrin	
Lake water	6.54 ± 1.86	8.05 ± 2.72	14.9 ± 1.51
Pond water	9.04 ± 1.96	8.32 ± 3.17	18.2 ± 2.14
Compost extract	4.61 ± 1.86	6.13 ± 0.88	4.1 ± 0.6
		Permethrin	
Lake water	4.74 ± 2.84	5.52 ± 0.89	3.4 ± 0.5
Pond water	11.21 ± 1.38	9.51 ± 0.66	9.2 ± 0.7
Compost extract	3.10 ± 0.69	4.69 ± 1.39	3.1 ± 0.3

Predicted and Measured LC50 for *C. dubia*



CA1848

$\alpha \approx 1$?

- BAF: $\alpha \approx 1$ (6 of 6)
- LC50: $\alpha \approx 1$ (4 of 6); $\alpha > 1$ (2 of 6)

- Variation likely inherent of biological tests
- $\alpha \approx 1$ ⇨ Adsorbed fraction not available

- Prediction:
  - BAF:
    - *Bifenthrin:* R^2 = 0.47-0.62; P < 0.001
    - Permethrin: R^2 = 0.50-0.75; P < 0.0001
  - LC50:
    - Bifenthrin: R^2 = 0.93 – 0.96; P < 0.005
    - Permethrin: R^2 = 0.92 – 0.98; P < 0.005
    - Both: R^2 = 0.62; P < 0.001

CDFG 1915

Study IV

- Bioaccumulation in surface water with DOM
  - ~17 surface waters with DOM
  - *D. magna* 24-h static tests
  - *C. dubia* LC50 tests
    - C-permethrin and C-cyfluthrin
  - Simultaneous PDMS fibers
  - Characterization of aquatic DOM:
    - UV absorbance to determine E4/E6
    - UV absorbance at 254 and 280 nm to determine aromaticity
    - Fluorescence to determine aromaticity
    - Titration to determine total and aromatic acids

001856

17 "Natural" Surface Water Samples

Water samples	pH	Alkalinity ($mg\ L^{-1}$)	Hardness ($mg\ L^{-1}$)	Ammonia ($mg\ L^{-1}$)	Cl^- ($mg\ L^{-1}$)	DOC ($mg\ L^{-1}$)
SJI	7.30	323	303	0.07	<0.2	20.2 ± 2.6
SDC	6.87	318	>1000	<0.02	<0.2	7.8 ± 0.3
EL	6.85	180	200	<0.02	<0.2	3.6 ± 0.2
BL	7.36	118	162	<0.02	<0.2	4.5 ± 0.1
FL	7.76	204	223	<0.02	<0.2	3.3 ± 0.9
PC	7.02	361	>1000	<0.02	<0.2	7.0 ± 0.3
SDI	7.14	317	>1000	0.02	<0.2	5.5 ± 0.8
SJ	7.75	470	>1000	<0.02	<0.2	18.1 ± 0.4
GC	7.48	215	242	<0.02	<0.2	1.2 ± 0.1
SAR	7.70	230	270	<0.02	<0.2	3.4 ± 0.4
SY	7.24	269	365	<0.02	<0.2	4.4 ± 0.1
BG	6.95	235	308	<0.02	<0.2	5.8 ± 0.9
SC	7.05	470	>1000	<0.02	<0.2	5.9 ± 0.1
SA	7.73	130	440	<0.02	<0.2	5.3 ± 0.9
LE	7.29	223	200	<0.02	<0.2	18.9 ± 0.1
RJ	6.67	304	302	<0.02	<0.2	5.5 ± 1.1
TC	6.85	198	220	<0.02	<0.2	4.6 ± 1.5

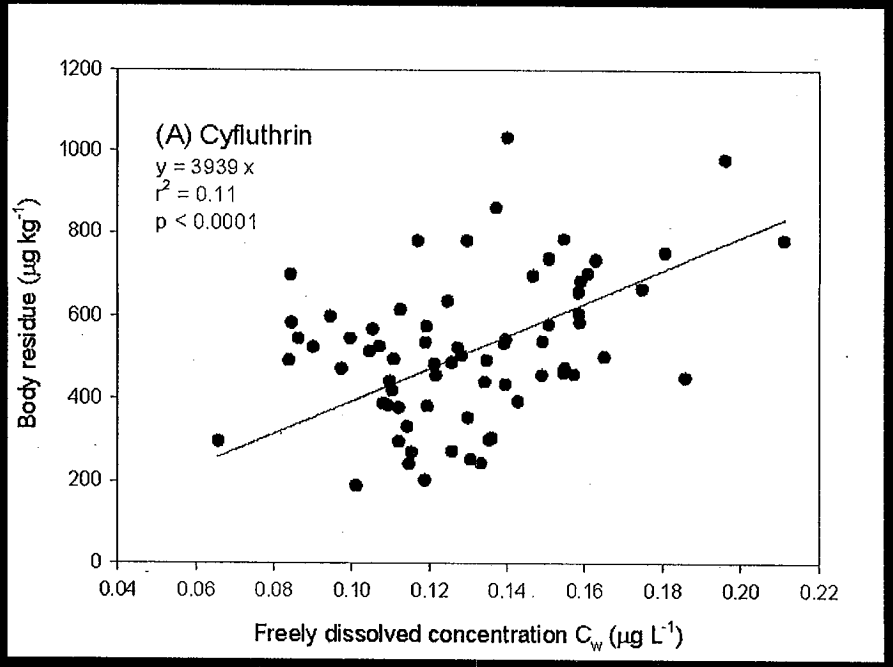
AR1-1954

Measured Free Concentration (ng/L)

Water samples	Permethrin	Cyfluthrin
Control	97 ± 9	182 ± 26
SJI	73 ± 4	80 ± 10
SDC	75 ± 5	139 ± 22
EL	76 ± 6	166 ± 15
BL	82 ± 4	138 ± 23
FL	88 ± 8	158 ± 20
PC	84 ± 10	97 ± 6
SDI	87 ± 9	125 ± 15
SJ	64 ± 8	122 ± 10
GC	79 ± 12	121 ± 18
SAR	78 ± 20	126 ± 10
SY	101 ± 11	131 ± 15
BG	99 ± 6	116 ± 11
SC	101 ± 14	116 ± 23
SA	97 ± 5	154 ± 10
LE	91 ± 5	118 ± 13
RI	96 ± 5	128 ± 16
TC	96 ± 3	126 ± 24

AQ1 1852

Correlation between *BR* and C_w (Cyfluthrin)



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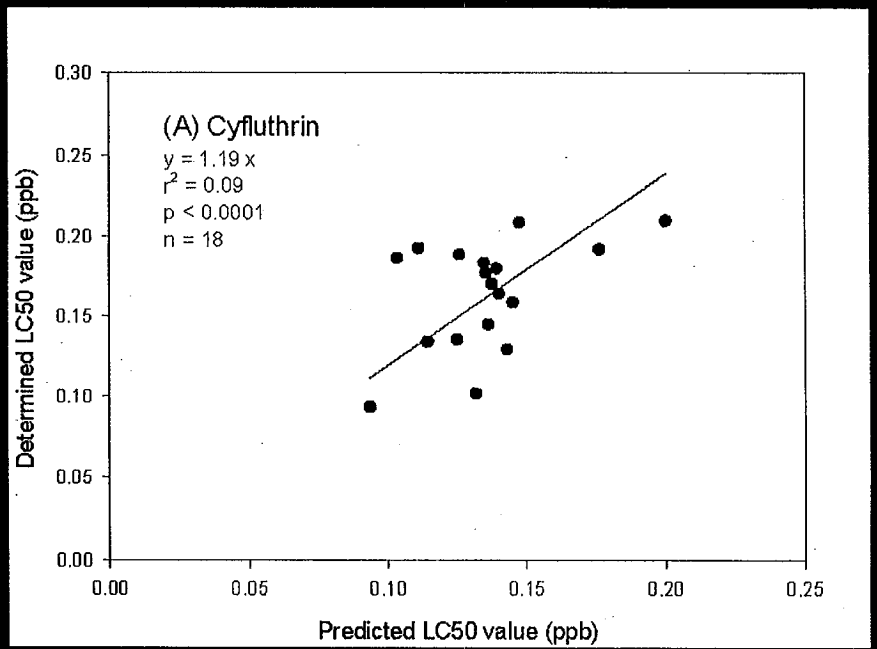
Measured LC50 Values (µg/L)

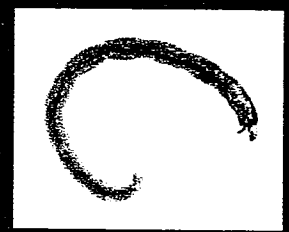
Water samples	*cis*-Permethrin	Cyfluthrin
Control	0.652 (0.484-0.856)*	0.093(0.050-0.146)
SIT	0.788(0.545-1.040)	0.210(0.154-0.288)*
SDC	0.622(0.427-0.824)	0.136(0.103-0.185)
EL	0.772(0.574-1.013)	0.187(0.138-0.271)*
BL	0.745(0.568-0.957)	0.189(0.112-0.292)*
FL	0.858(0.591-1.138)	0.134(0.097-0.194)*
PC	0.571(0.427-0.740)	0.192(0.126-0.279)*
SDI	0.580(0.407-0.718)	0.170(0.121-0.229)
SJ	0.299(0.212-0.385)*	0.164(0.113-0.231)*
GC	0.343(0.308-0.383)*	0.130(0.097-0.179)*
SAR	0.609(0.486-0.747)	0.145(0.105-0.185)*
SY	0.570(0.459-0.689)	0.102(0.027-0.395)*
BG	0.827(0.669-1.012)	0.209(0.144-0.298)
SC	0.585(0.677-0.793)	0.177(0.131-0.253)
SA	0.849(0.655-1.085)	0.193(0.142-0.283)*
LE	0.889(0.666-1.120)	0.159(0.105-0.234)
RI	0.865(0.672-1.098)	0.184(0.121-0.275)*
TC	0.996(0.764-1.286)*	0.180(0.127-0.280)*

Predicted and Measured LC50 for *C. dubia* (Cyfluthrin)

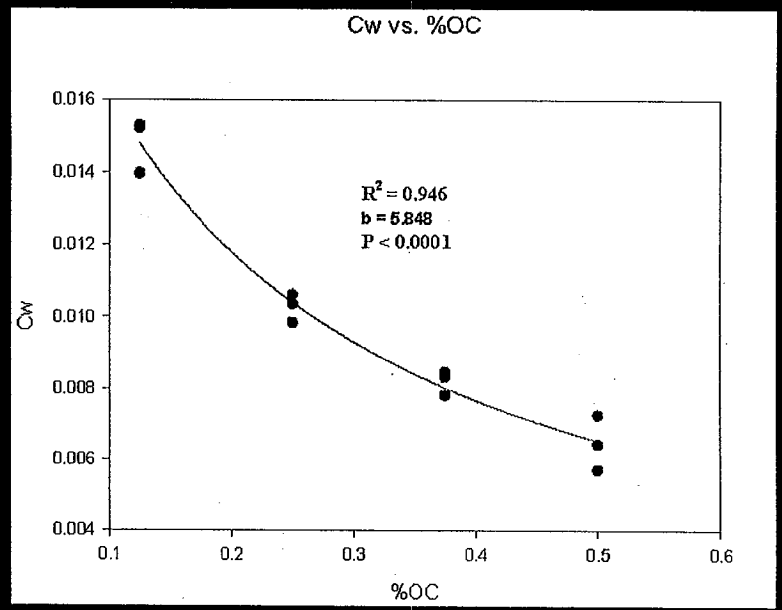


Sediment

- **Just started…**
- **Pore-water:**
  - Method development
  - Phase distribution
  - Role of DOM
  - …
- **Study design**
  - Bioaccumulation (*C. tentans*)
  - Acute toxicity (*C. tentans, H. azteca)*
  - Aging effect

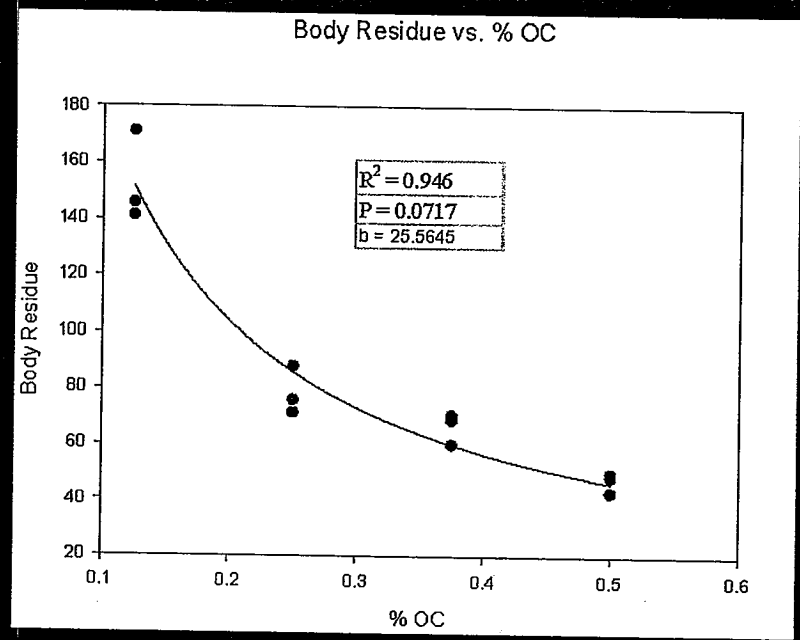


Pore-water "Free" Concentrations vs. Sediment OC%



ADL 1857

C. Tentan Body Residue (µg/kg) vs. Sediment OC%



$\alpha \approx 4$ (matrix effect? Not at equilibrium? …)

A01858

Future Directions

- Water column data
  - Possible to introduce a correction factor?
  - Possible to predict toxicity from C_{PDMS}?
  - Feasibility of using PDMS fibers for routine monitoring?
  - Feasibility for field deployment?
  - Other biomimetic samplers?
  - ...

$$LC_{50}^{*} = (1 + a[DOC])LC_{50}$$

$$LC_{50}^{*} = (1 + b[SS])LC_{50}$$

(GSD 1 of 1) 9/5/9

Future Directions

- Bioavailability in sediments
  - Matrix effect, method development
  - C Bioaccumulation by *C. tentans* and other benthic organisms
  - Correlation of *BR* and C_{PDMS}
  - LC50 of *C. tentans* and H. azteca
  - Correlation of LC50 with C_{PDMS}
  - Effect of sediment OC%
  - Effect of properties of sediment OM
  - Effect of aging
  - Prediction models
- Fibers to measure non-labeled porewater Cw
- Evaluation of field sediment samples
- ...

CA1368

Permethrin, Resmethrin, Sumithrin: Synthetic Pyrethroids For Mosquito Control

Updated: April 17, 2002

Mosquito Life Cycle / Synthetic Pyrethroids / Resources

Questions on Pesticides?

- National Pesticide Information Center (NPIC)

1-800-858-7378

EXIT disclaimer

The Environmental Protection Agency (EPA) evaluates and registers (licenses) pesticides to ensure that they can be used safely. These pesticides include products used in the mosquito control programs that states and communities have established. To evaluate any pesticide, EPA assesses a wide variety of tests to determine whether a pesticide has the potential to cause adverse effects on humans, wildlife, fish and plants, including endangered species and non-target organisms.

Officials responsible for mosquito control programs make decisions to use pesticides based on an evaluation of the risks to the general public from diseases transmitted by mosquitoes or on an evaluation of the nuisance level that communities can tolerate from a mosquito infestation. Based on surveillance and monitoring, mosquito control officials select specific pesticides and other control measures that best suit local conditions in order to achieve effective control of mosquitoes with the least impact on human health and the environment. It is especially important to conduct effective mosquito prevention programs by eliminating breeding habitats or applying pesticides to control the early life stages of the mosquito. Prevention programs, such as elimination of any standing water that could serve as a breeding site, help reduce the adult mosquito population and the need to apply other pesticides for adult mosquito control. Since no pesticide can be considered 100 percent safe, pesticide applicators and the general public should always exercise care and follow specified safety precautions during use to reduce risks. This fact sheet provides basic information on larvicides, a type of pesticide used in mosquito control programs.

What is the Mosquito Life Cycle?

▲ TOP

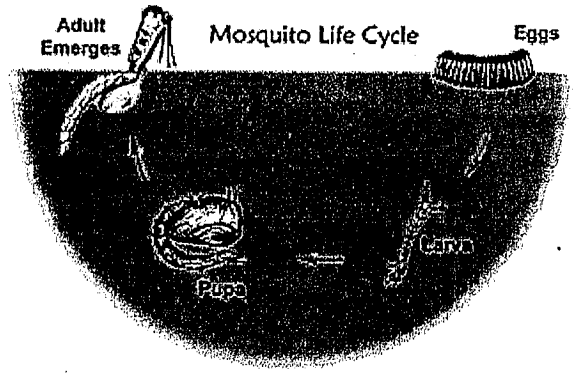
The mosquito goes through four distinct stages during its life cycle:

- **egg** - hatches when exposed to water;
- **larva** - (plural. - larvae) lives in the water; molts several times; most species surface to breathe air;
- **pupa** - (plural - pupae) does not feed; stage just prior to emerging as adult;

- **adult** - flies short time after emerging and after its body parts have hardened.

What are Synthetic Pyrethroids?

Pyrethroids are synthetic chemical insecticides that act in a similar manner to pyrethrins, which are derived from chrysanthemum flowers. Pyrethroids are widely used for controlling various insects. **Permethrin, resmethrin,** and **sumithrin** are synthetic pyrethroids commonly used in mosquito control programs to kill **adult mosquitoes.**



Leon County Mosquito Control, Tallahassee, FL

- **Permethrin** has been registered by EPA since 1977. It is currently registered and sold in a number of products such as household insect foggers and sprays, tick and flea sprays for yards, flea dips and sprays for cats and dogs, termite treatments, agricultural and livestock products, and mosquito abatement products.
- **Resmethrin** has been registered by EPA since 1971 and is used to control flying and crawling insects in the home, lawn, garden, and industrial sites. It can also be used to control insects on ornamental plants (outdoor and greenhouse use), on pets and horses, and as a mosquitocide. Because of its toxicity to fish, resmethrin is a Restricted Use Pesticide (RUP) that is available for use only by certified pesticide applicators or persons under their direct supervision.
- **Sumithrin** has been registered by EPA since 1975 and is used to control adult mosquitoes and as an insecticide in transport vehicles such as aircraft, ships, railroad cars, and truck trailers. It is also used as an insecticide and miticide in commercial, industrial, and institutional nonfood areas, in homes and gardens, in greenhouses, and in pet quarters and on pets.

How are Synthetic Pyrethroids Used in Adult Mosquito Control?

Most pyrethroid mosquito control products can be applied only by public health officials and trained personnel of mosquito control districts. Mosquito control professionals apply pyrethroids as an ultra-low volume (ULV) spray. ULV sprayers dispense very fine aerosol droplets that stay aloft and kill adult mosquitoes on contact. Pyrethroids used in mosquito control are typically mixed with a synergist compound, such as piperonyl butoxide, which enhances the effectiveness of the active ingredient. The product is often diluted in water or oi and applied at rates less than 1/100th of a pound of active ingredient or less than 4 fluid ounces of mixed formulation per acre.

Do Pyrethroids Pose Risks to Human Health?

Pyrethroids can be used for public health mosquito control programs without posing unreasonable risks to human health when applied according to the label. Pyrethroids are considered to pose slight risks of acute toxicity to humans, but at high doses, pyrethroids can affect the nervous system.

Do Pyrethroids Pose Risks to Wildlife or the Environment?

Pyrethroids used in mosquito control programs do not pose unreasonable risks to wildlife or the environment. Pyrethroids, when applied at mosquito control rates, are low in toxicity to mammals, and are practically nontoxic to birds. Mosquito control formulations of permethrin break down in the environment, and high temperatures and sunlight accelerate this process. However, pyrethroids are toxic to fish and to bees. For that reason, EPA has established specific precautions on the label to reduce such risks, including restrictions that prohibit the direct application of products to open water or within 100 feet of lakes, streams, rivers or bays.

What is The Current Regulatory Status of Pyrethroids?

As part of its responsibility to reassess all pesticides registered before 1984, EPA has given highest priority to reviewing more acutely toxic pesticides such as organophosphates and carbamates. Organophosphates are currently under review. Comprehensive reviews of the synthetic pyrethroids are scheduled for approximately 2004.

Where Can I Get More Information About Synthetic Pyrethroids and Mosquito Control? ▲ TOP

For more information about mosquito control in your area, contact your state or local health department. Other resources for information on public health, disease control, and mosquito control include the following:

Centers for Disease Control and Prevention (CDC) EXIT disclaimer
Tel: 970-221-6400
Fax: 970-221-6476
E-mail: dvbid@cdc.gov
Web site: http://www.cdc.gov

National Pesticide Information Center (NPIC) EXIT disclaimer
Tel: 1-800-858-7378
E-mail: npic@ace.orst.edu
Web site: http://npic.orst.edu/

West Nile Virus Resource Guide: http://npic.orst.edu/wnv/

American Mosquito Control Association (AMCA) EXIT disclaimer
Joseph M. Conlon, Technical Advisor
Tel/Fax: (904) 215-3008
E-mail: amca@earthlink.com

For more information regarding public health mosquito control or strategies for controlling mosquitoes around your home, contact EPA headquarters or one of the 10 regional offices.

Other Helpful EPA Publications

- Mosquitoes: How to Control Them (735-F-02-005)
- Malathion for Mosquito Control (735-F-02-006)
- Larvicides for Mosquito Control (735-F-02-007)
- Naled for Mosquito Control (735-F-02-008)

- Synthetic Pyrethroids for Mosquito Control (735-F-02-009)

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Last updated on Wednesday, November 30th, 2005
URL: http://www.epa.gov/pesticides/health/mosquitoes/pyrethroids4mosquitoes.htm

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  70 Years Ago in *Science News*

Print Article
E-mail Article

Week of Feb. 4, 2006; Vol. 169, No. 5 , p. 74

A Little Less Green?

Studies challenge the benign image of pyrethroid insecticides

Janet Raloff

Rachel Carson turned the pest-control world upside down in 1962. In *Silent Spring* (Mariner), she documented how long-lived organochlorine pesticides, most notoriously DDT, were not only ridding croplands of insects, streets of mosquitoes, and homes of spiders but also exacting a high toll on songbirds and other nontargeted species. The chemicals' broad-spectrum potency and resistance to breakdown, advantages in their use against pests, emerged as hazards.

TOXIC DRAINAGE. Excess irrigation water running off California farm fields enters this creek through a discharge pipe, thereby introducing pyrethroids and other pesticides. Weston

Shortly after the publication of Carson's book, industrialized

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countries began phasing out such persistent organic pollutants, or POPs. There's now a United Nations treaty aiming at their global elimination (SN: 11/8/03, p. 301: Available to subscribers at http://www.sciencenews.org/articles/20031108/note14.asp).

In the wake of organochlorine pesticides came organophosphate agents. Although these agents are highly effective, their toxicity to nontarget animals—including people—echoed the perils of DDT. Regulators responded, and by the middle 1990s, once-popular members of this class of agents—such as dursban, malathion, and chlorpyrifos—were being phased out or severely restricted in their uses.

In recent years, farmers and others have increasingly turned to products based on pyrethrins, chemicals made by certain members of the chrysanthemum family. Farmers in various parts of the world have for millennia used preparations from these flowers to protect crops from insects. Since the 1960s, manufacturers have produced synthetic analogs—called pyrethroids—of the herbal products' active ingredients.

Although pyrethroids have greater toxicity to insects and somewhat more resistance to breakdown than their natural counterparts do, studies have demonstrated that these synthetic chemicals pose little risk to most vertebrates, from songbirds to people.

Pyrethroids stand poised to overtake organophosphate insecticides for farm use and are already the leading insecticides sold to homeowners. However, emerging data show that even pyrethroids can pose serious environmental hazards. At concentrations found in streams, the chemicals can kill beneficial insects and crustaceans and may even be acting—below the radar screen—to poison fish and lizards.

Most of these findings came to light in some dozen presentations in Baltimore last November at the Society of Environmental Toxicology and Chemistry (SETAC) annual meeting. The research described there suggests that, at least where the mum-based pesticides might enter streams, these compounds should be used sparingly.

"The Environmental Protection Agency needs to take a closer look at pyrethroids" with an eye toward changing how the 22 such compounds that it has registered are marketed and used, argues Michael J. Lydy, an environmental toxicologist at Southern Illinois University in Carbondale. Ample and growing data, he says,

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challenge "the suggestion that in the environment, pyrethroids will be innocuous."

Hunting *thrins*

"Walk down the pesticide aisle of your local hardware store and read the active ingredients in insecticides. Nearly every one ends in 'thrin,'" a dead giveaway that it is a pyrethroid, observes Donald P. Weston, an environmental toxicologist at the University of California, Berkeley. Only a few pyrethroids—most notably esfenvalerate—lack that suffix.

Although many of these compounds have been used for decades, especially on farms, "no one had looked for them in the environment," Weston notes. In the past few years, he and his colleagues launched several surveys to check whether pyrethroids were causing harm in streams. Because these pesticides don't readily dissolve, but instead glom on to particles and quickly settle out of water, his team focused its analyses on sediments.

Their findings proved eye-opening, Weston told *Science News*.

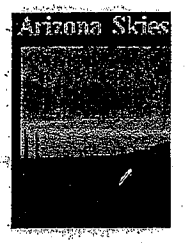
In one study of creeks adjacent to farmlands across a 10-county area in California's Central Valley, researchers looked for five pyrethroids and found one or more in at least three-quarters of the 70 sediments sampled.

The researchers then tested two stream dwellers: the amphipod *Hyalella azteca*, which is a small, shrimplike crustacean, and a larval midge of the species *Chironomus tentans*. Ecologists use these tiny "lab rats of the sediment-testing world" for toxicity assessments, Weston explains.

At 42 percent of the sampled sites, the sediment proved deadly to at least one of two species, his group reported 2 years ago.

In a follow-up study, the scientists spiked sediment samples from clean sites with six common pyrethroids to compare their toxic effects on *H. azteca*. They measured each compound's LC_{50}—the concentration lethal to 50 percent of animals exposed in a test.

In the April 2005 *Environmental Toxicology and Chemistry* (*ET&C*), the team reported that permethrin's LC_{50} was 60 to 110 parts per billion (ppb), depending on how much organic carbon the sediment contained. The LC_{50} for the remaining pyrethroids was far lower, indicating greater toxicity. The most toxic: lambda-cyhalothrin and



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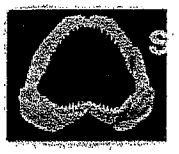
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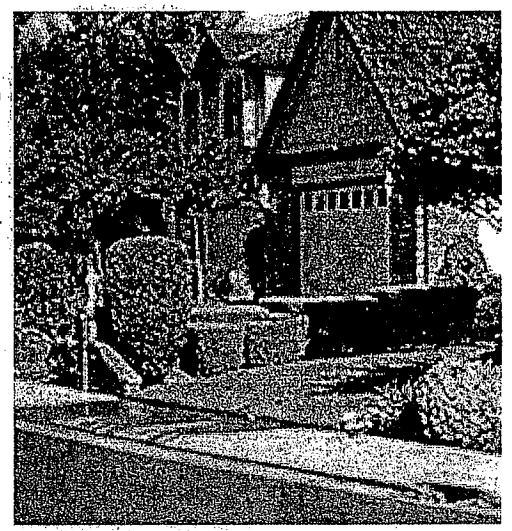
bifenthrin, which have an LC_{50} of 2 to 6 ppb.

The crustaceans' growth was significantly retarded at concentrations just one-third of a pyrethroid's LC_{50}.

Lawn pollution

Farm runoff isn't the only—or perhaps even the most important—way in which these agents get into streams. Weston and his Berkeley colleague Erin L. Amweg reported data at the SETAC meeting showing that pyrethroids are washed into waterways from suburban yards by rain and lawn watering.

In one recent study, Weston, Lydy, and others surveyed streams in Roseville, a suburb of Sacramento, Calif. Only a decade earlier, land along these creeks had been arid grassland. Since then, much of it has been converted to subdivisions sporting four homes per acre, most with manicured lawns.



RUNAWAY RUNOFF. Lawn-watering runoff at this home in Roseville, Calif., illustrates how pyrethroids used on the yard would be washed into storm drains, which are a direct conduit to neighborhood streams. Amweg

Roughly 90 percent of the stream sediments sampled contained bifenthrin, and the majority of them had bifenthrin concentrations toxic to *Hyalella*, the scientists report in the Dec. 15, 2005, *Environmental Science & Technology*. Often, one to five more pyrethroids were present.

In contrast, the pesticides didn't show up in waters draining Roseville sites free of residential development.

In toxicity, bifenthrin dominated the suburban sediments. Indeed, Lydy told *Science News*, "80 percent of our samples had enough toxicity due to bifenthrin alone to cause at least half of our [amphipods] to die." The team recorded pesticide concentrations as high as 437 ppb—that's about 100 times as great as its LC_{50} for *H. azteca* and 15 times the highest bifenthrin concentration seen in

sediments of creeks running through Central Valley croplands.

This indicates, Weston says, that the highest concentrations of pyrethroids in creek sediments trace to "classic suburbia—we're talking Mom, Dad, two kids, and a dog."

Although pesticides applied by professional exterminators around the perimeters of homes are a possible source of the creek contamination, the research group strongly suspects that much of the bifenthrin comes from lawn-care products. Some fertilizers even include bifenthrin, so that homeowners can feed their grass and kill bugs in one pass.

In the Roseville study, the pesticides didn't appear to travel far once they reached a creek, with the high concentrations appearing only within 100 yards or so of storm-drain outfalls.

What's not clear, Weston and others observe, is whether the California data reflect what's occurring nationally or might instead represent a worst-case scenario. For instance, Amweg presented data at the SETAC meeting indicating that creeks near Sacramento and San Francisco showed substantial sediment contamination but streams in Nashville didn't.

The California sites, unlike Nashville, get little summer rainfall to dilute stream pollutants. Moreover, many of California's urban areas rely on concrete storm drains to channel lawn runoff directly into streams, whereas the Nashville sites were separated from waterways by a corridor of greenery.

Too excited

Joel R. Coats of Iowa State University in Ames and his colleagues have been probing why pyrethroids "are as nasty as DDT [is] to a lot of aquatic life—including fish."

Pyrethroids poison pests by wreaking havoc on their nervous systems, as most insecticides do. When nerves transmit an impulse, Coats explains, "there's an electrical ripple that's triggered by sodium gates in [each cell] opening in sequence." Pyrethroids

perturb the nerve cells' sodium gates, however, so that once open, they never fully close, Coats says. The resulting sodium leaks maintain nerve cells in a state of overexcitation that kills the insects.

Because the nervous systems of crustaceans and many other soft-bodied aquatic animals resemble those of insects, these nontargeted animals are also vulnerable to pyrethroids.

HOW NEAT? Aquatic caddis fly nymphs build protective cases from plant debris. Ordinarily, a nymph cuts and stacks materials, log-cabin style, into an orderly, well-aerated covering (top inset). Pyrethroid-exposed nymphs, however, make chaotically structured dwellings from uncut parts (bottom inset) or forgo such protection altogether.
Johnson/OSU

Coats observes that mammals and birds gain some protection from pyrethroid poisoning by two mechanisms: production of esterase enzymes that inactivate the poisons by splitting them in half, and another metabolic process that employs oxidation. He reported at the SETAC meeting that although rainbow trout, bluegill, and fathead minnows can all oxidize pyrethroids, their esterase enzyme activity doesn't break apart the pesticides.

Although these pesticides may induce ill effects that fall short of lethality, toxicologists have generally been forced to focus on their deadliness, Weston says, because fatal concentrations tend to be at or near the minimum value at which current technology can detect the pesticides. If the pesticides cause sickness, therefore, it's likely to happen at concentrations too low to measure, he says. To get around this difficulty, some scientists have added minute amounts of the compounds to tanks of water containing aquatic animals.

At Oregon State University (OSU) in Corvallis, Katherine R. Johnson and her colleagues administered esfenvalerate to aquatic nymphs of the caddis fly (*Brachycentrus americanus*)—an insect eaten by many fish.

For protection from predators, these nymphs enshroud themselves in hard cases. As the OSU researchers increased pyrethroid concentrations above 0.05 ppb, formerly resting animals began fleeing their cases in increasing numbers, notes coauthor Jeffrey J. Jenkins. Among nymphs that fled, three-quarters of those exposed

to as little as 0.2 ppb esfenvalerate didn't rebuild their cases. Rebuilt cases were disordered and much weaker than the originals, the scientists reported at the SETAC meeting.

Conditional toxicity

Environmental stressors can sabotage pesticide-detoxification systems, even in animals that would otherwise withstand the chemicals, notes Larry G. Talent. At Oklahoma State University in Stillwater, he studied adult green anole lizards (*Anolis carolinensis*), 6 to 8 inches long, exposed to a pyrethroid product used to treat birds for mites and lice.

When he doused the lizards with a solution of the pesticide and then maintained the reptiles at a comfortable 95°F, none died. However, 70 percent of treated lizards died within 2 days when they were instead housed at a cool 68°F. Without pesticide exposure, the lizards showed no mortality at the lower temperature, Talent reports in the December 2005 *ET&C*.

Low temperatures, which might mimic night or winter environments, pose a double whammy for pyrethroid effects: Not only is the lizard's nervous system more vulnerable to poisoning but its metabolic breakdown of pollutants also slows.

Mark A. Clifford last year reported a similar synergy between two environmental stressors—pyrethroid exposure and a viral infection—in young salmon. The University of California, Davis fish pathologist exposed 2-month-old chinook salmon for 4 days to either esfenvalerate or chlorpyrifos, an organophosphate pesticide. He then seeded some of the aquariums holding the fish with infectious hematopoietic necrosis virus, which can kill juveniles.

Fish exposed to low doses of the virus survived, as did those exposed to either pesticide alone, Clifford's team reported in the July 2005 *ET&C*. Deaths occurred only in fish exposed to high concentrations of the virus or to both the pyrethroid and virus. Within 3 days of being exposed to either dose of virus, roughly 70 percent of the pesticide-exposed salmon fry were dead.

The pyrethroid's impact "was totally unexpected," Clifford says. Two follow-up trials confirmed that the initial observation was not a fluke.

Winds of change?

EPA considers new data when it periodically reviews its approvals

of pesticides registered before 1984. Reevaluations for permethrin, resmethrin, and cypermethrin are slated for completion this year, and three other pyrethroids are to be reviewed by 2008.

Because bifenthrin was registered in late 1985, it's not scheduled for such a reevaluation. In a statement to *Science News*, however, EPA's Office of Pesticide Programs (OPP) notes that this pesticide's manifestation of "certain toxic properties at the level of detection [makes it] challenging for the agency to determine whether risks from the use of this pesticide are acceptable."

In fact, the statement says, to better understand pyrethroids' toxicity and bioavailability to nontarget organisms, OPP is "reviewing the sediment toxicity studies on bifenthrin, cypermethrin, cyfluthrin, and esfenvalerate that were recently submitted [by Weston's group and others]." These pesticides were chosen as "surrogates," the statement says, for assessing the exposures and toxicity of other pyrethroids.

Indeed, OPP notes, despite their use on some 50 agricultural crops, some pyrethroids have only "conditional" approval from EPA, pending future evaluation of their sediment toxicity and of the value of buffer zones in keeping treated areas from tainting streams.

OPP says that it anticipates completing a "comparative assessment for pyrethroids" by December.

Pyrethroid manufacturers are already bracing for change.

Jim Fitzwater, a spokesman for bifenthrin-maker FMC Corp. of Philadelphia, says that homeowners need to be educated about how and when to apply lawn-care products containing pyrethroids. He notes that his company sells to consumer-products companies rather than consumers and says, "We're looking at working with [these] end-use manufacturers to do a better stewardship job."

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UP3 Project

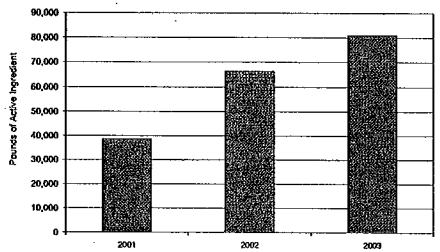
Summary

Sources of Pyrethroids in Urban Runoff

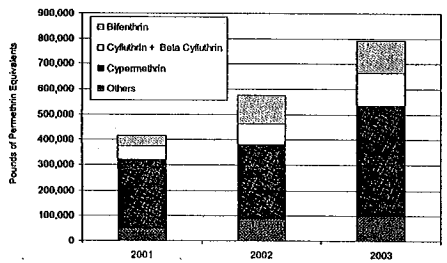
Kelly D. Moran, TDC Environmental, LLC, San Mateo, California

Bay Area Pyrethroid Use Has Doubled

Bay Area Pyrethroid Use Doubled Between 2001 and 2003



Three Pyrethroids Account for Most of the Toxic Equivalents Applied



Urban Runoff Carries Pesticides to Creeks

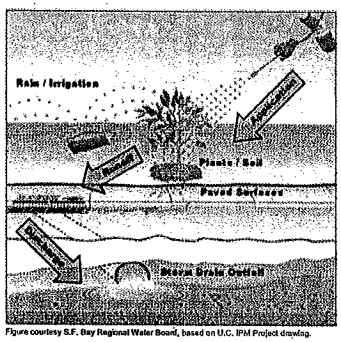
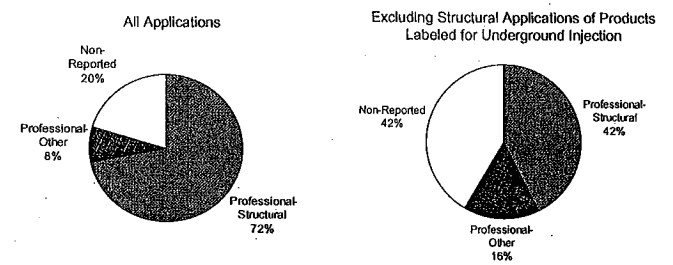


Figure courtesy S.F. Bay Regional Water Board, based on U.C. IPM Project drawing.

Outdoor Structural Pest Control Applications by Professionals Comprise 40% to 70% of Bay Area Outdoor Pyrethroid Applications (Permethrin Equivalents)



Outdoor Structural Pest Control Is Most Important for Creeks

Washoff Fractions Are Higher (than Lawn & Garden Applications) Due to Applications on Impervious Surfaces

The fraction of pesticide that is washed off of an application site depends, in part, on the characteristics of the application site. Urban surfaces can be broadly categorized into:

Impervious surfaces—hard surfaces like roofs, walkways, streets, parking lots, driveways, and buildings.

Pervious surfaces—areas where water may infiltrate to some degree, like landscaping and lawns.

For pesticides—like other pollutants—washoff fractions are greatest on impervious surfaces (TDC 2003; Pitt 1987; Pitt 1999; Sartor & Boyd 1972; U.S. EPA 1983).

Pyrethroids applied for structural pest control—particularly for commercial and multi-family residential buildings—are applied to both impervious and pervious surfaces. In contrast, lawn & garden applications are almost exclusively to pervious surfaces. Available data are not sufficient to complete quantitative estimates of washoff.

Conclusions/Recommendations for Agencies

Priority Pyrethroids for Water Quality

Using pesticide use reporting and sales data, toxicity data, and washoff fractions, the following pyrethroids are identified as priority pyrethroids for water quality:

- Bifenthrin
- Cyfluthrin and Beta Cyfluthrin
- Cypermethrin
- Permethrin

Priority Actions

Obtain more data on pyrethroid use in urban areas, especially outdoor structural pest control applications.

Obtain more data on pyrethroid washoff fractions, especially for pervious surfaces.

Pyrethroid Toxicities Differ Greatly – But Application Rates Must Be Considered When Making Comparisons

Pyrethroid	Average Sediment 10-Day *Hyalella azteca* LC 50 (µg/g organic carbon)	Number of Times More Toxic than Permethrin	Quantity Applied per 1000 sq. ft. for an Outdoor Structural Pest Control Application (g of Permethrin Equivalents)
Bifenthrin	0.52	21	46 to 91
Cyfluthrin	1.08	10	1 to 13
Beta-Cyfluthrin	? (assume same as cyfluthrin)	Assume ~ 10	10 to 20
Cypermethrin	0.37	29	266 to 532
Deltamethrin	0.79	14	12 to 18
Esfenvalerate	1.54	7	2 to 14
Lambda-Cyhalothrin	0.45	24	NC
Permethrin	10.83	1	4 to 74
Tralomethrin	? (assume same as permethrin)	Assume ~ 1	NC

NC – Not calculated. Source: Amweg et al. 2005; Maund et al. 2002

Methods

Pesticide use reporting and sales data were obtained from the California Department of Pesticide Regulations databases (DPR 2002, 2003 & 2005). (The most recent data available reflect pesticide sales & use in 2003.) Unreported use—primarily residential use—was estimated on a per-capita basis from statewide unreported use (total sales – total reported use). Application rates and allowable pesticide uses were obtained from product labels. Based on product labels and indoor formulations, the analysis assumes that indoor use of the priority pyrethroids comprises a relatively small fraction of their total use.

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PYRETHROID PESTICIDE ILLNESSES IN OCCUPATIONAL SETTINGS

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California Department of Health Services, Oakland, California[1], and Public Health Institute, Berkeley, California[2]

This project was partially funded by the National Institute for Occupational Safety and Health and the United States Environmental Protection Agency.

ABSTRACT

BACKGROUND The use of pyrethroid insecticides is encouraged because they are considered nontoxic to humans. In 1999, over 500,000 pounds of pyrethroids were used commercially in California. Because of prevalent use, large numbers of workers are exposed to these insecticides. However, the role of pyrethroids in causing disease in exposed workers has not been profiled.

METHODS To characterize occupational pyrethroid-induced illness, a review was conducted of all cases reported by physicians, poison control centers and others to a state occupational pesticide illness surveillance system from January 1, 1998 to March 30, 2000.

RESULTS Out of 844 occupational exposures to non-disinfectant pesticides, 134 cases (15.9%) representing 45 exposure incidents were related to pyrethroids. Selected variables are summarized below:

Variables	Indoor Air Exposures	All Other Exposures
• No. illnesses related to pyrethroid pesticides (%)	38 (28.4)	96 (71.6)
• No. males (% of illnesses in category)	11 (29.0)	77 (80.2)
• Age: mean (range)	37.1 (19 – 55)	34.0 (13 – 68)
• No. workers per exposure incident: mean (range)	2.9 (1-10)	3.0 (1-49)
• Symptomatic (> 1 symptom): n (%)	37 (97.4)	81 (84.4)
• Type II pyrethroid involved: n (%)	24 (63.2)	78 (81.3)

CONCLUSION Pyrethroids were responsible for a large number of occupational pesticide illnesses. Illnesses occurred in a variety of workers and in a wide range of exposure scenarios, including indoor air exposures (over one-fourth of cases). The higher prevalence of females in indoor air exposures and males in non-indoor air exposures most likely reflects the workforce in these settings. The longer acting Type II pyrethroids were responsible for more illnesses than Type I compounds.

BACKGROUND

Pyrethroid insecticides are the light-stable synthetic derivatives of pyrethrin, natural insecticidal extracts of the chrysanthemum flower.

Pyrethroid pesticides are widely used

- Replacing more acutely toxic insecticides, e.g., organophosphates
- Considered non-toxic to humans
- Over 500,000 pounds of commercial use were reported in California in 1999
- Examples of use:
  - Structural pest control (offices, residences)
  - Agriculture (wide variety of crops, e.g., fruits, grains, ornamental flowers)
- Often used in combination with the synergist piperonyl butoxide

Mechanism of Toxicity

- Sodium channel toxin
  - Stereospecific affinity for nerve membrane sodium channels
  - Prolongs inactivation, or sodium "tail current"
- Pyrethroids may be roughly categorized into Type I & Type II
  - Type I (noncyano pyrethroids)
    - Short sodium tail currents
    - DDT-like poisoning syndrome in animals (whole body tremor at high doses)
    - Examples: Permethrin, Resmethrin
  - Type II (α-cyano pyrethroids)
    - Longer sodium tail currents
    - Tremors, salivation, choreoathetosis, seizures at high doses (in animals)
    - Examples: Cypermethrin, Esfenvalerate
- In animals, toxicity enhanced by simultaneous high-dose exposure to some organophosphates

Known Acute Human Health Effects of Pyrethroid Formulations

- Paresthesia, burning, itching, numbness, erythema
- Irritant and allergic contact dermatitis
- Airway hyperresponsiveness in asthmatics
- Dizziness, headache, fatigue, vomiting, diarrhea, fasciculations, seizures, pulmonary edema

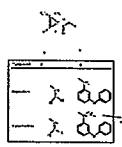


Figure 1. Chemical Structure of Type I and Type II Pyrethroid Insecticides

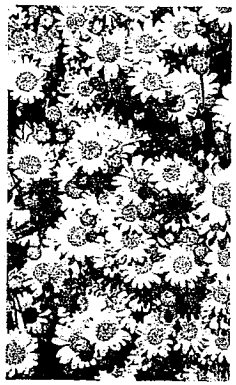


Figure 2. *Chrysanthemum cinerariaefolium*, the pyrethrum flower, is the source of natural insecticidal pyrethrins.

METHODS

In California, suspected occupational & pesticide illnesses are reportable conditions. Both physicians and poison control centers may report pesticide illness.

- The California Department of Health Services (CDHS) uses these reports to conduct surveillance for occupational pesticide illnesses. Disinfectants are excluded.
- Surveillance reports are supplemented with
  - Medical records
  - Field investigations of select cases
  - Interviews with workers, employers, regulatory agencies
  - County Agricultural Commissioner investigation reports of select cases
- A review was conducted of all cases that involved exposure to a pyrethroid insecticide reported to CDHS' occupational pesticide illness surveillance program between January 1, 1998 and March 30, 2001.
- Data was abstracted from initial reports and coded according to a system developed by the National Institute for Occupational Safety and Health. All cases that reported exposure to a specific pyrethroid insecticide were included in the analysis, regardless of final case classification.
- Data was entered into an MS Access (relational) database and analyzed using SAS.

RESULTS

All results are for cases reported to CDHS between January 1,1998 and March 30, 2001.

Table 1. Selected Characteristics of Occupational Pesticide Illnesses Involving Pyrethroid Insecticides.

• No. occupational pesticide illnesses:	844
• No. involving pyrethroid insecticides (% of all cases)	134 (15.9)
• No. male (% of pyrethroid cases)	88 (65.7)
• Age: mean (range)	34.9 (13 – 68)
• No. exposure incidents	45
• Average no. workers per incident (range)	3.0 (1 – 49)
• No. cases involving simultaneous exposure to pyrethroids and other pesticides (% of all pyrethroids cases)	87 (64.9)
• No. cases involving Type II compounds (% of pyrethroid cases)	102 (76.1)

- Most cases involved exposure to multiple pesticides. In these cases, attribution of health effects to a particular pesticide category may be problematic.

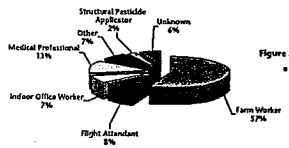


Figure 3. Occupations of 134 Pyrethroid Illness Cases

- Illnesses occurred in a variety of other workers, including
  - Flight attendants (as a result of aircraft "disinsection")
  - Medical professionals (during treatment of contaminated patients)
  - Office workers (following structural pest control applications)
- A large incident involving exposure to multiple pesticides including pyrethroids affected farmworkers, office workers and medical professionals

Figure 4. Occupational pyrethroid illnesses were most frequently reported among farm workers. Pyrethroids are commonly used in lettuce production.

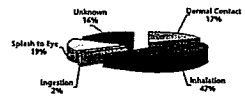
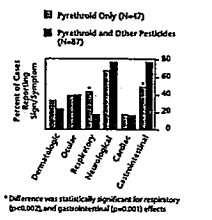


Figure 5. Route of Exposure for 134 Pyrethroid Illness Cases

- More than one route of exposure may have been reported for each case.



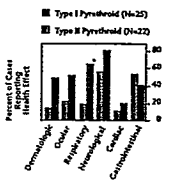
*Difference was statistically significant for respiratory (p=0.002), and gastrointestinal (p=0.001) effects

Figure 6. Symptoms and Signs Reported for Pyrethroid only vs. Multiple Pesticide Exposures

- The data did not allow distinguishing the roles of the various pesticides, inert ingredients, and synergists in producing these health effects.

Table 2. Signs and Symptoms Most Commonly Reported by 47 Cases Exposed to Pyrethroid Insecticides Only

Organ System	Signs & Symptoms
• Dermatologic	Erythema Irritation and pain Pruritus
• Ocular	Conjunctivitis Irritation and pain Lacrimation Pruritus
• Respiratory	Cough Dyspnea Pleuritic chest pain Upper respiratory pain/irritation
• Gastrointestinal	Nausea Vomiting
• Neurologic	Anxiety Headache Dizziness Tingling sensation (hands, face, etc.)
• Cardiac	Palpitations



*Difference was statistically significant for respiratory effects, p<0.001

Figure 7. Cases with Exposure to Pyrethroids Only: Type I vs. Type II Compounds

- 50% (11/22) of the Type I cases were flight attendants who reported prolonged exposure aboard aircraft on long flights.

Figure 8. Floriculture is one of several industries that use pyrethroid insecticides.

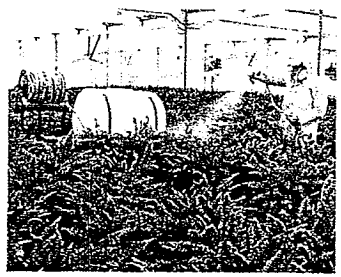


Figure 9. Product substitution, personal protective equipment and restricted entry intervals can prevent pyrethroid induced illness.

CONCLUSIONS

- Exposure to pyrethroid insecticide formulations are associated with a large number of occupational pesticide illnesses in a wide variety of workers.
- Most cases involved simultaneous exposures to multiple pesticides. This may be due to either enhanced toxicity (synergistic effects) or prevalent use of pesticide mixtures.
- Respiratory and dermatologic effects were reported more frequently among workers exposed to (1) only pyrethroid pesticides compared to those exposed to multiple pesticides and (2) Type I pyrethroids compared to Type II pyrethroids.
- The longer-acting Type II (cyano) pyrethroids were associated with a larger number of occupational illnesses overall. This may be due to usage patterns or to the toxicity of these compounds.
- The shorter acting Type I pyrethroids were also associated with illness, particularly when prolonged exposure occurred in an enclosed space.

RECOMMENDATIONS

- The potential for human health effects following exposure to pyrethroid insecticide formulations, alone or in combination with other pesticides, should be recognized by health care practitioners.
- Exposure to pyrethroids should be minimized through measures such as product substitution, administrative controls such as restricted entry intervals, and engineering controls such as appropriate personal protective equipment.

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Fact Sheet 2006–3028

March 2006

Pesticides in the Nation's Streams and Ground Water, 1992–2001—A Summary

The PDF for the report is 3,747 kb

The use of pesticides to control weeds, insects, and other pests has resulted in a range of benefits, including increased food production and reduction of insect-borne disease, but also raises questions about possible adverse effects on the environment, including water quality. A decadal assessment by the National Water-Quality Assessment (NAWQA) Program of the United States Geological Survey (USGS) provides the most comprehensive national-scale analysis to date of pesticide occurrence and concentrations in streams and ground water, based on results from studies completed during 1992–2001. Among the major findings are that pesticides are frequently present in streams and ground water, are seldom at concentrations likely to affect humans, but occur in many streams at concentrations that may have effects on aquatic life or fish-eating wildlife. This Fact Sheet highlights national findings regarding pesticide occurrence, distribution and sources, and the potential for effects on humans, aquatic life, and fish-eating wildlife. It serves as a companion product to the USGS Circular entitled "The Quality of Our Nation's Waters—Pesticides in the Nation's Streams and Ground Water, 1992–2001."

Pesticide Occurrence

Pesticides and degradates are typically present throughout most of the year in streams draining watersheds with substantial agricultural or urban areas, but are less common in ground water.

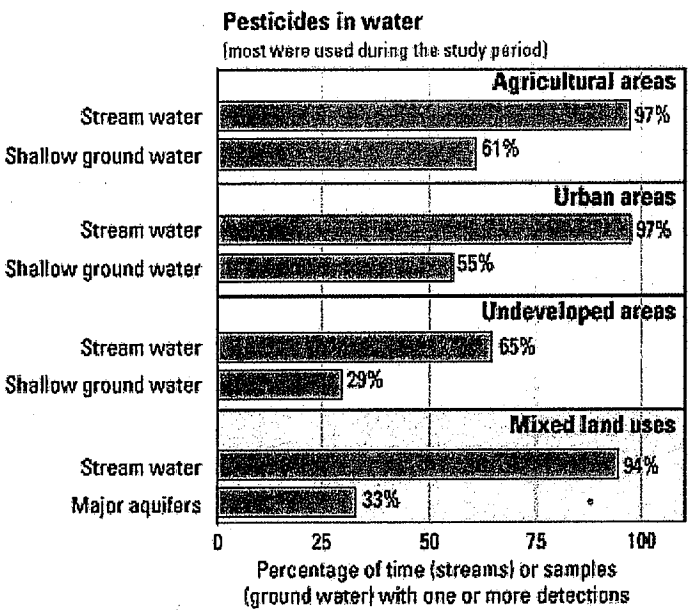
At least one pesticide was detected in water from all streams studied and, as shown in the graph below, pesticide compounds were detected throughout most of the year in water from streams with agricultural (97 percent of the time), urban (97 percent), or mixed-land-use watersheds (94 percent). In addition, organochlorine pesticides (such as DDT) and their degradates and by-products were found in fish and bed-sediment samples from most streams in agricultural, urban, and mixed-land-use watersheds—and in more

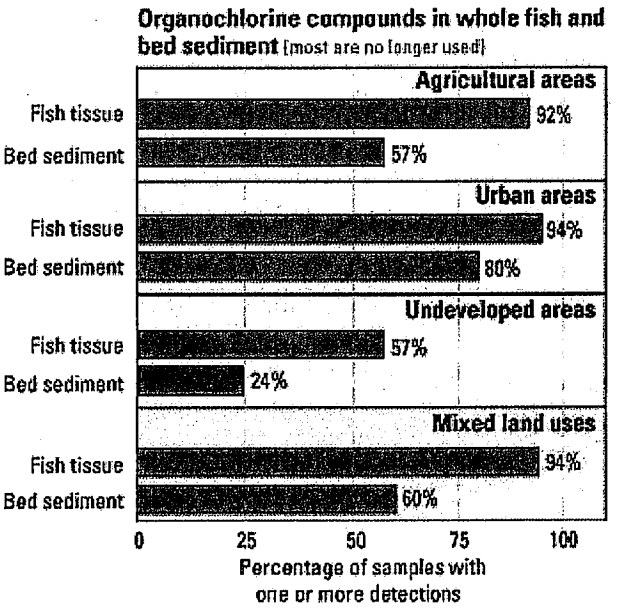
than half the fish from streams with predominantly undeveloped watersheds. Most of the organochlorine pesticides have not been used in the United States since before the NAWQA studies began, but their continued presence demonstrates their persistence in the environment.

Pesticides were less common in ground water than in streams. They occurred most frequently in shallow ground water beneath agricultural and urban areas, where more than 50 percent of wells contained one or more pesticide compounds. About one-third of the deeper wells sampled, which tap major aquifers used for water supply, contained one or more pesticides or degradates.

The findings show that streams are most vulnerable to pesticide contamination, but ground water also merits careful monitoring—especially in agricultural and urban areas. Shallow ground water in some of these areas is used for drinking water and ground-water contamination is difficult to reverse once it occurs.

The occurrence of pesticides in streams and ground water does not necessarily cause adverse effects because detections were often at low concentrations. NAWQA's assessment of potential effects is based on comparing measured concentrations to water-quality benchmarks, as described on the following page. Benchmarks are estimates of the concentrations above which pesticides may have adverse effects on humans, aquatic life, or fish-eating wildlife. For example, less than 10 percent of NAWQA stream sites and about 1 percent of wells had concentrations greater than a human-health benchmark.





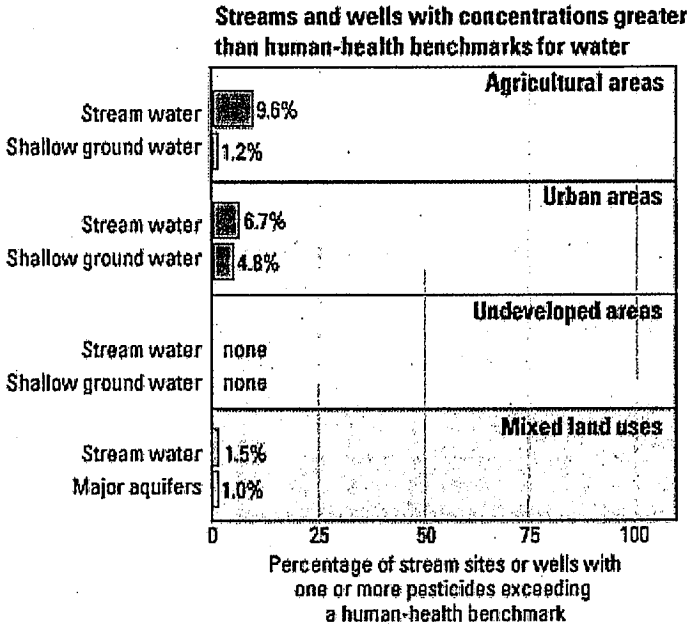
Potential for Effects on Human Health

Concentrations of pesticides in streams and ground water were typically below water-quality benchmarks for human health.

No streams draining undeveloped watersheds and only one stream with a mixed-land-use watershed had concentrations greater than a human-health benchmark. Annual mean concentrations of one or more pesticides exceeded a human-health benchmark in 8 of 83 agricultural streams and in 2 of 30 urban streams. Agricultural streams located in the Corn Belt (Illinois, Indiana, Iowa, Nebraska, Ohio, and parts of adjoining States) and the Mississippi River Valley accounted for most concentrations that exceeded benchmarks—all by atrazine, cyanazine (no longer in use by the end of the study), or dieldrin (no longer in use when the study began). The two urban streams where benchmarks were exceeded are in Texas (diazinon) and Hawaii (dieldrin).

None of the NAWQA stream sites were located at drinking-water intakes. For perspective, however, the Nation's 1,679 public water-supply intakes on streams were evaluated in the context of NAWQA land-use classifications and pesticide findings. Eighty-seven percent of the water-supply intakes are on streams draining undeveloped and mixed-land-use watersheds and are therefore unlikely to withdraw water with concentrations that are greater than a human-health benchmark. The likelihood of pesticide concentrations exceeding a human-health benchmark is greatest for those streams draining agricultural or urban watersheds, which account for about 12 and 1 percent, respectively, of public water-supply intakes on streams.

Human-health benchmarks were seldom exceeded in ground water. One or more pesticides exceeded a benchmark in about 1 percent of the 2,356 domestic and 364 public-supply wells that were sampled. The greatest proportion of wells with a pesticide concentration greater than a benchmark was for those tapping shallow ground water beneath urban areas (4.8 percent). The urban wells with benchmark exceedances included 1 public-supply, 3 domestic, and 37 observation wells. All concentrations greater than a benchmark were accounted for by dieldrin (72 wells), dinoseb (4), atrazine (4), lindane (2), and diazinon (1).



Screening-Level Assessment of Potential Effects

The potential for pesticides to adversely affect human health, aquatic life, or fish-eating wildlife was evaluated by a screening-level assessment similar in concept to U.S. Environmental Protection Agency (USEPA) screening-level assessments. The screening-level assessment is primarily intended to identify and prioritize needs for further investigation and is not a substitute for comprehensive risk assessment, which includes additional factors. Concentrations of pesticides measured at NAWQA sampling sites were compared with water-quality benchmarks derived from standards and guidelines established by USEPA, toxicity values from USEPA pesticide risk assessments, and selected guidelines from other sources. Most of the benchmarks are estimates of no-effect levels, such that concentrations below the benchmarks are expected to have a low likelihood of adverse effects and concentrations above a benchmark may have adverse effects, with the likelihood increasing as the concentration increases.

Potential for Effects on Aquatic Life and Wildlife

Concentrations of pesticides were greater than water-quality benchmarks for aquatic life and (or) fish-eating wildlife in more than half of the streams with substantial agricultural and urban areas in their watersheds.

Of the 178 streams sampled nationwide that have watersheds dominated by agricultural, urban, or mixed land uses, 56 percent had one or more pesticides in water that exceeded at least one aquatic-life benchmark. Urban streams had concentrations that exceeded one or more benchmarks at 83 percent of sites—mostly by the insecticides diazinon, chlorpyrifos, and malathion—although frequencies of exceedance declined during the study period. Concentrations exceeded benchmarks in 95 percent of urban streams sampled during 1993–1997 and in 64 percent of streams during 1998–2000. Agricultural streams had concentrations that exceeded one or more benchmarks at 57 percent of sites—most frequently by chlorpyrifos, azinphos-methyl, atrazine, *p,p'*-DDE, and alachlor. As the use of alachlor declined through the study period, its benchmark exceedances also declined, with none during the last 3 years of study.

Aquatic-life benchmarks for organochlorine pesticide compounds in bed sediment also were frequently exceeded in urban areas (70 percent of urban stream sites). Most compounds that exceeded aquatic-life benchmarks for sediment were derived from organochlorine pesticides that have not been used since before the study began, such as DDT, chlordane, aldrin and dieldrin. In agricultural streams, aquatic-life benchmarks were exceeded at 31 percent of sites—most often by DDT compounds and dieldrin.

Comparisons of concentrations of organochlorine compounds in whole fish with wildlife benchmarks indicate a wide range of potential for effects on fish-eating wildlife. The ranges of percentages shown on the graph below reflect the uncertainties in benchmarks for fish-eating wildlife due to the lack of consensus on national-scale benchmarks or toxicity values. Similar to bed sediment, benchmarks for fish were exceeded most often by compounds related to DDT, dieldrin, and chlordane in urban streams, and by DDT compounds, dieldrin, and toxaphene in agricultural streams in areas where historical use on crops was most intense.

Assessment and management of the potential effects of pesticides on aquatic life and wildlife are complicated by the combined presence in streams of (1) currently used pesticides and degradates, and (2) organochlorine pesticide compounds derived from pesticides that were largely banned prior to 1990. The widespread potential for adverse effects shown by the screening-level assessment—combined with the uncertainty due to the preliminary nature of the assessment and the complexity of pesticide exposure—indicate a continuing need to study the effects of pesticides on aquatic life and wildlife under the conditions of pesticide exposure that occur in the environment.

Frequently Detected Pesticides and Relations to Land Use and Pesticide Use

Pesticides detected most frequently in streams and ground water are among those used most heavily during the study or in the past. Their occurrence follows patterns in land use and use intensity, with additional influence—especially for ground water—by natural

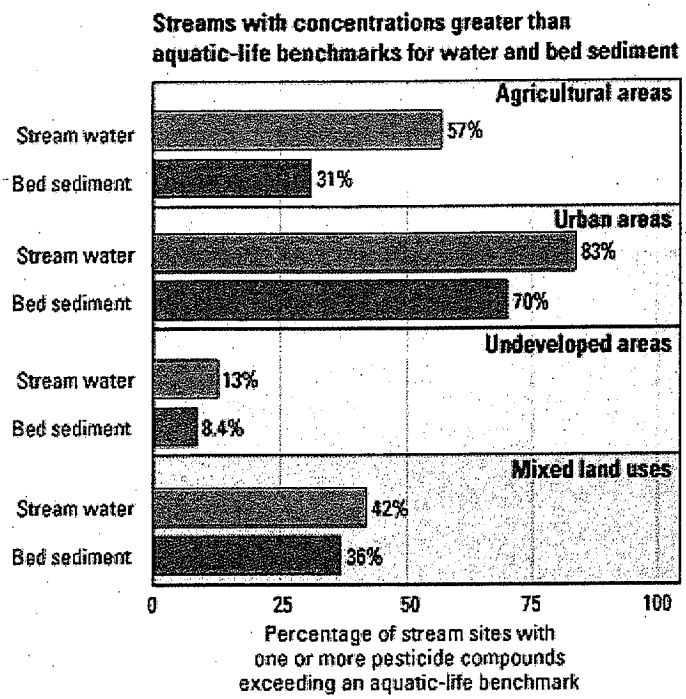
factors and management practices.

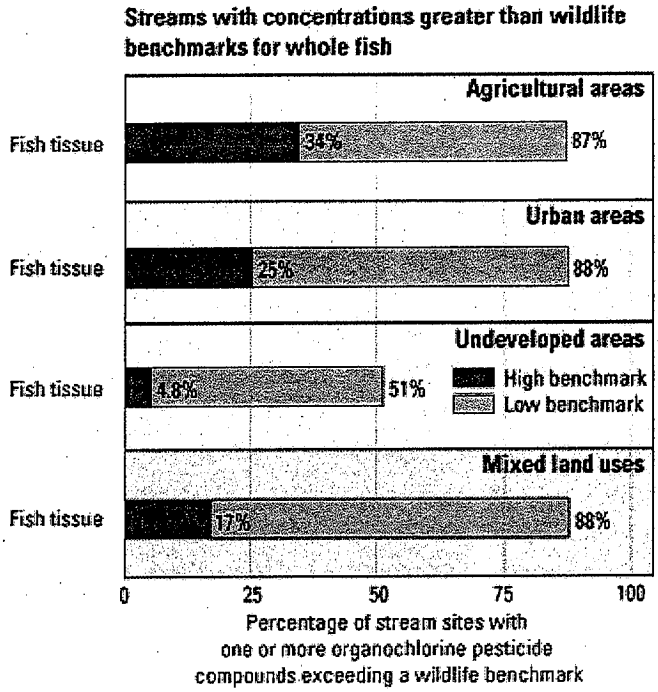
The most frequently detected herbicides that are used mainly for agriculture—atrazine, metolachlor, cyanazine, alachlor, and acetochlor—generally were detected most often and at the highest concentrations in water samples from streams in agricultural areas with their greatest use, particularly in the Corn Belt. Five herbicides commonly used in urban areas—simazine, prometon, tebuthiuron, 2,4-D, and diuron—and three commonly used insecticides—diazinon, chlorpyrifos, and carbaryl—were most frequently detected in urban streams throughout the Nation, often at higher concentrations than in agricultural streams. Total DDT was measured at some of the highest concentrations in bed sediment and fish in parts of the Southeast and in parts of California, Oregon, and Washington, where DDT was historically used on cotton, tobacco, orchards or other crops.

Land use and pesticide use are not the only factors influencing the occurrence of pesticides. Natural features and land-management practices also affect their distribution, particularly in ground water. Ground water is most vulnerable to contamination in areas with highly permeable soil and aquifer materials and where drainage practices do not divert recharge to streams and other surface water.

Pesticide concentrations in stream water also vary by season, with lengthy periods of low concentrations punctuated by seasonal pulses of much higher concentrations. For example, in streams that drain farmland throughout most of the Corn Belt, concentrations of herbicides were generally highest during spring runoff following pesticide application. Similarly, concentrations of diazinon were highest during the winter in parts of the San Joaquin Valley, California, when applications to dormant almond orchards were followed by rainfall.

Understanding the correlations of pesticide occurrence with the amounts and characteristics of pesticides used can help managers to anticipate and prioritize the pesticides most likely to affect water quality in different land-use settings. Some hydrologic settings where ground water is least vulnerable to contamination are those where streams are most vulnerable, and vice versa. The entire hydrologic system and its complexities, therefore, need to be considered in evaluating the potential for pesticide contamination of streams and ground water. In addition, seasonal patterns in pesticide concentrations are important to consider, both in managing the quality of drinking water withdrawn from streams in agricultural and urban settings and in evaluating the potential for adverse effects on aquatic life. Effective management of streams may require increased monitoring—including high-frequency sampling during seasons when intense pesticide use coincides with periods of high runoff—so that periods with elevated pesticide concentrations are adequately characterized.





Mixtures and Degradates

Pesticides most commonly occur as mixtures of multiple compounds, rather than individually, including degradates resulting from the transformation of pesticides in the environment.

Streams in agricultural and urban areas almost always contained complex mixtures of pesticides and degradates. More than 90 percent of the time, water samples from streams with agricultural, urban, or mixed-land-use watersheds contained 2 or more pesticides or degradates, and about 20 percent of the time they had 10 or more. Mixtures were less common in ground water. Nevertheless, about half of the shallow wells in agricultural areas and about a third of shallow wells in urban areas contained 2 or more pesticides and degradates—less than 1 percent had 10 or more. The herbicides atrazine (and its degradate, deethylatrazine), simazine, metolachlor, and prometon were common in mixtures found in streams and ground water in agricultural areas. The insecticides diazinon, chlorpyrifos, carbaryl, and malathion were common in mixtures found in urban streams.

Degradates are often as common in streams and ground water as their parent pesticides. For example, atrazine, the most heavily used herbicide in the Nation during the study period, was found together with one of its several degradates, deethylatrazine, in about 75 percent of stream samples and about 40 percent of ground-water samples collected in agricultural areas across the Nation. Degradates are particularly important in ground water, which moves relatively slowly through soils and aquifers, providing the extended

time and conditions favorable for transformation of pesticides. Most degradates are less toxic than their parent pesticide, but some have similar or greater toxicities.

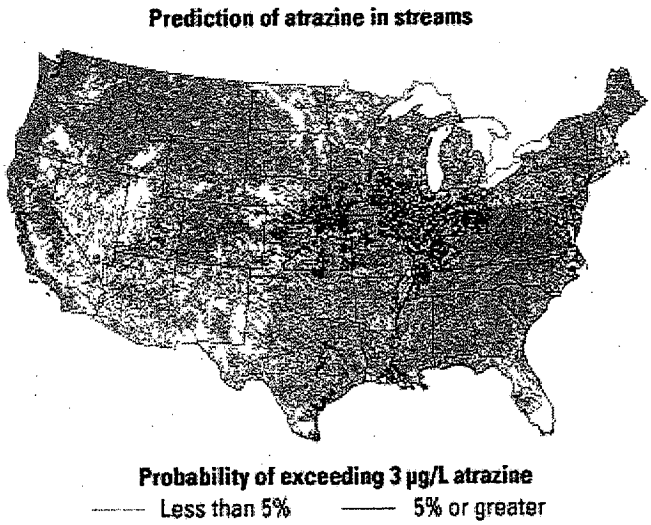
The widespread and common occurrence of pesticide mixtures, particularly in streams, means that the total combined toxicity of pesticides in water and other media often may be greater than that of any single pesticide compound that is present. Continued research is needed on the potential toxicity of pesticide mixtures, including degradates, to humans, aquatic life, and wildlife. NAWQA data on the occurrence and characteristics of mixtures and degradates is helping to target and prioritize toxicity assessments.

From Monitoring to Prediction

National-scale modeling and prediction of pesticide levels in unmonitored areas is increasingly possible for some pesticides, particularly for streams.

NAWQA data are sufficiently extensive to support national statistical models that can be used to estimate the concentrations or occurrence of some pesticides in streams and ground water where they have not yet been measured. Such spatial extrapolation is fundamental to extending NAWQA's findings on sources and factors that affect pesticide occurrence —such as pesticide use and land use, climate, and soil characteristics—to a more comprehensive national assessment that includes unmonitored areas. The NAWQA model for atrazine in streams, for example, can be used to predict the likelihood that the annual average concentration of atrazine in untreated stream water exceeds the USEPA drinking-water standard of 3 micrograms per liter in any stream in the Nation (see map below). Atrazine concentrations were predicted to be highest in the Corn Belt and parts of the southern Mississippi River Valley, where use is high and natural features favor the transport of pesticides by runoff to streams. Streams shown in red on the map are estimated to have more than a 5-percent chance of having an annual mean concentration greater than the USEPA standard. Some of these streams may not be suitable as sources of drinking water without the use of strategies to lower concentrations. These types of analyses can be used to identify locations that have the greatest likelihood of water-quality problems and that are the highest priority for additional monitoring.

Expanding the capability for prediction and extrapolation is a critical step for national water-quality assessment, as well as for cost-effective management of water resources, because both require more information (pesticides, places, and times) than can be directly measured.



Trends in Pesticides

Some trends in pesticide concentrations are already evident, showing responses to regulatory actions and reduced use.

NAWQA findings provide a framework for assessing whether pesticide levels in the Nation's streams and ground water are increasing or decreasing over time. For many streams and aquifers, it is too early to tell whether levels are changing, because historical data are insufficient or too inconsistent. Some trends are evident, however, and a first look at trends shows examples of both decreasing and increasing levels of certain pesticides in streams and ground water.

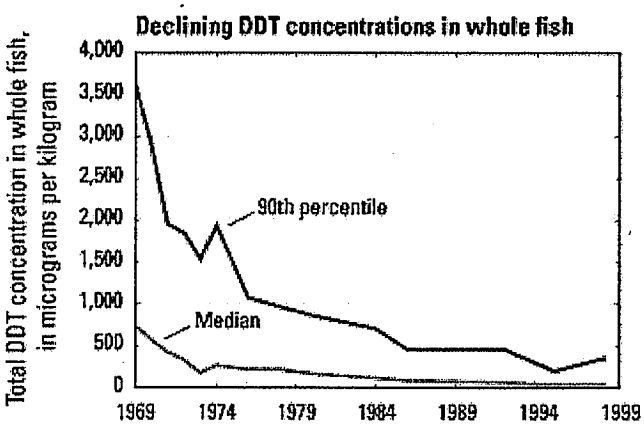
The most complete story of trends in response to regulatory action and reduced pesticide use is the decline in organochlorine pesticide concentrations that followed reductions in use during the 1960s and bans on uses in the 1970s and 1980s. Concentrations of total DDT in fish, for example, decreased rapidly from the 1960s through the 1970s, and then more slowly during the 1980s and 1990s, as documented by data from the U.S. Fish and Wildlife Service and NAWQA. Just as notable as the declines, however, is the finding that persistent organochlorine pesticide compounds still occur at levels greater than benchmarks for fish-eating wildlife in many urban and agricultural streams across the Nation.

In contrast, NAWQA findings show that concentrations of relatively mobile and short-lived pesticides in stream water respond more rapidly to changes in use than the less mobile and more persistent organochlorine insecticides. For example, increases in acetochlor and decreases in alachlor are evident in streams in the Corn Belt, where acetochlor partially replaced alachlor for control of weeds in corn beginning in 1994. The changes in use were reflected quickly in stream concentrations, generally within 1 to 2 years. Similarly, concentrations of diazinon decreased significantly from 1998 to 2004 in 5 of 7 urban and

mixed-land-use streams sampled in the Northeast, consistent with the USEPA-mandated phase-out of nonagricultural uses of diazinon that began in 2002.

Ground water responds more slowly than stream water to changes in pesticide use. A persistent pesticide or degradate can remain in ground water long after its use is discontinued because of the slow rates of ground-water flow and the resulting long residence time of water and pesticides in ground-water flow systems.

Long-term and consistent data for assessing trends is essential for tracking water-quality response to changes in pesticide use and management practices, for providing early warning of unanticipated problems, and for updating and improving models. Long-term monitoring is particularly important for assessing the occurrence of pesticides in ground water and the occurrence of persistent compounds in streams because concentrations change slowly, sometimes taking decades to respond to changes in use.



Priorities for Filling Information Gaps for Pesticides

The NAWQA water-quality assessment serves as a foundation for improving water-resource assessment and management, but major gaps in critical information about pesticides still persist and continue to present challenges to scientists, managers, and policymakers. Some of the most important steps needed to fill gaps are listed below:

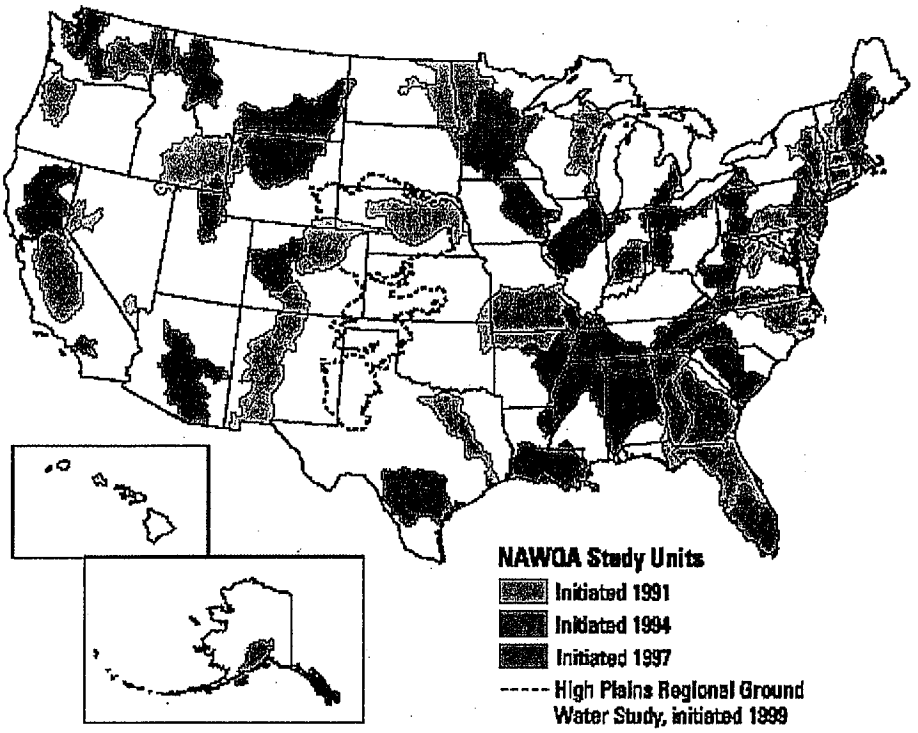
- Improve tracking of pesticide use in agricultural and non-agricultural areas, including amounts, locations, and timing
- Add assessments of pesticides not yet studied, including some already in use as well as new pesticides
- Improve assessment and understanding of degradates, including their distribution and potential effects
- Evaluate toxicities of mixtures and their potential to affect humans, aquatic life, and wildlife

- Evaluate the performance of management practices and their effects on concentrations and transport of pesticides
- Improve methods for prediction of pesticide levels in unmonitored areas
- Sustain and expand long-term monitoring for trends

NAWQA Approach to Pesticide Assessment

NAWQA assessments of pesticides followed a nationally consistent approach in 51 of the Nation's major river basins and aquifer systems, referred to as "Study Units, with 20 Study Units studied during 1992–1995; 16 during 1996–1998; and 15 during 1998–2001. Nationally, water samples for pesticide analysis were collected from 186 stream sites, bed-sediment samples were collected from 1,052 stream sites, and fish samples were collected from 700 stream sites. Ground-water samples were collected from 5,047 wells.

Most water samples were analyzed for 75 pesticides and 8 degradates, including 20 of the 25 most heavily used herbicides and 16 of the 25 most heavily used insecticides. In addition, 32 organochlorine pesticide compounds were analyzed in bed sediment and (or) fish tissue, including 19 pesticides and 13 degradates or manufacturing by-products. Most of the organochlorine pesticides are no longer used in the United States, but organochlorine compounds still persist in the environment.



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This Fact Sheet and the Circular are free of charge and are on the World Wide Web at http://water.usgs.gov/nawqa.

Included at this web site are data used for national summaries of pesticides, maps of chemical use and pesticide occurrence, information on sampling designs and

methodology, and background on data analysis.

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USGS Circular 1291

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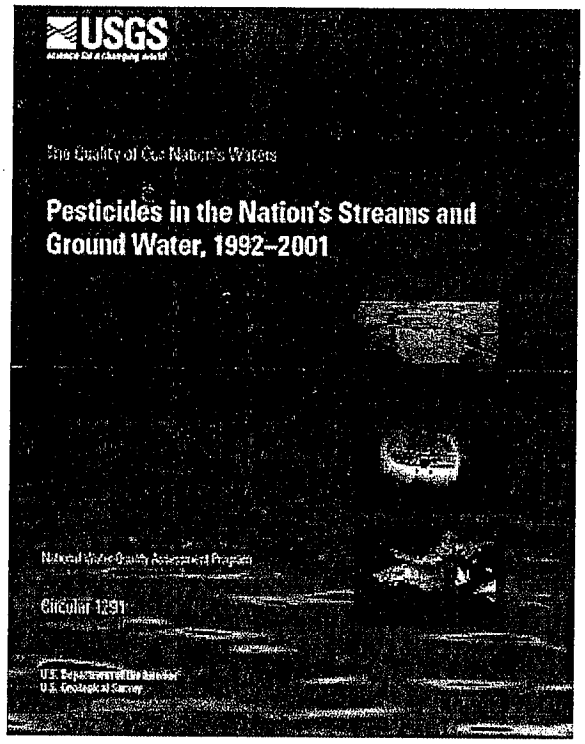
The Quality of Our Nation's Waters

Pesticides in the Nation's Streams and Ground Water, 1992–2001

By Robert J. Gilliom, Jack E. Barbash, Charles G. Crawford, Pixie A. Hamilton, Jeffrey D. Martin, Naomi Nakagaki, Lisa H. Nowell, Jonathan C. Scott, Paul E. Stackelberg, Gail P. Thelin, and David M. Wolock



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USGS Circular 1291–Revisions

Revision History for Circular 1291

Revision date	Edition Number	Revision description	Revision report files(s)
March 15, 2006	1	Page 81, last sentence of the second paragraph: "23 percent" was changed to "28 percent".	circ1291.pdf, circ1291_chapter5.pdf
March 15, 2006	1	Page 81, figure 5-11 caption: "23 percent" was changed to "28 percent".	circ1291.pdf, circ1291_chapter5.pdf
March 15, 2006	1	Typos and minor word corrections were made to pages 7, 15, 16, 85, and 142	circ1291.pdf

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Congressional Briefing - Pesticides

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**Pesticides in the Nation's Streams and Ground Water:
A Decade of Assessments Provide Information
for Future Protection**

**Congressional Briefing
Friday, March 3, 2006
9:30 am – 11:30 am
2318 Rayburn House Office Building**

The U.S. Geological Survey's National Water Quality Assessment Program (NAWQA) will release a report documenting its nationwide assessment of pesticides in streams and ground water from a decade of monitoring and analysis. The report will be released at this briefing and available for briefing attendees.

The USGS assessment provides the most comprehensive national-scale analysis to date of pesticide occurrence, concentrations, and potential for aquatic life, and wildlife. Among the major findings are that pesticides are frequently present in streams and ground water, were seldom found at concentrations likely to affect humans, but were found in many streams at concentrations that may have effects on aquatic life or fish-eating wildlife.

The assessment also begins to examine two important topics with implications for the future—prediction of pesticides in unmonitored areas and long-term trends.

USGS findings can be used to help guide and inform state and national regulations and policies for water-quality protection, such as those currently being deliberated in the 2007 Farm Bill. For example, the science-based insights can help decision makers better anticipate the types of pesticides most likely to affect water quality in urban and agricultural areas, and improve investments in water-quality monitoring and management across the Nation's diverse environmental and pesticide use patterns.

Briefing Speakers:

Robert Hirsch, USGS Associate Director for Water, will describe the elements of the NAWQA design and significance of NAWQA's studies, providing a context for the pesticide

findings.

Bob Gilliom, NAWQA Pesticide Synthesis Team Leader, will present key findings and implications.

Jim Jones, Director, Office of Pesticides of the U.S. Environmental Protection Agency (EPA) will present implications of the findings and collaborative efforts by EPA and USGS to enhance the science base for EPA policy decisions.

The briefing is cosponsored by the Water Environment Federation and the Environmental and Energy Study Institute in cooperation with the U.S. Geological Survey.

For more information contact: Carol Werner, EESI Executive Director at cwerner@eesi.org or Patricia Sinicropi, WEF Legislative Counsel at psinicropi@wef.org

The briefing is free and open to the public. No registration is required.

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NAWQA Pesticide National Synthesis Project

Publications - CIRC 1291

New report released:

The Quality of Our Nation's Waters

Pesticides in the Nation's Streams and Ground Water, 1992-2001

This release marks the completion of NAWQA's decadal assessment on pesticide occurrence and concentrations in streams and ground water based on results from 51 studies across the Nation. The U.S. Geological Survey (USGS) assessment provides the most comprehensive national-scale analysis to date of pesticide occurrence, distribution and sources, and potential for effects on humans, aquatic life, and wildlife. The assessment also begins to examine two important topics with implications for the future—prediction of pesticides in unmonitored areas and long-term trends.

This publication is available for download in PDF format

Available companion products and supporting materials:

- Companion USGS Fact Sheet 2006-3028 (6 pages)
- Briefing sheet prepared for a congressional briefing in Washington D.C. on March 3, 2006 (2 pages)
- Frequently Asked Questions (FAQs)
- Press release
- Supporting technical information, including maps on pesticide use; graphs, maps, and tables in the USGS Circular with explanations and downloadable data; and detailed information on NAWQA's sampling methodology, monitoring design, and analyses (available on-line only)

A full listing of NAWQA activities is available at: http://water.usgs.gov/nawqa/

For additional information on the pesticide assessment, please contact:
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Page Contact Information: Bob Gilliom
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Fact Sheet 2006-3028

March 2006

Pesticides in the Nation's Streams and Ground Water, 1992–2001—A Summary

The PDF for the report is 3,747 kb

The use of pesticides to control weeds, insects, and other pests has resulted in a range of benefits, including increased food production and reduction of insect-borne disease, but also raises questions about possible adverse effects on the environment, including water quality. A decadal assessment by the National Water-Quality Assessment (NAWQA) Program of the United States Geological Survey (USGS) provides the most comprehensive national-scale analysis to date of pesticide occurrence and concentrations in streams and ground water, based on results from studies completed during 1992–2001. Among the major findings are that pesticides are frequently present in streams and ground water, are seldom at concentrations likely to affect humans, but occur in many streams at concentrations that may have effects on aquatic life or fish-eating wildlife. This Fact Sheet highlights national findings regarding pesticide occurrence, distribution and sources, and the potential for effects on humans, aquatic life, and fish-eating wildlife. It serves as a companion product to the USGS Circular entitled "The Quality of Our Nation's Waters—Pesticides in the Nation's Streams and Ground Water, 1992–2001."

Pesticide Occurrence

Pesticides and degradates are typically present throughout most of the year in streams draining watersheds with substantial agricultural or urban areas, but are less common in ground water.

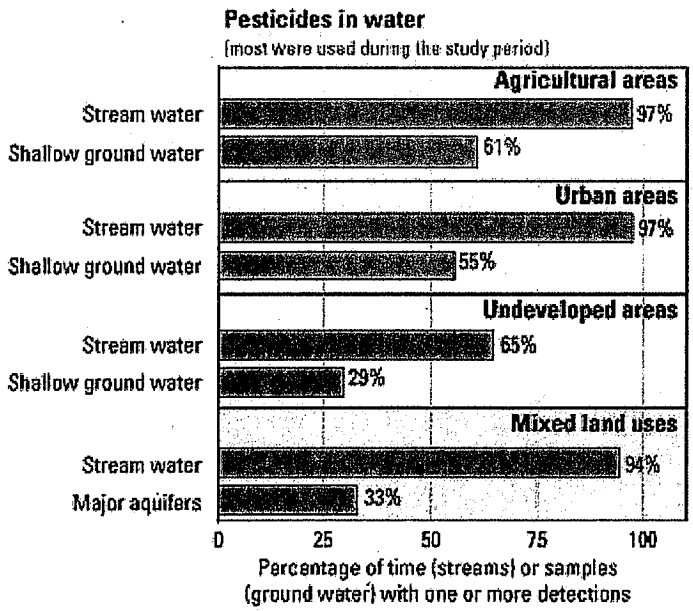
At least one pesticide was detected in water from all streams studied and, as shown in the graph below, pesticide compounds were detected throughout most of the year in water from streams with agricultural (97 percent of the time), urban (97 percent), or mixed-land-use watersheds (94 percent). In addition, organochlorine pesticides (such as DDT) and their degradates and by-products were found in fish and bed-sediment samples from most streams in agricultural, urban, and mixed-land-use watersheds—and in more

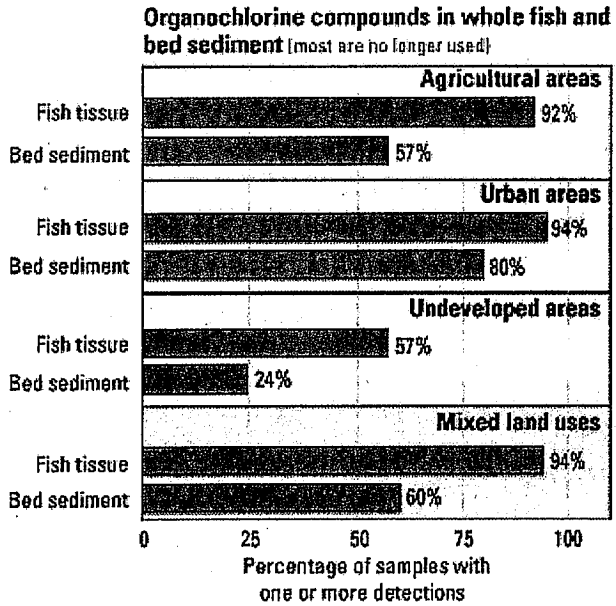
than half the fish from streams with predominantly undeveloped watersheds. Most of the organochlorine pesticides have not been used in the United States since before the NAWQA studies began, but their continued presence demonstrates their persistence in the environment.

Pesticides were less common in ground water than in streams. They occurred most frequently in shallow ground water beneath agricultural and urban areas, where more than 50 percent of wells contained one or more pesticide compounds. About one-third of the deeper wells sampled, which tap major aquifers used for water supply, contained one or more pesticides or degradates.

The findings show that streams are most vulnerable to pesticide contamination, but ground water also merits careful monitoring—especially in agricultural and urban areas. Shallow ground water in some of these areas is used for drinking water and ground-water contamination is difficult to reverse once it occurs.

The occurrence of pesticides in streams and ground water does not necessarily cause adverse effects because detections were often at low concentrations. NAWQA's assessment of potential effects is based on comparing measured concentrations to water-quality benchmarks, as described on the following page. Benchmarks are estimates of the concentrations above which pesticides may have adverse effects on humans, aquatic life, or fish-eating wildlife. For example, less than 10 percent of NAWQA stream sites and about 1 percent of wells had concentrations greater than a human-health benchmark.





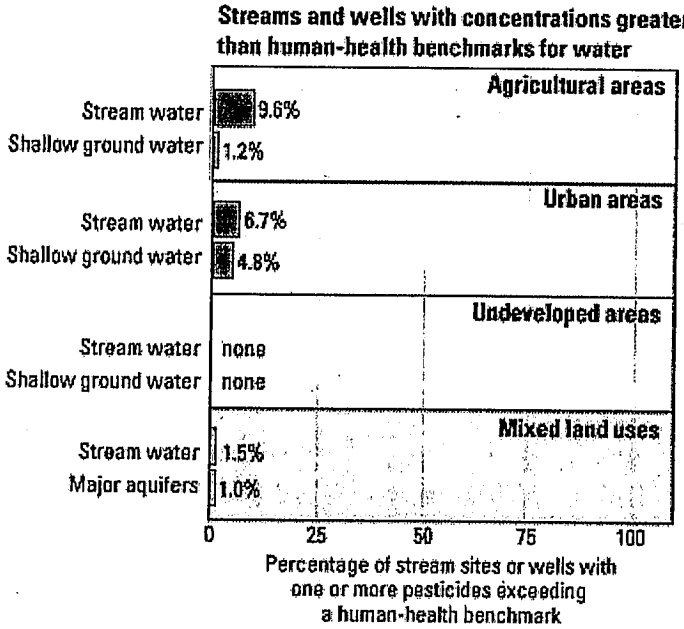
Potential for Effects on Human Health

Concentrations of pesticides in streams and ground water were typically below water-quality benchmarks for human health.

No streams draining undeveloped watersheds and only one stream with a mixed-land-use watershed had concentrations greater than a human-health benchmark. Annual mean concentrations of one or more pesticides exceeded a human-health benchmark in 8 of 83 agricultural streams and in 2 of 30 urban streams. Agricultural streams located in the Corn Belt (Illinois, Indiana, Iowa, Nebraska, Ohio, and parts of adjoining States) and the Mississippi River Valley accounted for most concentrations that exceeded benchmarks—all by atrazine, cyanazine (no longer in use by the end of the study), or dieldrin (no longer in use when the study began). The two urban streams where benchmarks were exceeded are in Texas (diazinon) and Hawaii (dieldrin).

None of the NAWQA stream sites were located at drinking-water intakes. For perspective, however, the Nation's 1,679 public water-supply intakes on streams were evaluated in the context of NAWQA land-use classifications and pesticide findings. Eighty-seven percent of the water-supply intakes are on streams draining undeveloped and mixed-land-use watersheds and are therefore unlikely to withdraw water with concentrations that are greater than a human-health benchmark. The likelihood of pesticide concentrations exceeding a human-health benchmark is greatest for those streams draining agricultural or urban watersheds, which account for about 12 and 1 percent, respectively, of public water-supply intakes on streams.

Human-health benchmarks were seldom exceeded in ground water. One or more pesticides exceeded a benchmark in about 1 percent of the 2,356 domestic and 364 public-supply wells that were sampled. The greatest proportion of wells with a pesticide concentration greater than a benchmark was for those tapping shallow ground water beneath urban areas (4.8 percent). The urban wells with benchmark exceedances included 1 public-supply, 3 domestic, and 37 observation wells. All concentrations greater than a benchmark were accounted for by dieldrin (72 wells), dinoseb (4), atrazine (4), lindane (2), and diazinon (1).



Screening-Level Assessment of Potential Effects

The potential for pesticides to adversely affect human health, aquatic life, or fish-eating wildlife was evaluated by a screening-level assessment similar in concept to U.S. Environmental Protection Agency (USEPA) screening-level assessments. The screening-level assessment is primarily intended to identify and prioritize needs for further investigation and is not a substitute for comprehensive risk assessment, which includes additional factors. Concentrations of pesticides measured at NAWQA sampling sites were compared with water-quality benchmarks derived from standards and guidelines established by USEPA, toxicity values from USEPA pesticide risk assessments, and selected guidelines from other sources. Most of the benchmarks are estimates of no-effect levels, such that concentrations below the benchmarks are expected to have a low likelihood of adverse effects and concentrations above a benchmark may have adverse effects, with the likelihood increasing as the concentration increases.

Potential for Effects on Aquatic Life and Wildlife

Concentrations of pesticides were greater than water-quality benchmarks for aquatic life and (or) fish-eating wildlife in more than half of the streams with substantial agricultural and urban areas in their watersheds.

Of the 178 streams sampled nationwide that have watersheds dominated by agricultural, urban, or mixed land uses, 56 percent had one or more pesticides in water that exceeded at least one aquatic-life benchmark. Urban streams had concentrations that exceeded one or more benchmarks at 83 percent of sites—mostly by the insecticides diazinon, chlorpyrifos, and malathion—although frequencies of exceedance declined during the study period. Concentrations exceeded benchmarks in 95 percent of urban streams sampled during 1993–1997 and in 64 percent of streams during 1998–2000. Agricultural streams had concentrations that exceeded one or more benchmarks at 57 percent of sites—most frequently by chlorpyrifos, azinphos-methyl, atrazine, *p,p'*-DDE, and alachlor. As the use of alachlor declined through the study period, its benchmark exceedances also declined, with none during the last 3 years of study.

Aquatic-life benchmarks for organochlorine pesticide compounds in bed sediment also were frequently exceeded in urban areas (70 percent of urban stream sites). Most compounds that exceeded aquatic-life benchmarks for sediment were derived from organochlorine pesticides that have not been used since before the study began, such as DDT, chlordane, aldrin and dieldrin. In agricultural streams, aquatic-life benchmarks were exceeded at 31 percent of sites—most often by DDT compounds and dieldrin.

Comparisons of concentrations of organochlorine compounds in whole fish with wildlife benchmarks indicate a wide range of potential for effects on fish-eating wildlife. The ranges of percentages shown on the graph below reflect the uncertainties in benchmarks for fish-eating wildlife due to the lack of consensus on national-scale benchmarks or toxicity values. Similar to bed sediment, benchmarks for fish were exceeded most often by compounds related to DDT, dieldrin, and chlordane in urban streams, and by DDT compounds, dieldrin, and toxaphene in agricultural streams in areas where historical use on crops was most intense.

Assessment and management of the potential effects of pesticides on aquatic life and wildlife are complicated by the combined presence in streams of (1) currently used pesticides and degradates, and (2) organochlorine pesticide compounds derived from pesticides that were largely banned prior to 1990. The widespread potential for adverse effects shown by the screening-level assessment—combined with the uncertainty due to the preliminary nature of the assessment and the complexity of pesticide exposure—indicate a continuing need to study the effects of pesticides on aquatic life and wildlife under the conditions of pesticide exposure that occur in the environment.

Frequently Detected Pesticides and Relations to Land Use and Pesticide Use

Pesticides detected most frequently in streams and ground water are among those used most heavily during the study or in the past. Their occurrence follows patterns in land use and use intensity, with additional influence—especially for ground water—by natural

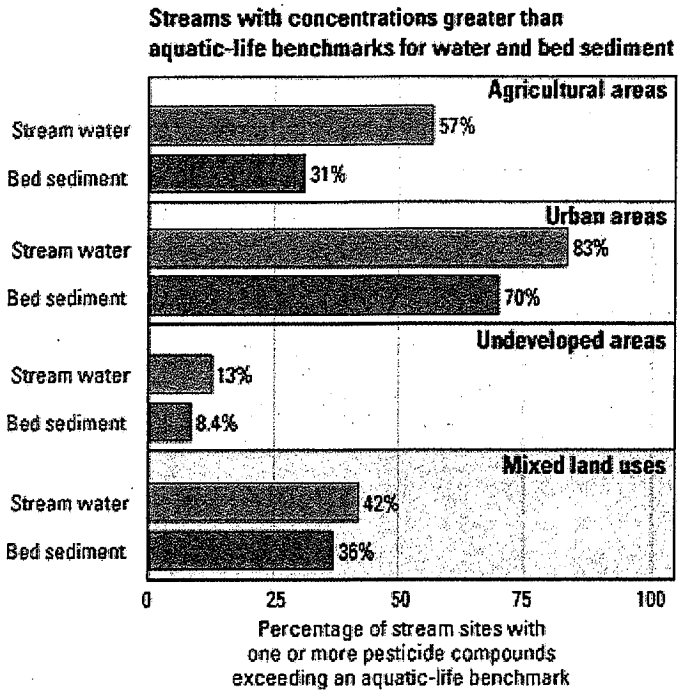
factors and management practices.

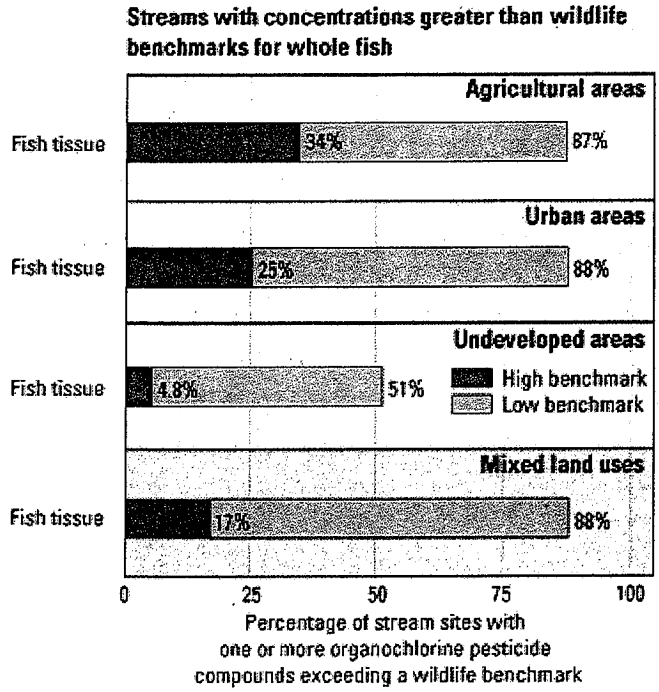
The most frequently detected herbicides that are used mainly for agriculture—atrazine, metolachlor, cyanazine, alachlor, and acetochlor—generally were detected most often and at the highest concentrations in water samples from streams in agricultural areas with their greatest use, particularly in the Corn Belt. Five herbicides commonly used in urban areas—simazine, prometon, tebuthiuron, 2,4-D, and diuron—and three commonly used insecticides—diazinon, chlorpyrifos, and carbaryl—were most frequently detected in urban streams throughout the Nation, often at higher concentrations than in agricultural streams. Total DDT was measured at some of the highest concentrations in bed sediment and fish in parts of the Southeast and in parts of California, Oregon, and Washington, where DDT was historically used on cotton, tobacco, orchards or other crops.

Land use and pesticide use are not the only factors influencing the occurrence of pesticides. Natural features and land-management practices also affect their distribution, particularly in ground water. Ground water is most vulnerable to contamination in areas with highly permeable soil and aquifer materials and where drainage practices do not divert recharge to streams and other surface water.

Pesticide concentrations in stream water also vary by season, with lengthy periods of low concentrations punctuated by seasonal pulses of much higher concentrations. For example, in streams that drain farmland throughout most of the Corn Belt, concentrations of herbicides were generally highest during spring runoff following pesticide application. Similarly, concentrations of diazinon were highest during the winter in parts of the San Joaquin Valley, California, when applications to dormant almond orchards were followed by rainfall.

Understanding the correlations of pesticide occurrence with the amounts and characteristics of pesticides used can help managers to anticipate and prioritize the pesticides most likely to affect water quality in different land-use settings. Some hydrologic settings where ground water is least vulnerable to contamination are those where streams are most vulnerable, and vice versa. The entire hydrologic system and its complexities, therefore, need to be considered in evaluating the potential for pesticide contamination of streams and ground water. In addition, seasonal patterns in pesticide concentrations are important to consider, both in managing the quality of drinking water withdrawn from streams in agricultural and urban settings and in evaluating the potential for adverse effects on aquatic life. Effective management of streams may require increased monitoring—including high-frequency sampling during seasons when intense pesticide use coincides with periods of high runoff—so that periods with elevated pesticide concentrations are adequately characterized.





Mixtures and Degradates

Pesticides most commonly occur as mixtures of multiple compounds, rather than individually, including degradates resulting from the transformation of pesticides in the environment.

Streams in agricultural and urban areas almost always contained complex mixtures of pesticides and degradates. More than 90 percent of the time, water samples from streams with agricultural, urban, or mixed-land-use watersheds contained 2 or more pesticides or degradates, and about 20 percent of the time they had 10 or more. Mixtures were less common in ground water. Nevertheless, about half of the shallow wells in agricultural areas and about a third of shallow wells in urban areas contained 2 or more pesticides and degradates—less than 1 percent had 10 or more. The herbicides atrazine (and its degradate, deethylatrazine), simazine, metolachlor, and prometon were common in mixtures found in streams and ground water in agricultural areas. The insecticides diazinon, chlorpyrifos, carbaryl, and malathion were common in mixtures found in urban streams.

Degradates are often as common in streams and ground water as their parent pesticides. For example, atrazine, the most heavily used herbicide in the Nation during the study period, was found together with one of its several degradates, deethylatrazine, in about 75 percent of stream samples and about 40 percent of ground-water samples collected in agricultural areas across the Nation. Degradates are particularly important in ground water, which moves relatively slowly through soils and aquifers, providing the extended

time and conditions favorable for transformation of pesticides. Most degradates are less toxic than their parent pesticide, but some have similar or greater toxicities.

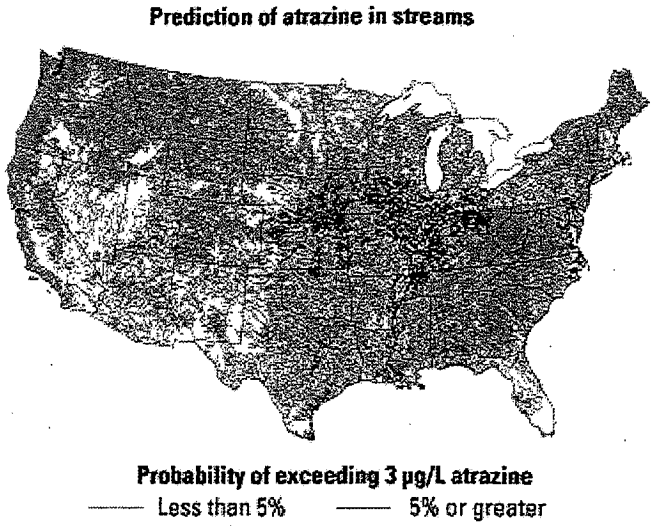
The widespread and common occurrence of pesticide mixtures, particularly in streams, means that the total combined toxicity of pesticides in water and other media often may be greater than that of any single pesticide compound that is present. Continued research is needed on the potential toxicity of pesticide mixtures, including degradates, to humans, aquatic life, and wildlife. NAWQA data on the occurrence and characteristics of mixtures and degradates is helping to target and prioritize toxicity assessments.

From Monitoring to Prediction

National-scale modeling and prediction of pesticide levels in unmonitored areas is increasingly possible for some pesticides, particularly for streams.

NAWQA data are sufficiently extensive to support national statistical models that can be used to estimate the concentrations or occurrence of some pesticides in streams and ground water where they have not yet been measured. Such spatial extrapolation is fundamental to extending NAWQA's findings on sources and factors that affect pesticide occurrence —such as pesticide use and land use, climate, and soil characteristics—to a more comprehensive national assessment that includes unmonitored areas. The NAWQA model for atrazine in streams, for example, can be used to predict the likelihood that the annual average concentration of atrazine in untreated stream water exceeds the USEPA drinking-water standard of 3 micrograms per liter in any stream in the Nation (see map below). Atrazine concentrations were predicted to be highest in the Corn Belt and parts of the southern Mississippi River Valley, where use is high and natural features favor the transport of pesticides by runoff to streams. Streams shown in red on the map are estimated to have more than a 5-percent chance of having an annual mean concentration greater than the USEPA standard. Some of these streams may not be suitable as sources of drinking water without the use of strategies to lower concentrations. These types of analyses can be used to identify locations that have the greatest likelihood of water-quality problems and that are the highest priority for additional monitoring.

Expanding the capability for prediction and extrapolation is a critical step for national water-quality assessment, as well as for cost-effective management of water resources, because both require more information (pesticides, places, and times) than can be directly measured.



Trends in Pesticides

Some trends in pesticide concentrations are already evident, showing responses to regulatory actions and reduced use.

NAWQA findings provide a framework for assessing whether pesticide levels in the Nation's streams and ground water are increasing or decreasing over time. For many streams and aquifers, it is too early to tell whether levels are changing, because historical data are insufficient or too inconsistent. Some trends are evident, however, and a first look at trends shows examples of both decreasing and increasing levels of certain pesticides in streams and ground water.

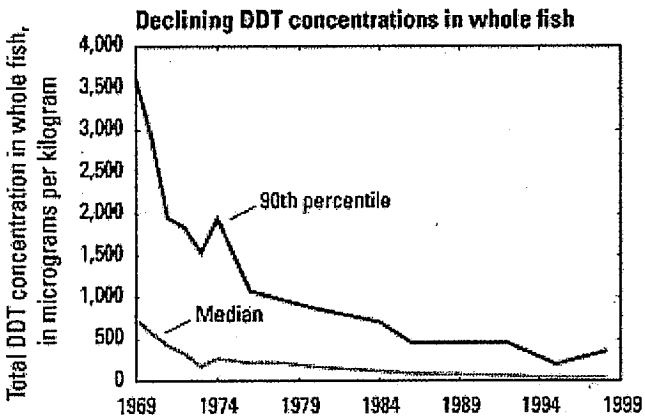
The most complete story of trends in response to regulatory action and reduced pesticide use is the decline in organochlorine pesticide concentrations that followed reductions in use during the 1960s and bans on uses in the 1970s and 1980s. Concentrations of total DDT in fish, for example, decreased rapidly from the 1960s through the 1970s, and then more slowly during the 1980s and 1990s, as documented by data from the U.S. Fish and Wildlife Service and NAWQA. Just as notable as the declines, however, is the finding that persistent organochlorine pesticide compounds still occur at levels greater than benchmarks for fish-eating wildlife in many urban and agricultural streams across the Nation.

In contrast, NAWQA findings show that concentrations of relatively mobile and short-lived pesticides in stream water respond more rapidly to changes in use than the less mobile and more persistent organochlorine insecticides. For example, increases in acetochlor and decreases in alachlor are evident in streams in the Corn Belt, where acetochlor partially replaced alachlor for control of weeds in corn beginning in 1994. The changes in use were reflected quickly in stream concentrations, generally within 1 to 2 years. Similarly, concentrations of diazinon decreased significantly from 1998 to 2004 in 5 of 7 urban and

mixed-land-use streams sampled in the Northeast, consistent with the USEPA-mandated phase-out of nonagricultural uses of diazinon that began in 2002.

Ground water responds more slowly than stream water to changes in pesticide use. A persistent pesticide or degradate can remain in ground water long after its use is discontinued because of the slow rates of ground-water flow and the resulting long residence time of water and pesticides in ground-water flow systems.

Long-term and consistent data for assessing trends is essential for tracking water-quality response to changes in pesticide use and management practices, for providing early warning of unanticipated problems, and for updating and improving models. Long-term monitoring is particularly important for assessing the occurrence of pesticides in ground water and the occurrence of persistent compounds in streams because concentrations change slowly, sometimes taking decades to respond to changes in use.



Priorities for Filling Information Gaps for Pesticides

The NAWQA water-quality assessment serves as a foundation for improving water-resource assessment and management, but major gaps in critical information about pesticides still persist and continue to present challenges to scientists, managers, and policymakers. Some of the most important steps needed to fill gaps are listed below:

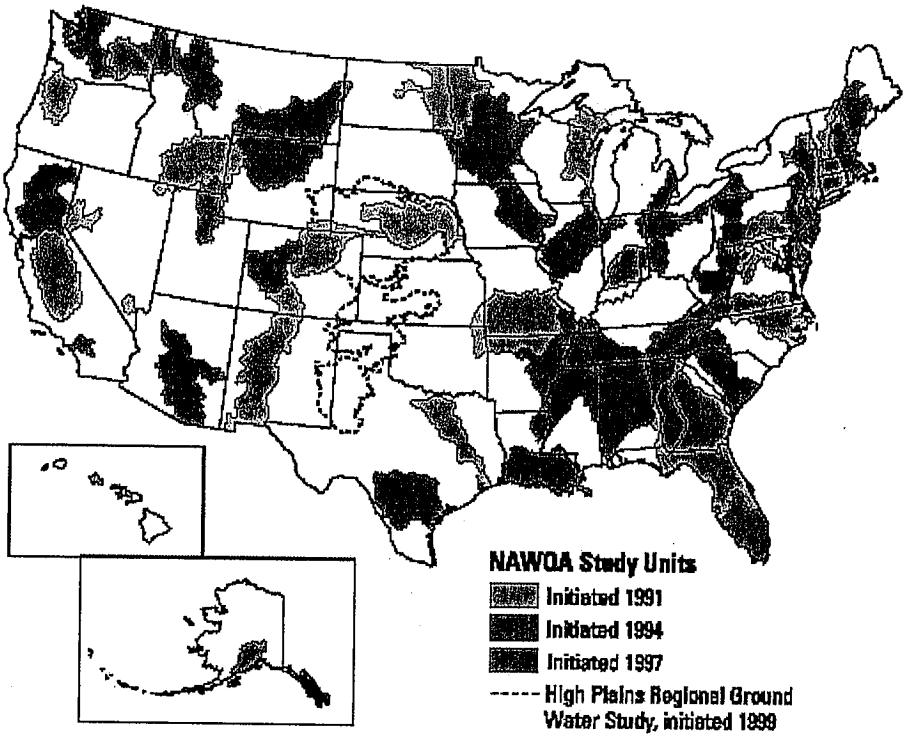
- Improve tracking of pesticide use in agricultural and non-agricultural areas, including amounts, locations, and timing
- Add assessments of pesticides not yet studied, including some already in use as well as new pesticides
- Improve assessment and understanding of degradates, including their distribution and potential effects
- Evaluate toxicities of mixtures and their potential to affect humans, aquatic life, and wildlife

- Evaluate the performance of management practices and their effects on concentrations and transport of pesticides
- Improve methods for prediction of pesticide levels in unmonitored areas
- Sustain and expand long-term monitoring for trends

NAWQA Approach to Pesticide Assessment

NAWQA assessments of pesticides followed a nationally consistent approach in 51 of the Nation's major river basins and aquifer systems, referred to as "Study Units, with 20 Study Units studied during 1992–1995; 16 during 1996–1998; and 15 during 1998–2001. Nationally, water samples for pesticide analysis were collected from 186 stream sites, bed-sediment samples were collected from 1,052 stream sites, and fish samples were collected from 700 stream sites. Ground-water samples were collected from 5,047 wells.

Most water samples were analyzed for 75 pesticides and 8 degradates, including 20 of the 25 most heavily used herbicides and 16 of the 25 most heavily used insecticides. In addition, 32 organochlorine pesticide compounds were analyzed in bed sediment and (or) fish tissue, including 19 pesticides and 13 degradates or manufacturing by-products. Most of the organochlorine pesticides are no longer used in the United States, but organochlorine compounds still persist in the environment.



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By Robert J. Gilliom and Pixie A. Hamilton

Layout and design by Phillip J. Redman

USGS promotes public access to water quality information

This Fact Sheet and the Circular are free of charge and are on the World Wide Web at http://water.usgs.gov/nawqa.

Included at this web site are data used for national summaries of pesticides, maps of chemical use and pesticide occurrence, information on sampling designs and

methodology, and background on data analysis.

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USGS
science for a changing world

Pesticides in the Nation's Streams and Ground Water, 1992-2001—*What findings may mean to human health, aquatic life, and fish-eating wildlife*

The U.S. Geological Survey (USGS) released a report today (March 3, 2006) describing the occurrence of pesticides in streams and ground water during 1992-2001, concluding that pesticides are typically present throughout the year in most streams in urban and agricultural areas of the Nation, but are less common in ground water. Findings show that pesticides are seldom at concentrations likely to affect humans, but do occur in many streams, particularly those draining urban and agricultural areas, at concentrations that may affect aquatic life or fish-eating wildlife.

Pesticide concentrations and potential effects on human health

- Concentrations of individual pesticides analyzed in this study were usually lower than U.S. Environmental Protection Agency (EPA) drinking-water standards and guidelines for human health.
- Less than 10 percent of streams draining agricultural and urban watersheds, and less than 2 percent of streams draining undeveloped watersheds or those with a mix of land uses had concentrations greater than these human-health benchmarks.
- All USGS stream samples were representative of ambient, untreated water, and not finished, treated drinking water. The samples were not collected at drinking-water intakes.
- For perspective, the findings were evaluated in the context of the Nation's 1,679 public water-supply intakes on streams. Eighty-seven percent of these intakes are on streams draining watersheds with undeveloped or mixed land use (as classified by USGS), and are, therefore, unlikely to withdraw water with concentrations greater than a human-health benchmark.
- Pesticides were less common in ground water than streams; less than 1 percent of domestic and public-supply wells sampled by USGS exceeded EPA drinking-water standards and guidelines. Most exceedences were by dieldrin, which is no longer used.

Pesticide concentrations and potential effects on aquatic life and fish-eating wildlife

- Pesticide concentrations exceeded water-quality benchmarks for the protection of aquatic life and (or) fish-eating wildlife in more than one-half of the sampled streams in urban and agricultural areas.
- More than 80 percent of urban streams sampled had concentrations that exceeded one or more benchmarks, mostly by the insecticides diazinon, chlorpyrifos, and malathion, although exceedences declined during the study period (95 percent of urban streams sampled during 1993-1997 and 64 percent during 1998-2000).
- USGS findings show strong relations between the occurrence of pesticides and their use. Some of the frequently detected pesticides, including the insecticide diazinon and the herbicides alachlor and cyanazine, are declining since their uses were reduced or cancelled.

(over)

Briefing sheet prepared for a congressional briefing in Washington, D.C., March 3, 2006

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- DDT, dieldrin, and chlordane—organochlorine pesticides that were no longer in use when the study began—were the most frequently detected compounds in bed sediment and fish in urban and agricultural areas where they accumulate in aquatic ecosystems. Concentrations of these compounds in fish declined following reductions in their use during the 1960s and elimination of all uses in the 1970s and 1980s, and continue to slowly decline.
- Just as notable as the declines, however, is the finding that these organochlorine pesticides still occur at levels greater than benchmarks for aquatic life and fish-eating wildlife in many urban and agricultural streams across the Nation. This is due to their persistence in the environment. Because these compounds tend to adhere to sediment, soil-erosion management could help to reduce the transport of these residual compounds to streams.
- The most common mode of pesticide exposure is to mixtures rather than individual pesticides. The common occurrence of pesticide mixtures, particularly in streams, means that the total combined toxicity of pesticides in water, sediment, and fish may be greater than that of any single pesticide compound that is present.
- Assessments of the potential effects of pesticides on aquatic life and fish-eating wildlife are complicated not only by mixtures of currently used pesticides, but also by the combined presence in streams of currently used pesticides (as well as their degradates) and the historically used organochlorine compounds derived from pesticides that were largely banned prior to 1990.
- Studies of mixtures are still in the early stages, and it may take years for researchers to advance understanding of the actual potential for effects. USGS findings indicate that studies of mixtures should be a high priority.

Context for interpreting pesticide levels and potential effects

- The detection of pesticides alone does not necessarily translate into adverse impacts on humans, aquatic life, or fish-eating wildlife. USGS analytical methods are designed to measure very low concentrations—sometimes parts per trillion—that are well below water-quality benchmarks for most pesticides. Use of these analytical methods is necessary to identify emerging issues and to track changes in concentrations over time.
- The USGS report is not a risk-assessment study and findings should not be confused with risk assessments for specific pesticides by the EPA. However, to place findings in a context for understanding potential effects on human health, aquatic life, and fish-eating wildlife, measured concentrations by USGS were compared to water-quality benchmarks derived from standards and guidelines established by EPA, toxicity values from EPA pesticide risk assessments, and selected guidelines from other sources. Water-quality benchmarks are estimates of concentrations above which pesticides may have adverse effects on human health, aquatic life, or fish-eating wildlife. The USGS screening-level assessment is primarily intended to identify and prioritize needs for further investigation.

How USGS data are used—USGS has worked closely with the EPA during the 10-year study, who uses the data extensively in their exposure and risk assessments for regulating the use of pesticides. For example, EPA used USGS data in its risk assessments for the reevaluation of diazinon, chlorpyrifos, cyanazine and alachlor. Uses of three of these pesticides (diazinon, chlorpyrifos and cyanazine) have now been significantly limited, and usage of alachlor was voluntarily reduced and largely replaced by a registered alternative. The USGS findings show strong relations between the occurrence of pesticides and their use, and point out that some of the frequently detected pesticides, including the insecticide diazinon and the herbicides alachlor and cyanazine, are declining. As new pesticides are approved for use, EPA will continue to need monitoring data to ensure that levels in the environment are safe.

NAWQA Pesticide National Synthesis Project

Publications - CIRC 1291

The Quality of Our Nation's Waters

Pesticides in the Nation's Streams and Ground Water, 1992-2001

Frequently Asked Questions

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Questions related to why, what, where, and when pesticides were assessed in the National Water-Quality Assessment (NAWQA) study

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- What study areas were assessed for pesticides?
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- Did the NAWQA study characterize drinking water?
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- Which pesticides were detected most frequently in fish and bed sediment?

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- How can NAWQA findings guide monitoring strategies?
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Why study pesticides? | BACK TO QUESTIONS |

About 1 billion pounds of conventional pesticides are used each year in the United States to control weeds, insects, and other pests (http://www.epa.gov/oppbead1/pestsales/) . The use of pesticides has resulted in a range of benefits, including increased food production and reduction of insect-borne disease, but also raises questions about possible harm to the environment, including potential effects on drinking-water sources and aquatic life.

How are pesticides released into the environment? | BACK TO QUESTIONS |

Pesticides are released into the environment primarily through their application to agricultural lands, including croplands, orchards, and pastures, and for nonagricultural pest control, such as on lawns and gardens, commercial areas, and rights-of-way. In 2001, agriculture accounted for about three-quarters of total national use, with the remaining quarter being applied for a wide range of non-agricultural purposes. The National Water-Quality Assessment (NAWQA) Program focused primarily on "nonpoint" sources of pesticides resulting from applications for pest management, although some sites downstream from major metropolitan areas also may be influenced by point sources, such as discharges from wastewater-treatment plants.

Where can the general public get information on individual pesticide | BACK TO QUESTIONS |

Information about selected pesticides can be accessed in EPA fact sheets http://www.epa.gov/pesticides/factsheets/index.htm . These fact sheets provide technical information on pesticides; for example, information about newly registered pesticides and re-registration eligibility decisions made on individual organophosphate pesticides, and information on biological pesticides. The National Pesticide Information Center, a cooperative effort of EPA and Oregon State University, also has many informative fact sheets on a myriad of individual pesticides (http://npic.orst.edu/npicfact.htm)

What pesticides did NAWQA study? | BACK TO QUESTIONS |

NAWQA measured the broadest range of pesticide compounds ever addressed in a national study. Even so, many pesticides in current use and most pesticide degradates were not measured. Most NAWQA water samples were analyzed for 75 pesticides and 8 degradates, including 20 of the 25 most heavily used herbicides and 16 of the 25 most heavily used insecticides, but few fungicides, fumigants, or other types of pesticides. In addition, 32 organochlorine pesticide compounds were analyzed in bed sediment and (or) fish tissue, including 19 parent pesticides and 13 degradates or manufacturing by-products. Most of the organochlorine pesticides are no longer used in the United States, but the parent compounds, degradates, or by-products still may persist in the environment. Although pesticide compounds analyzed by NAWQA represent many of the heavily used herbicides and insecticides, they only included a fraction of all pesticides currently in use, and few of their degradates. NAWQA findings can provide insights about what to expect for those pesticides not measured, but must be considered as only a partial assessment of currently used pesticides.

What study areas were assessed for pesticides? | BACK TO QUESTIONS |

NAWQA assessments of pesticides were conducted in 51 major river basins and aquifer systems (referred to as "Study Units") across the Nation, from Florida to the Pacific Northwest and including Hawaii and Alaska, plus the High Plains Regional Ground Water Study. Collectively, these areas account for more than 70 percent of total water use (excluding thermoelectric and hydropower), and more than 50 percent of the Nation's supply of drinking water. The areas are representative of the Nation's major hydrologic landscapes, and agricultural and urban sources of pesticides. (Go to the NAWQA web site for a map of study units.)

How do the individual NAWQA study areas fit into a national design? | BACK TO QUESTIONS |

Each of the studies in the 51 major river basins and aquifers systems throughout the 10-year period of analysis followed a nationally consistent approach and used uniform methods of sampling and analysis. Water-quality conditions in a specific locality or watershed can be compared to those in other geographic regions and at different periods of time. Collectively, the assessments advance an understanding of the quality of our Nation's waters and whether water quality is getting better or worse over time. Information at different scales helps to bridge local, State, regional, and national efforts to manage the Nation's water resources.

Are other national assessments of pesticides available? | BACK TO QUESTIONS |

The NAWQA assessment of pesticides provides the most comprehensive national-scale analysis to date of pesticide occurrence and concentrations in streams and ground water. Data are also collected by States, Tribes, utilities, localities, and other organizations but not at the national scale.

Did the NAWQA study address changes and trends during the 10-year period of study (1992-2001)? | BACK TO QUESTIONS |

In general, no, because the NAWQA assessment was not designed to look at changes in pesticides (trends) that may have occurred during the period of study (1992-2001). Rather, the 10-year period reflects the total time for NAWQA to sample and assess pesticides in all 51 Study Units across the Nation. In order to effectively study the large areas, given the logistical and budget constraints, Study Units were assessed on a rotational schedule, with intensive data collection for the first 20 study units from 1992-1995, 16 study units from 1996-1998, and 15 study units and the High Plains study from 1999-2001. The combined results for the 1992-2001 study-period represent a composite picture of the decade. Most analyses of pesticides in stream water in the national compilation of data are based on one year of data for each site, generally representing the single most complete year of sampling, in order to give equal influence to each stream. Data analyses for ground water were based on one sample per well and data analyses for stream bed sediment and fish tissue were based on one sample per site.

NAWQA findings from the 1992-2001 national assessment provide a framework for trends and future assessment on whether pesticide levels in the Nation's streams and ground water are increasing or decreasing over time. The major thrust for evaluating trends will, therefore, occur in the subsequent decade of NAWQA studies when selected streams and wells are systematically reassessed. However, an

initial look at some changes that did emerge in the first ten-year assessment is noted below (see question related to changes).

How were NAWQA sampling sites selected? | BACK TO QUESTIONS |

NAWQA sampling sites are part of a "targeted" monitoring design that focuses on understanding the relations between water-quality conditions and the natural and human factors that cause those conditions. Monitoring sites are therefore not selected randomly within a grid, but because they represent certain human activities, environmental settings, or hydrologic conditions during different seasons or times of year. For example, sites may be selected to assess the effects of agriculture and urban development on pesticide and nutrient contamination in streams. Sampling locations for streams and ground water were selected or "targeted" to represent specific agricultural, urban, undeveloped, and mixed land-use settings of greatest significance to water resources in the primary hydrologic settings within each of the 51 Study Units. Sites were selected by local Study Unit teams in collaboration with local organizations, States, and Tribes, as well as NAWQA national teams. Streams and ground water were sampled most intensively in agricultural and urban areas because of the importance of assessing pesticide occurrence in areas where the compounds are used most intensively. This NAWQA approach focuses on achieving an understanding of the relations between water-quality conditions—such as related to pesticide occurrence—and the natural and human factors that cause those conditions. The assessment did not focus on specific sites with known water-quality problems or narrowly defined "issues of the day," but rather on the condition of the total resource.

How does the NAWQA design and sampling-site selection differ from a probabilistic-monitoring design? | BACK TO QUESTIONS |

NAWQA uses a "targeted" monitoring design in which sites are not selected randomly within a grid, but because the represent certain human activities, land uses, environmental settings, or hydrologic conditi during different seasons or times of year (see question above). Such monitoring is useful to answer questions related to water-quality conditions and the natural and human factors that cause those conditions. Probabilistic monitoring involves random selection of sites across a certain geographic area. Such monitoring is useful for getting an unbiased, broad geographic snapshot of "whether or not there is a problem" and "how big the problem is." Many probabilistic monitoring programs implemented by the States and the U.S. Environmental Protection Agency (EPA) provide quantitative, statistically valid estimates of, for example, the number of impaired stream miles with a region or State (http://www.epa.gov/emap/) . Probabilistic monitoring and more "targeted" monitoring (such as by NAWQA) answer different types of questions and provide different types of information that are both critical for understanding the ambient resource. Ideally, data-collection and laboratory analytical methods should be consistent and comparable between the two methods so that findings can be integrated and conclusions can go beyond what each can provide individually.

What defines an "agricultural" and "urban" stream site in the NAWQA study? | BACK TO QUESTIONS |

"Agricultural" streams drain watersheds that contain greater than 50 percent agricultural land and less than 5 percent urban land. The agricultural streams sampled are diverse in climate, geography, and crop types, and span coastal, desert, and temperate environmental settings. Agricultural settings included, for example, areas dominated by production of corn in the Midwest; wheat in the Great Plains; poultry in the east; pineapple in Hawaii; and vegetables in California. "Urban" streams drain watersheds that contain greater than 25 percent urban land and less than 25 percent agricultural land. The urban settings studied were primarily residential, typically with low-to-medium population densities (300 to 5,600 people per

square mile).

Did the NAWQA study characterize drinking water? | BACK TO QUESTIONS |

None of the USGS stream sampling sites were located at drinking-water intakes. NAWQA assessments characterized the quality of untreated, ambient water resources in the Nation's streams and ground water, and not the quality of finished, treated drinking water (as would be done by monitoring water from water-treatment plants or from household taps). By focusing on the quality of streams and ground water in their present conditions (ambient water quality), NAWQA complements many Federal, State, and local drinking-water monitoring programs.

How many streams and wells were sampled? | BACK TO QUESTIONS |

Water samples for pesticide analysis were collected from 186 streams within the 51 Study Units, bed-sediment samples were collected from 1,052 stream sites, and fish samples were collected from 700 stream sites. Ground-water samples were collected from 5,047 wells in 187 ground-water study areas (each study generally included 20 to 30 wells). Shallow ground water (generally less than 20 feet below the water table) was sampled in agricultural, urban, and undeveloped areas, mostly from new or existing observation wells or domestic supply wells. Deeper ground water was sampled from wells that tap major aquifers, which was almost exclusively from existing wells used either for domestic or public supply. Fewer stream sites were sampled for water because the study of each site requires numerous water samples over time, whereas bed-sediment, fish, and ground water studies were based on one sample per site.

How many samples were collected at each site? | BACK TO QUESTIONS |

Water samples were collected from streams throughout the year, including high-flow and low-flow conditions. Sampling was most intensive during the time of highest pesticide use and runoff—generally weekly or twice monthly for a 4- to 9-month period. During the active study periods in each Study Unit, most sites were sampled 20 to 40 times a year, with the most intense sampling during the seasonal periods of highest pesticide use. Data analyses for ground water was based on one sample per well. Repeated sampling, such as that conducted at stream sites, was not included for ground water because of the comparatively slow rate of change in most ground-water systems, relative to streams.

How are NAWQA data used by others? | BACK TO QUESTIONS |

Local, State, Tribal, and national stakeholders use NAWQA information to design and implement strategies for managing, protecting, and monitoring water resources in many different hydrologic and land-use settings across the Nation (http://water.usgs.gov/nawqa/xrel.pdf). For example, the Alabama Department of Agriculture and Industries states that "the NAWQA Program has filled a tremendous void in the pesticide data that the State of Alabama must acquire in the development of the EPA-mandated State Pesticide Management Plan. The NAWQA data are used to make important determinations and the plan can target the areas of greatest importance."

USGS has worked closely with the U.S. Environmental Protection Agency (EPA) during the 10-year study. EPA uses the data extensively in their exposure and risk assessments for regulating the use of pesticides. (Learn more about how EPA regulates certain chemicals or types of pesticides at http://www.epa.gov/pesticides/factsheets/reg_fs.htm). For example, EPA used USGS data in its risk

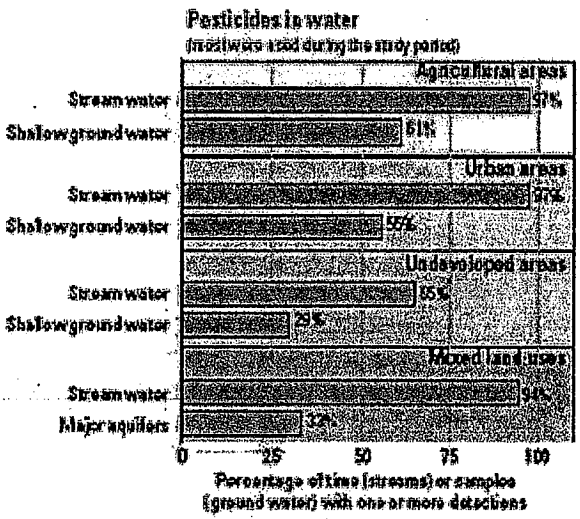
assessments for the reevaluation of diazinon, chlorpyrifos, cyanazine and alachlor. Uses of three of the pesticides (diazinon, chlorpyrifos and cyanazine) have now been significantly limited, and usage of alachlor was voluntarily reduced and largely replaced by a registered alternative. The USGS findings show strong relations between the occurrence of pesticides and their use, and point out that some of the frequently detected pesticides, including the insecticide diazinon and the herbicides alachlor and cyanazine, are declining. As new pesticides are approved for use, EPA will continue to need monitoring data to ensure that levels in the environment are safe.

EPA and USGS have also collaborated in developing statistical models to predict concentrations of atrazine and other pesticides in streams across the country. The models increase EPA's capability to identify areas predicted to have significant impacts on water quality from pesticide use, especially where monitoring data are not available. The model results also are used to identify locations where additional monitoring is most needed to evaluate the ecological condition of watersheds.

Are pesticides present in stream water and ground water? | BACK TO QUESTIONS |

The simple answer is "yes"—pesticides are frequently present. However, this answer needs to be broken down by streams versus ground water, which have quite different levels of occurrence; and by currently used pesticides versus pesticides that are no longer used.

In stream water, one or more pesticide compounds were almost always present at detectable levels (represented below by the upper bar in each land-use category). There were detectable concentrations in water more than 90 percent of the time across all streams sampled that had significant agricultural or urban land use in their watersheds. Undeveloped streams had detectable pesticides more than half the time. Most of the pesticides measured in water were in use during the study period. Ground water had frequent detections in well samples compared to streams, but pesticides nevertheless were found in more than half the wells tapping shallow ground water in agricultural and urban areas (represented by the lower bar in each land-use category). There were detections in one third of the existing production wells sampled in major aquifers.



How many different kinds of pesticides were detected in water? |

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BACK TO QUESTIONS |

About 40 pesticide compounds, of the more than 100 examined by NAWQA, accounted for most detections in water, fish, and sediment. Twenty five pesticide compounds, including 24 pesticides and 1 degradate, were each detected in more than 10 percent of water samples from streams in agricultural, urban, or mixed land-use settings, or in more than 2 percent of wells in agricultural or urban settings. Additional information about selected pesticides can be accessed in EPA fact sheets http://www.epa.gov/pesticides/factsheets/index.htm . These fact sheets provide technical information on pesticides; for example, information about newly registered pesticides and re-registration eligibility decisions made on individual organophosphate pesticides, and information on biological pesticides. The National Pesticide Information Center, a cooperative effort of EPA and Oregon State University, also has many informative fact sheets on a myriad of individual pesticides (http://npic.orst.edu/npicfact.htm)

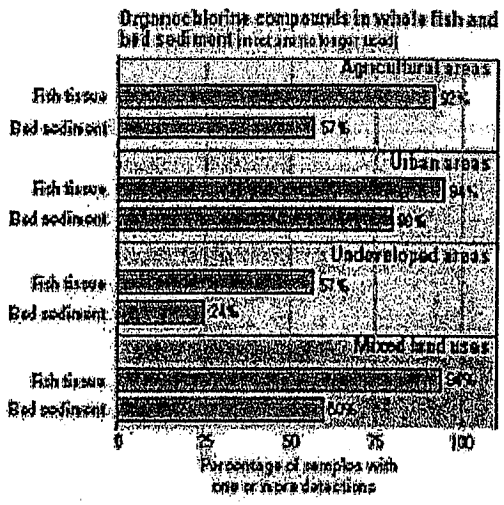
Which pesticides were detected most frequently in water? | BACK TO QUESTIONS |

The pesticide compounds detected most frequently in streams and ground water were mainly those with the most extensive use in agricultural and urban areas —either during the study period or historically—and those with the greatest mobility and (or) persistence in the hydrologic system.

The specific pesticides most frequently detected in water included herbicides used most heavily in agriculture, herbicides with major nonagricultural uses, and several insecticides. Three herbicides mainly used for agricultural purposes—atrazine, metolachlor, and cyanazine—were among the most frequently detected in agricultural streams and were more frequently detected in agricultural streams than in urban streams. In contrast, three herbicides commonly used in urban areas—simazine, prometon, and tebuthiuron—were detected more often in urban streams than in agricultural streams. Finally, insecticides were found much more frequently in urban streams than in most agricultural streams, with diazinon, chlorpyrifos and carbaryl most frequently detected. The same relative patterns were observed in ground water, but at much lower frequencies of detection. Overall, results for each individual pesticide reveal a unique pattern of distribution resulting from its primary uses, the distributions of land uses and crops, and the chemical and physical properties of the pesticide.

Were pesticides present in stream bed sediment and fish? | BACK TO QUESTIONS |

In streams, organochlorine compounds, such as DDT and their degradates and by-products were found in fish and bed-sediment samples from most streams in agricultural, urban, and mixed-land-use watersheds and in more than half the fish from streams with predominantly undeveloped watersheds. Most of the organochlorine pesticides have not been used in the United States since before the NAWQA studies began, but their continued presence demonstrates their persistence in the environment. More than 90 percent of fish-tissue samples from streams with developed watersheds had one or more detectable compounds and most sites had detections in bed sediment as well.



Which pesticides were detected most frequently in fish and bed sediment? | BACK TO QUESTIONS |

Thirteen organochlorine pesticide compounds, including historically used parent pesticides and their degradates and by-products, were each found in more than 10 percent of fish or bed-sediment samples from streams draining watersheds with either agricultural, urban, or mixed land use. In fish tissue, as well as bed sediment, the most frequently detected organochlorine compounds were those related to DDT, chlordane, and dieldrin. All uses of DDT were cancelled in 1972 and all uses of chlordane and dieldrin were cancelled by 1988.

Do pesticides only occur in agricultural areas? | BACK TO QUESTIONS |

No, pesticides occur in all land-use settings and occur where they are used. In fact, one of the major findings in the NAWQA study is the strong correlation between pesticide occurrence and land use and use intensity. The most intensive pesticide applications are in agricultural and urban areas, including substantial use for home, lawn, and garden pest control in residential areas.

How do pesticides differ between agricultural and urban areas? | BACK TO QUESTIONS |

The pesticides and degradates detected most frequently in streams and ground water in agricultural and urban areas were mainly those with the most extensive use—either during the study period or historically. Five herbicides commonly used in urban areas—simazine, prometon, tebuthiuron, 2,4-D, and diuron—and three commonly used insecticides—diazinon, chlorpyrifos, and carbaryl—were most frequently detected in the urban streams sampled, often at higher concentrations than in agricultural streams. The most frequently detected herbicides that are used mainly for agriculture—atrazine, metolachlor, cyanazine, alachlor, and acetochlor—generally were detected most often and at the highest concentrations in water samples from streams in agricultural areas with their greatest use, particularly in the Corn Belt.

What is the relation between pesticide use and pesticide occurrence? |

BACK TO QUESTIONS |

Pesticide use is a major determining factor in pesticide occurrence, particularly in streams. For example, concentrations of atrazine, metolachlor, simazine, acetochlor, 2,4-D, chlorpyrifos, and diazinon in stream samples directly correlate with where they are used on crops. Some of the highest concentrations of atrazine were observed in streams within the Corn Belt and other areas where corn is a primary crop and where the herbicide is most heavily used. The NAWQA study clearly indicates that as pesticide use changes, such as in response to such factors as regulations and market forces, levels of pesticides in water samples change. Findings therefore must be evaluated in context of chemical use, during and after the study. For example, levels of the herbicide alachlor declined in streams in the Corn Belt (generally including Illinois, Indiana, Iowa, Nebraska, and Ohio, as well as parts of adjoining States) throughout the study period as its use on corn and soybeans declined, with no levels greater than its aquatic-life benchmark by the end of the study. In contrast, both the use and the levels of atrazine, the most heavily used herbicide in the Corn Belt region, remained relatively high throughout the study period.

The U.S. Environmental Protection Agency (EPA), which has worked closely with the USGS during the 10-year study, uses the data extensively in their exposure and risk assessments for regulating the use of pesticides (Learn more about how EPA regulates certain chemicals or types of pesticides at http://www.epa.gov/pesticides/factsheets/reg_fs.htm). For example, EPA used USGS data in its risk assessments for the reevaluation of diazinon, chlorpyrifos, cyanazine and alachlor. Uses of three of these pesticides (diazinon, chlorpyrifos and cyanazine) have now been significantly limited, and usage of alachlor was voluntarily reduced and largely replaced by a registered alternative. The USGS findings show strong relations between the occurrence of pesticides and their use, and point out that some of the frequently detected pesticides, including the insecticide diazinon and the herbicides alachlor and cyanazine, are declining. As new pesticides are approved for use, EPA will continue to need monitoring data to ensure that levels in the environment are safe.

Why is understanding pesticide use important? | BACK TO QUESTIONS |

The strong correlations of pesticides found with the amounts and characteristics of pesticides used can help managers to anticipate and prioritize the pesticides most likely to affect water quality in different land-use settings. For those pesticides that are still being applied, reducing their use is likely to be the most effective way to reduce their concentrations in the hydrologic system, particularly for streams. For organochlorine pesticide compounds derived from past use, farm management practices that control the erosion of soil are likely to help reduce their transport to streams.

Do we have adequate data on pesticide use? | BACK TO QUESTIONS |

Unfortunately, current chemical-use information is generally insufficient—and in urban areas essentially unavailable—for local and regional water-resource management and decision making. Improved tracking of chemical use is needed to definitely attribute specific pollutants to different sources in nonpoint runoff and support management actions.

What additional factors complicate pesticide occurrence? | BACK TO QUESTIONS |

Three factors complicate the occurrence of pesticides in streams and ground water, including strong seasonal patterns, the prevalence of mixtures of pesticides, and the frequent occurrence of degradates.

(see the next 3 questions below)

How often do mixtures occur? | BACK TO QUESTIONS |

Pesticides almost always occur as complex mixtures of multiple compounds, rather than individually, whether in water, bed sediment, or fish tissue. Throughout most of the year (more than 90 percent of the time), water samples from streams with agricultural, urban, or mixed-land-use watersheds contained 2 or more pesticides or degradates, and about 20 percent of the time they had 10 or more. Mixtures were less common in ground water. Nevertheless, about half of the shallow wells in agricultural areas and about a third of the shallow wells in urban areas contained 2 or more pesticides and degradates—less than 1 percent had 10 or more. The co-occurrence of pesticides included thousands of unique mixtures, some uncommon and some very common. The herbicides atrazine (and its degradate, deethylatrazine), simazine, metolachlor, and prometon were common in mixtures found in streams and ground water in agricultural areas. The insecticides diazinon, chlorpyrifos, carbaryl, and malathion were common in mixtures found in urban streams. Studies of mixtures are still in the early stages, and it may take years for researchers to attain major advances in understanding their occurrence and potential for effects. The common occurrence of pesticide mixtures, particularly in streams, however, suggest that the study of mixtures should be a high priority.

What is a degradate and how often did degradates occur? | BACK TO QUESTIONS |

Degradates are compounds formed by transformation of a pesticide by chemical, photochemical, or biological reactions. Factors that govern the formation and distribution of degradates in the hydrologic system include the use and persistence of parent pesticides, the persistence and mobility of the degradates, and the physical, chemical, and biological conditions in the environment. In many cases, transformation results in the conversion of the parent compound to a compound that is less toxic, but some degradates have similar or greater toxicities than their parent pesticide. Degradates were often as common in streams and ground water as their parent pesticides. For example, DDT, which was first used more than 50 years ago and discontinued about 30 years ago, was detected in fish from about 30 percent of agricultural streams, whereas DDE, a more stable degradate of DDT, was detected in fish from 90 percent of sampled agricultural streams. Atrazine, the most heavily used herbicide in the Nation during the study period, was found together with one of its several degradates, deethylatrazine, in about 75 percent of stream samples and about 40 percent of ground-water samples collected in agricultural areas across the Nation. Enhanced assessments of the occurrence and behavior of degradates in the hydrologic environment are needed, which would supplement the toxicity testing of major degradates now required by EPA as part of its risk assessments for pesticide registration. The enhanced assessments could include improved coverage of degradates in water-quality monitoring, continued research on pesticide transformations and transport in the hydrologic environment, and more comprehensive inclusion of degradates in toxicity studies.

Do pesticides occur all year long? | BACK TO QUESTIONS |

Pesticide concentrations in stream water vary by season, with lengthy periods of low concentrations punctuated by seasonal pulses of much higher concentrations. For example, in streams that drain farmland throughout most of the Corn Belt, concentrations of herbicides were generally highest during spring runoff following pesticide applications. Effective management of streams may thereby require increased monitoring—including high-frequency sampling during seasons when intense pesticide use coincides with periods of high runoff—so that the periods with the highest pesticide concentrations are adequately characterized.

Does pesticide detection automatically mean harmful effects? | BACK TO QUESTIONS |

No. The presence of 'detectable' pesticides does not necessarily translate into adverse effects on humans or aquatic ecosystems because detections were often at low concentrations. USGS analytical methods are designed to measure low levels—sometimes parts per trillion—that are well below water-quality benchmarks for most pesticides. By this approach, the assessment helps to identify emerging issues and to track changes in concentrations over time, and it provides a comprehensive screen on the types of pesticides we can expect to see in different settings and areas of the country.

Did USGS do a risk assessment on pesticides? | BACK TO QUESTIONS |

No. The USGS report is NOT a risk assessment study and findings should not be confused with risk assessments for specific pesticides by EPA. However, to place findings in a context for understanding potential effects on human health and aquatic life, measured concentrations by NAWQA were compared to screening level, water-quality benchmarks derived from standards and guidelines established by EPA, toxicity values from EPA pesticide risk assessments, and selected guidelines from other sources. The water-quality benchmarks are estimates of the concentrations below which adverse effects on humans, aquatic life, or fish-eating wildlife are not expected to occur. The screening-level assessment is primarily intended to identify and prioritize needs for further investigation (see next question).

How did NAWQA assess potential effects? | BACK TO QUESTIONS |

To help place pesticide-occurrence data in a human-health or environmental context, NAWQA assessed potential effects based on comparing measured concentrations to water-quality benchmarks, which are estimates of the concentrations above which pesticides may have adverse effects on humans, aquatic life, or fish-eating wildlife. This "screening-level" assessment provides an initial perspective on the relevance of pesticide concentrations to human and environmental health, and is intended to identify and prioritize sites and pesticides that may require further investigation. Benchmarks are only indicators and should not be confused with detailed risk and toxicity assessments that are conducted by EPA in determining the safety of pesticides.

Most of the benchmarks used in the NAWQA screening-level assessment were derived from standards and guidelines established by EPA, toxicity values from EPA pesticide risk assessments, and selected guidelines from other sources. Most of the water-quality benchmarks are estimates of no-effect levels, such that concentrations below the benchmarks are expected to have a low likelihood of adverse effects. The presence of pesticides in streams or ground water at concentrations that exceed benchmarks does not indicate that adverse effects are certain to occur. Conversely, concentrations that are below benchmarks do not guarantee that adverse effects will not occur, but indicate that they are expected to be negligible.

What are the characteristics and limitations of the NAWQA assessment of potential effects? | BACK TO QUESTIONS |

There are several complexities and limitations. The potential for effects on humans, aquatic life, or wildlife may either be under or over estimated by benchmark comparisons in specific situations—the screening-level results are primarily intended to identify and prioritize needs for further investigation.

- Most of the water-quality benchmarks are estimates of no-effect levels, such that concentrations below the benchmarks are expected to have a low likelihood of adverse effects and concentrations

above a benchmark may have adverse effects, with the likelihood increasing as the concentration increases.

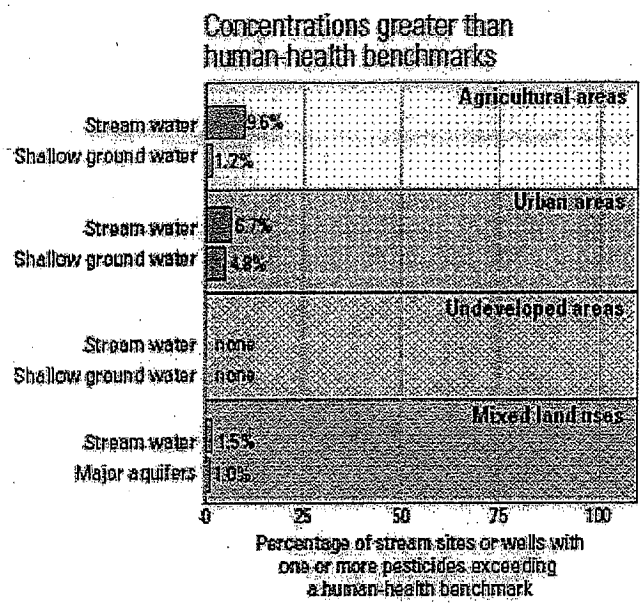
- The presence of pesticides in streams or ground water at concentrations that exceed benchmarks does not indicate that adverse effects are certain to occur. Conversely, concentrations that are below benchmarks do not guarantee that adverse effects will not occur, but indicate that they are expected to be negligible.
- Some compounds analyzed by NAWQA do not have water-quality benchmarks. The NAWQA study did not include all pesticides and degradates.
- Most benchmarks in the NAWQA analyses were based on toxicity tests of individual chemicals, whereas NAWQA results indicate that pesticides usually occur as mixtures. Comparisons to single-compound benchmarks may tend to underestimate the potential for adverse effects for some sites.
- Water-quality benchmarks for different pesticides and media are not always comparable because they have been derived by a number of different approaches, using a variety of types of toxicity values.
- For some benchmarks, there is substantial uncertainty in underlying estimates of no-effect levels, depending on the methods used to derived them and the quantity and types of toxicity information on which they are based. This is especially true of fish-tissue benchmarks for the protection of fish-eating wildlife, for which there is no consensus on national-scale benchmarks or toxicity values.
- Comparisons of concentrations of organochlorine compounds in whole fish with wildlife benchmarks indicate a wide range of potential for effects on fish-eating wildlife due to the lack of consensus on national-scale benchmarks or toxicity values.
- Estimates of pesticide exposure derived from NAWQA concentration measurements are also uncertain—particularly estimates of short-term exposure of aquatic organisms to pesticides in stream water. Generally, short-term average concentrations in stream water, such as 4-day values, are underestimated from NAWQA data.

Were water-quality benchmarks available for all pesticides? | BACK TO QUESTIONS |

One or more EPA drinking-water standards or guidelines were available for 47 of the 83 pesticides and degradates analyzed by NAWQA. A total of 62 of the pesticide compounds analyzed by NAWQA in water have one or more aquatic-life benchmarks.

What is the potential for effects on human health? | BACK TO QUESTIONS |

None of the USGS stream sampling sites were located at drinking-water intakes. However, for perspective, NAWQA measurements were compared to human-health benchmarks derived from U.S. Environmental Protection (EPA) agency drinking-water standards and guidelines, indicating that concentrations of individual pesticides were almost always lower than the human-health benchmarks. Less than 2 percent of streams draining undeveloped or mixed land-use watersheds and less than 10 percent of agricultural and urban streams had concentrations greater than these human-health benchmarks. Pesticides were less common in ground water than streams; less than 1 percent of domestic wells and public-supply wells used for drinking water exceeded EPA drinking-water standards and guidelines. Most exceedences were by dieldrin, which is no longer used.



How do I learn more about pesticide safety? | BACK TO QUESTIONS |

EPA has developed "health and safety fact sheets" that include information such as safety precautions in applying pesticides to control mosquitoes, product recalls and EPA's process for protecting the public from pesticide residues in food, including the special efforts taken to protect infants and children http://www.epa.gov/pesticides/factsheets/health_fs.htm If you don't find an answer to your question about a chemical, you can try the National Pesticide Information Center (NPIC), which is a cooperative effort of EPA and Oregon State University. NPIC provides science-based information about a variety of pesticide-related subjects, including pesticide products, recognition and management of pesticide poisonings, toxicology, and environmental chemistry (http://npic.orst.edu/). NPIC also lists state pesticide regulatory agencies, and provides links to their Web site. NPIC can be contacted at: 1-800-858-7378 or by email at npic@ace.orst.edu. In addition, NPIC has produced many informative fact sheets (http://npic.orst.edu/npicfact.htm).

How do I learn more about how pesticides are regulated? | BACK TO QUESTIONS |

EPA has developed "Regulatory Action Fact Sheets" on how EPA regulates certain chemicals or types of pesticides (http://www.epa.gov/pesticides/factsheets/reg_fs.htm).

How do I learn more about how drinking water is regulated? | BACK TO QUESTIONS |

The EPA, together with States, Tribes, and its many partners, protects public health by ensuring safe drinking water and protecting ground water. The agency oversees implementation of the Safe Drinking Water Act, which is the national law safeguarding drinking water provided by public water systems in America. Search the EPA website for safe water and learn about drinking water and ground water programs authorized under the Safe Drinking Water Act, such as how to find information about water quality; how to test your water quality; more information on drinking-water standards; how to find

information about specific contaminants and pubic water systems; and more (http://www.epa.gov/safewater/).

Are pesticides monitored in domestic wells? | BACK TO QUESTIONS |

Most government agencies do not require routine monitoring of water quality for domestic wells. Although regulations vary within and among States, the quality of water from privately owned domestic wells generally is the homeowner's responsibility. Routine monitoring is not required; however, most States and some local agencies provide guidance to domestic well owners through Web sites and printed materials. (http://www.epa.gov/safewater/privatewells/whereyoulive_state.html)

Why do pesticides exceed water-quality benchmarks for aquatic life and fish-eating wildlife more often in urban areas than in agricultural areas? | BACK TO QUESTIONS |

Exceedences in urban areas primarily relate to the more frequent presence of insecticides, which can be more toxic to aquatic life than herbicides. The pesticides with the greatest potential to affect urban streams during the study period were diazinon, chlorpyrifos, and malathion. The use of diazinon declined since the end of the 1992-2001 study period. Nonagricultural uses of chlorpyrifos have also been declining because of use restrictions (and the use of other pesticides may be changing as well). The reductions in use of some of the pesticides with the greatest potential for adverse effects (based on the USGS screening-level assessment) indicates that recent EPA restrictions on uses of diazinon and chlorpyrifos have the potential to reduce possible effects on aquatic life in urban streams if their uses are replaced with pesticides that reach streams in less toxic amounts or alternative approaches to pest control.

Are concentrations high enough to kill fish? | BACK TO QUESTIONS |

Concentrations of pesticides seldom occurred at levels thought to be toxic to fish (but rather toxicity applies mostly to aquatic plants and invertebrates). Less than 10 percent of urban and agricultural streams had levels of a pesticide that exceeded a benchmark for fish

Do NAWQA pesticide findings suggest that fishing in streams and lakes may be unsafe?| BACK TO QUESTIONS |

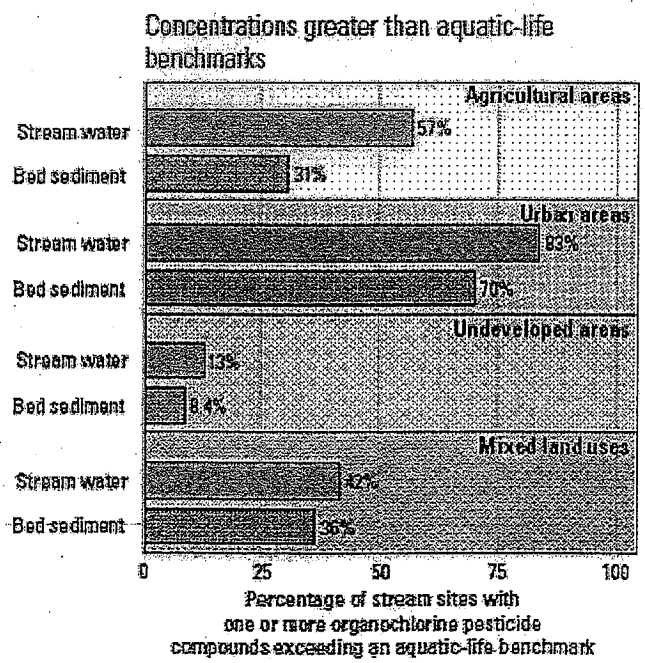
USGS does not regulate or issue fish-consumption advisories. People are advised to contact their local, State, and Tribal departments of health, environmental control, ecology, or fish and game for updated information on fish consumption advisories.

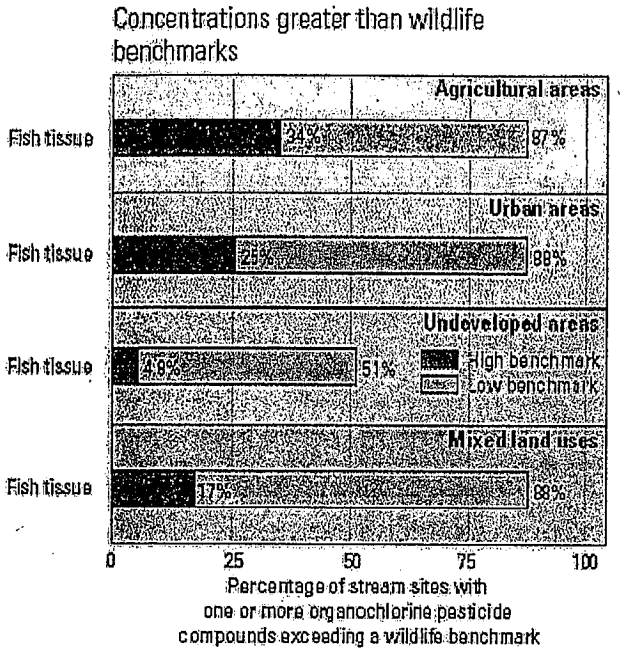
What additional complexities should be considered in the assessment of potential effects on aquatic life and fish-eating wildlife? | BACK TO QUESTIONS |

Pesticides may have substantially greater effects on aquatic ecosystems than on humans based on comparisons of USGS findings to water-quality benchmarks for aquatic life and fish-eating wildlife. More than 80 percent of urban streams and more than 50 percent of agricultural streams had concentrations in water of at least one pesticide—mostly those in use during the study period—that exceeded a water-quality benchmark for aquatic life.

Urban streams had the highest proportion of benchmark exceedances in water (more than 80 percent of sites)—mostly by the insecticides diazinon, chlorpyrifos, and malathion—although frequencies of exceedance declined during the study period. Specifically, concentrations exceeded benchmarks in 95 percent of urban streams sampled during 1993-97 and in 64 percent of streams during 1998-2000. Most urban uses of diazinon and chlorpyrifos have been phased out since 2001 because of use restrictions impose by EPA. More than 50 percent of the agricultural streams had concentrations that exceeded one or more benchmarks. In the agricultural streams, the pesticides chlorpyrifos, azinphos-methyl, p,p'-DDE, and alachlor were among those most often found at concentrations that may affect aquatic life, with each being most important in areas where its use on crops is or was greatest. As the use of alachlor declined through the study period, its benchmark exceedences also declined, with none during the last 3 years of study.

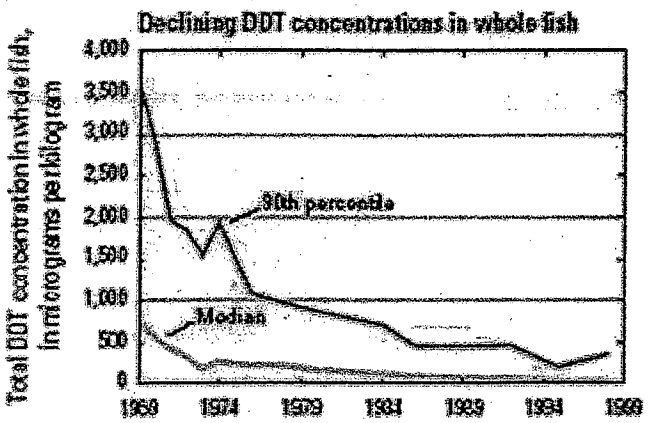
Organochlorine pesticide compounds—mostly from pesticides that were no longer in use when the study began (such as DDT)— still persist in the environment and frequently exceeded aquatic-life benchmarks for concentrations in bed sediment, and wildlife benchmarks for concentrations in fish tissue, at stream sites in urban and agricultural areas. Comparisons of concentrations of organochlorine compounds in fish tissue with wildlife benchmarks indicate a wide range of potential for effects on fish-eating wildlife. The ranges of percentages shown on the graph reflect the uncertainties in benchmarks for fish-eating wildlife due to the lack of consensus on national-scale benchmarks or toxicity values. Pesticide compounds most commonly found in fish and stream sediment were primarily related to three organochlorine pesticides—DDT, dieldrin (plus aldrin), and chlordane. These compounds most frequently exceeded water-quality benchmarks for aquatic life and fish-eating wildlife in urban streams and in agricultural streams in areas where historical use on crops was greatest. For example, total DDT was measured at some of the highest concentrations in bed sediment and fish in parts of the Southeast and in parts of California, Oregon, and Washington, where DDT was historically used on cotton, tobacco, orchards, or other crops.





Are some examples of pesticide trends evident in streams? | BACK TO QUESTIONS |

Yes. NAWQA has only begun to look at trends, but early results provide an indication of what to expect. A first look at trends shows examples of both decreasing and increasing levels of certain pesticides in streams and ground water, showing responses to regulatory actions and reduced use. The most complete story of trends is the decline in concentrations of organochlorine pesticides that followed reductions in use during the 1960s and bans on uses in the 1970s and 1980s. Concentrations of total DDT in fish, for example, decreased rapidly from the 1960s through the 1970s and then more slowly during the 1980s and 1990s. Just as notable as the declines, however, is the finding that these persistent organochlorine pesticide compounds still occur at levels greater than benchmarks for fish-eating wildlife in many urban and agricultural streams across the Nation. The decline in organochlorine compounds will continue, but they have long half-lives and we can expect levels to occur above benchmarks in some streams for years or even decades to come.



NAWQA findings also show some examples of trends involving more recently used pesticides. Concentrations of relatively mobile and short-lived pesticides in stream water respond more rapidly to changes in use than the less mobile and more persistent organochlorine insecticides discussed above. For example, increases in acetochlor and decreases in alachlor are evident in streams in the Corn Belt where acetochlor partially replaced alachlor for control of weeds in corn beginning in 1994. The changes in use were reflected quickly in stream concentrations, generally within 1 to 2 years. Similarly, concentrations of diazinon decreased significantly from 1998 to 2004 in 5 of 7 urban and mixed-land-use streams sampled in the Northeast, consistent with the EPA-mandated phase-out of nonagricultural uses of diazinon that began in 2002. More information on the phase-out of diazinon by EPA is available at: http://www.epa.gov/pesticides/op/diazinon.htm .

Are some examples of pesticide trends evident in ground water? | BACK TO QUESTIONS |

Ground water responds more slowly than streams to changes in pesticide use—taking years and even decades for changes in quality to occur. A persistent pesticide or degradate can remain in ground water long after its use has been discontinued because of the slow rates of ground-water flow and the resulting long residence time of water and contaminants in ground-water flow systems. This is evident from a number of studies in different parts of the country. For example, bromacil remained at detectable levels in ground water in parts of Florida for several years after it was not longer used, and dieldrin, which is no longer used, was still detectable at concentrations greater than its human-health benchmark in 73 wells sampled by NAWQA.

Can the NAWQA assessment help to predict pesticide occurrence in unmonitored areas? | BACK TO QUESTIONS |

USGS data and analyses are now sufficiently extensive to support national statistical models that can be used to estimate concentrations or the occurrence of some pesticides in streams and ground water where they have not yet been measured. Expanding this predictive capability is a critical step for national water-quality assessments, as well as for cost-effective management of water resources, because both require more information than can be directly measured.

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NAWQA's WARP (Watershed Regressions for Pesticides) model was developed from measured pesticide concentrations in streams, together with information on pesticide use and land use, climate and soil characteristics, and other natural features. This model can be used to predict the likelihood that the annual average concentrations of atrazine in untreated stream water exceeds specified levels of concern. Atrazine concentrations were predicted to be highest in the Corn Belt and parts of the southern Mississippi River Valley, where use is high and natural features favor the transport of pesticides by runoff to streams. Current modeling efforts involve expansion to other pesticides. A USGS ground-water model was developed to predict the presence of atrazine in shallow ground water within agricultural areas across the Nation, and shows the highest frequencies of atrazine detections in parts of the Midwest, Great Plains, Pacific Northwest, and Mid-Atlantic regions where atrazine is heavily used in hydrologic settings that favor the transport of pesticides to ground water. USGS is working closely with EPA on the development of these predictive tools. Model estimates can be used to identify locations that have the greatest likelihood of elevated pesticide concentrations and that are therefore the highest priority for additional monitoring.

What are the next steps and priorities for filling information gaps for pesticides? | BACK TO QUESTIONS |

One of the most important gaps to be filled is improved tracking of pesticide use in agricultural and non-agricultural areas, including amounts, locations, and timing. Given the direct relations between pesticide use and occurrence, improvement in the extent, frequency, and quality of quantitative data on agricultural use—and development of comparable and reliable data sources for nonagricultural pesticide use—would have major benefits for assessment and management of pesticides in streams and ground water.

In addition, long-term consistent data for assessing trends is essential for tracking water-quality response to changes in pesticide use and management practices, for providing early warning of unanticipated problems, and for updating and improving models.

Evaluations also are needed to make direct links between management practices—such as irrigation methods, subsurface drains, integrated pest management, and retention of wetlands and buffers—and the concentrations and transport of pesticides in streams and ground water. Field-scale studies have shown that certain management practices can influence pesticides in streams and ground water, but the effectiveness of these practices needs to be systemically assessed at regional and national scales.

Finally, we must dedicate resources to gather ancillary data necessary to interpret pesticides and other water-quality data.. This includes better information on the ecological and habitat condition of the stream, land-use changes, water use, land-management practices, geomorphology and stream networks, geologic setting, and also point-source discharges. Unfortunately, many of these spatial data are lacking. However, these are critical to help put the pesticide information in an improved context

What can I do as a homeowner? | BACK TO QUESTIONS |

Effective solutions depend on the commitment of a multitude of individuals because nonpoint pollution results largely from everyday activities. This can be a challenge because the consequences of individual actions (such as application of chemicals on lawns and disposal of household chemicals) on the degradation of water resources are not well understood. In addition, in the agricultural community, there is some economic incentive to reduce chemical use and improve application efficiency. But, for individual homeowners who apply chemicals in much smaller quantities and less frequently, there is little economic incentive to optimize the use of chemicals. Excessive application more often than not has minimal economic impact to the individual homeowner, whereas the collective environmental impact can be large.

How can NAWQA findings guide monitoring strategies? | BACK TO QUESTIONS |

Improved monitoring of pesticides may require:

- Inclusion of pesticides not yet assessed (such as fungicides and fumigants in current use, as well as many new or increasingly used herbicides and insecticides, such as glyphosate and pyrethroid insecticides
- Routine re-evaluation of monitoring as chemical use changes over time and new pesticides are introduced.
- Monitoring over seasons, when intense pesticide use coincides with periods of high runoff
- Monitoring over the long time
- Investments in tracking chemical use
- Investments in gathering ancillary information on the environmental landscape and human factors controlling water quality
- Measuring pesticides in a "total resource" context, including in streams and ground water
- Measuring water quantity, including stream flow and ground-water levels and flow directions
- Gathering information on aquatic systems and habitat, along with chemical measurements

Is NAWQA continuing to monitor and assess pesticides and other water-quality conditions? | BACK TO QUESTIONS |

In 2001, USGS began its second decade of intensive water-quality assessments and is returning to 42 of the Study Units that were assessed in the first decade from 1991-2001. In this second cycle of studies, NAWQA has expanded its assessment to include new pesticides with high usage in agricultural and populated areas of the country. A major evaluation of trends is planned in the second decade when the Study Units are reassessed and an increasing number of stream and ground-water sampling sites will have had consistent monitoring over a ten-year period. In addition, NAWQA will continue to assess factors and processes that affect pesticide and other water-quality conditions, and examine the linkages among sources of chemicals and other disturbances that degrade water quality, transport of chemicals through the hydrologic system, and potential effects of chemicals and other water-quality disturbances on humans and aquatic ecosystems. The occurrence, trends, transport, and fate will be evaluated at regional and national scales.

Who can I contact for more information on the NAWQA pesticide assessment? | BACK TO QUESTIONS |

Robert J. Gilliom, USGS, Chief, National Synthesis Project, Pesticides
Placer Hall— 6000 J Street
Sacramento, CA 95819-6129
Email: rgilliom@usgs.gov
Phone: (916)-278-3094

Who can I contact in EPA for more information on pesticides? | BACK TO QUESTIONS |

Arty Williams, EPA, Associate Director
Enviornmental Fate and Effects Division

1200 Pennsylvania Ave., NW
Washington D.C. 20460
Email:Williams.arty@epa.gov
Phone: (703)-305-7695

Are NAWQA national assessments available for other types of chemical compounds? | BACK TO QUESTIONS |

Yes. NAWQA is conducting similar national assessments for volatile organic compounds (VOCs) (http://sd.water.usgs.gov/nawqa/vocns/), nutrients (http://water.usgs.gov/nawqa/nutrients/), trace elements (http://water.usgs.gov/nawqa/trace/), and ecology (http://water.usgs.gov/nawqa/ecology/).

How can I retrieve more technical information on NAWQA's methodology and design? | BACK TO QUESTIONS |

All supporting technical information on the monitoring design, sampling methodology, and analyses can be accessed: http://ca.water.usgs.gov/pnsp/pubs/circ1291/supporting_info.php

How can I retrieve raw data? | BACK TO QUESTIONS |

You can retrieve pesticide data associated with the USGS Circular 1291 by accessing: http://ca.water.usgs.gov/pnsp/pubs/circ1291/supporting_info.php Downloadable data can be obtained for individual maps, graphs, and tables included in the report. You can also download data on pesticides and other chemical, biological, and physical characteristics for streams and ground water from NAWQA's data warehouse: http://water.usgs.gov/nawqa/data This data warehouse integrates more than 11 million records on water quality, ecology, and hydrology from the 51 river basins and aquifers across the Nation, 1992-2001.

Can I download graphics and maps from the report? | BACK TO QUESTIONS |

Explanations are provided for each graphic, map and table, as well as the capability to download the data used in their creation.

Accessibility FOIA Privacy Policies and Notices

U.S. Department of the Interior | U.S. Geological Survey

Page Contact Information: Bob Gilliom
Page Last Modified: March 03 2006

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News Release

Pesticides in the Nation's Streams and Ground Water

Release	Contact	Phone
March 3, 2006	Robert Gilliom	916-278-3094
	Donna Myers	703-648-5012

Today, the U.S. Geological Survey released a report describing the occurrence of pesticides in streams and ground water during 1992-2001. The report concludes that pesticides are typically present throughout the year in most streams in urban and agricultural areas of the Nation, but are less common in ground water. The report also concludes that pesticides are seldom at concentrations likely to affect humans. However in many streams, particularly those draining urban and agricultural areas, pesticides were found at concentrations that may affect aquatic life or fish-eating wildlife.

Dr. Robert Hirsch, Associate Director for Water, said, "While the use of pesticides has resulted in a wide range of benefits to control weeds, insects, and other pests, including increased food production and reduction of insect-borne disease, their use also raises questions about possible effects on the environment, including water quality." Hirsch also commented that "the USGS assessment provides the most comprehensive national-scale analysis to date of pesticide occurrence in streams and ground water. Findings show where, when, and why specific pesticides occur, and yield science-based implications for assessing and managing pesticides in our water resources."

The USGS findings show strong relations between the occurrence of pesticides and their use, and point out that some of the frequently detected pesticides, including the insecticide diazinon and the herbicides alachlor and cyanazine, are declining.

USGS has worked closely with the U.S. Environmental Protection Agency (EPA) during the 10-year study. EPA uses the data extensively in their exposure and risk assessments for regulating the use of pesticides. For example, EPA used USGS data in its risk assessments for the reevaluation of diazinon, chlorpyrifos, cyanazine and alachlor. Uses of three of these pesticides (diazinon, chlorpyrifos and cyanazine) have now been significantly limited, and usage of alachlor was voluntarily reduced and largely replaced by a registered alternative.

The USGS report is based on analysis of data collected from 51 major river basins and aquifer systems across the Nation from Florida to the Pacific Northwest and including Hawaii and Alaska, plus a regional study in the High Plains aquifer system.

Although none of the USGS stream sampling sites were located at drinking-water intakes, a screening-level assessment was done by USGS to provide an initial perspective on the relevance of the pesticide concentrations to human health. USGS measurements were compared to EPA drinking-water standards and guidelines. Concentrations of individual pesticides were almost always lower than the standards and guidelines, representing less than 10 percent of the sampled stream sites and about 1 percent of domestic and public-supply wells.

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However, pesticides may have substantially greater effects on aquatic ecosystems than on humans based on a screening-level comparison of USGS measurements to water-quality benchmarks for aquatic life and fish-eating wildlife. More than 80 percent of urban streams and more than 50 percent of agricultural streams had concentrations in water of at least one pesticide—mostly those in use during the study period—that exceeded a water-quality benchmark for aquatic life. Water-quality benchmarks are estimates of concentrations above which pesticides may have adverse effects on human health, aquatic life, or fish-eating wildlife.

Insecticides, particularly diazinon, chlorpyrifos, and malathion frequently exceeded aquatic-life benchmarks in urban streams. Most urban uses of diazinon and chlorpyrifos, such as on lawns and gardens, have been phased out since 2001 because of use restrictions imposed by the EPA. The USGS data indicate that concentrations of these pesticides may have been declining in some urban streams even before 2001—benchmark exceedences in urban streams were least frequent late in the study. A case study of diazinon shows declining concentrations in several urban streams in the Northeast during 1998-2004.

In agricultural streams, the pesticides chlorpyrifos, azinphos-methyl, p,p'-DDE, and alachlor were among those most often found at concentrations that may affect aquatic life, with each being most important in areas where its use on crops is or was greatest. According to senior author Robert Gilliom, however, "Pesticide use is constantly changing in response to such factors as regulations and market forces and findings from this decade-long study need to be examined in relation to changes in use during and after the study. For example, levels of the herbicide alachlor declined in streams in the Corn Belt (generally including Illinois, Indiana, Iowa, Nebraska, and Ohio, as well as parts of adjoining states) throughout the study period as its use on corn and soybeans declined, with no levels greater than its aquatic-life benchmark by the end of the study. In contrast, both the use and the levels of atrazine, the most heavily used herbicide in the Corn Belt region, remained relatively high throughout the study period."

In addition, DDT, dieldrin, and chlordane—organochlorine pesticide compounds that were no longer in use when the study began—were frequently detected in bed sediment and fish in urban and agricultural areas. Concentrations of these compounds in fish declined following reductions in their use during the 1960s and elimination of all uses in the 1970s and 1980s, and continue to slowly decline. Just as notable as the declines, however, is the finding that these persistent organochlorine pesticides still occur at levels greater than benchmarks for aquatic life and fish-eating wildlife in many urban and agricultural streams across the Nation.

The USGS study also reported that pesticides seldom occurred alone—but almost always as complex mixtures. Most stream samples and about half of the well samples contained two or more pesticides, and frequently more.

Gilliom explained that "The potential effects of contaminant mixtures on people, aquatic life, and fish-eating wildlife are still poorly understood and most toxicity information, as well as the water-quality benchmarks used in this study, has been developed for individual chemicals. The common occurrence of pesticide mixtures, particularly in streams, means that the total combined toxicity of pesticides in water, sediment, and fish may be greater than that of any single pesticide compound that is present. Studies of the effects of mixtures are still in the early stages, and it may take years for researchers to attain major advances in understanding the actual potential for effects. Our results indicate, however, that studies of mixtures should be a high priority."

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The report, "Pesticides in the Nation's Streams and Ground Water, 1992-2001," Circular 1291 is available at http://pubs.usgs.gov/circ/2005/1291/, or by calling 1-888-ASK-USGS, or by fax 303-202-4693. In-depth information about the pesticide assessment may be found at: http://water.usgs.gov/nawqa/ under "What's New."

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NAWQA Pesticide National Synthesis Project

Publications - CIRC 1291

The Quality of Our Nation's Waters

Pesticides in the Nation's Streams and Ground Water, 1992-2001

Supplemental Technical Information (available on-line only)

BACK TO CIRCULAR 1291 Materials Page

Descriptions of Figures and Tables:

Figures -- Choose a chapter and click on "Go"

Select a Chapter | Go | Show All | Hide Figures

Tables

Table 3-1

Each stream sampled by NAWQA was classified according to the dominant land uses in its watershed. The land-use data set used for these classifications was an enhanced version of the 1992 National Land Cover Data (NLCD), which classified land use for each 30-by-30-meter area of land in the conterminous United States. The original and enhanced versions of the NLCD are described, respectively, by Vogelmann and others (2001) and Nakagaki and Wolock (2005).

Table 5-1

The most common unique mixtures of pesticides and degradates found in stream water and ground water illustrate the diversity and complexity of mixtures that occur in agricultural and urban areas. The mixtures detected most frequently for each number of compounds are shown for each land use, with all detections included, regardless of concentration. These most common unique mixtures serve as examples, rather than as a comprehensive compilation of all the most important mixtures, because other mixtures occurred

almost as frequently.

Table 5-2

The most common unique mixtures of organochlorine pesticide compounds found in fish tissue were dominated by compounds derived from commercial formulations of DDT, DDD, and chlordane, as well as dieldrin The mixtures detected most frequently for each number of compounds are shown for each land use. These most common mixtures serve as examples, rather than having unique importance, because many other mixtures occur almost as frequently.

Table 6-1

Most wells sampled for agricultural and urban land-use studies were shallow observation wells that are not used for drinking water, but about 29 percent of wells sampled in agricultural areas were domestic wells. Most wells sampled for the major aquifer studies are used for drinking water; about 13 percent were public-supply wells, and 71 percent were domestic wells. Overall, about 1 percent of all domestic and public-supply wells had concentrations of a pesticide greater than a human-health benchmark.

Table 6-2 (not available at this time)

Selected studies of pesticide mixtures containing diazinon illustrate the spectrum of possible responses for such mixtures The types of compounds included are two organophosphate insecticides (OP), a pyrethroid insecticide (P), a triazine herbicide (T), and a nutrient.

Appendices

Appendix 1. Pesticide compounds analyzed in NAWQA samples

Appendix 2. Properties affecting the transport and fate of selected pesticide compounds

Appendix 3. Water-quality benchmarks for pesticide compounds analyzed in NAWQA samples

Appendix 4. List of abbreviations, acronyms, and units of measurement

Appendix 5. NAWQA sampling sites and their characteristics

Appendix 6. Downloadable water-quality data files

Appendix 7. Statistical summaries of water-quality data - **not available at this time**

Appendix 8. Methods and approach for NAWQA pesticide data analysis - **not available at this time**

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Table 3–1. Each stream sampled by NAWQA was classified according to the dominant land uses in its watershed. The land-use data set used for these classifications was an enhanced version of the USGS 1992 National Land Cover Data (NLCD), which classified land use for each 30-by-30-meter area of land in the conterminous United States. The original and enhanced versions of the NLCD are described, respectively, by Vogelmann and others (2001) and Nakagaki and Wolock (2005).

Land-use classification	Watershed land-use criteria
Agricultural	> 50 percent agricultural land and ≤ 5 percent urban land
Urban	> 25 percent urban land and ≤ 25 percent agricultural land
Undeveloped	≤ 5 percent urban land and ≤ 25 percent agricultural land
Mixed	All other combinations of urban, agricultural, and undeveloped land

How this table was made:

This table defines the national land-use classifications used to characterize stream sites sampled by NAWQA. The objective was to establish a consistent approach for national analysis. Briefly, the percentage of land area within each watershed comprised by up to 25 different land-cover types was determined using national land-cover data. The total agricultural land, total urban land, and total undeveloped land were calculated (as a percentage of total watershed area) by summing the percentages of land cover classifications fitting each of these three categories. Each site then was assigned to one of 4 national land-use classes (agricultural, urban, undeveloped, and mixed land use), depending on the amount of agricultural, urban, and undeveloped land within the watershed, using the criteria listed in this table. Ultimately, a few sites had their classifications adjusted if the land use area percentages within the watershed were substantially different from the sources of water at the stream sampling site. More detail

is provided below:

- The initial determination of land use within each watershed was made using an enhanced version of the 1992 National Land Cover Data (NLCD), which classifies land use for each 30-meter-square area of land in the conterminous U.S. The original 1992 NLCD contained 21 land-cover classifications, such as low intensity residential, row crop, and deciduous forest (Vogelmann and others, 2001; U.S. Geological Survey, 1999). The enhanced version of the 1992 NLCD (NLCDe) was developed by integrating selected classifications from U.S. Geological Survey's Land Use and Land Cover (LULC) Dataset (Fegeas and others, 1983; U.S. Geological Survey, 1998) as enhanced by Price and others (2003), with the 1992 NLCD. As described in Nakagaki and Wolock (2005) and shown below in Figure A, the NLCDe contains 25 land-cover classifications (the original 21 land-cover classifications plus 4 additional ones).

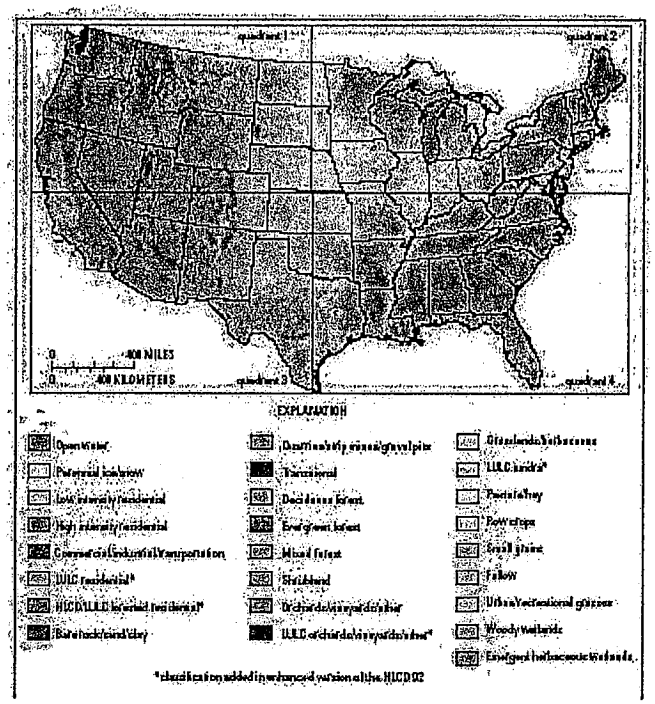

Figure A: The above map shows the "enhanced" 30-m resolution National Land Cover Data 1992 (NLCDe) for the conterminous U.S., including boundaries of the four quadrant grids. Because of limitations of the ArcInfo GRID data model, four separate quadrant grids, rather than a single grid, were generated. (From Nakagaki and Wolock, 2005).

- For each site, the percentage of the watershed corresponding to each of three aggregated land use categories, was calculated as follows:
  - **Total agricultural land**: the sum of row crops, small grains, pasture/hay, LULC orchards/vineyards/other*, and fallow.
  - **Total urban land**: the sum of low intensity residential, high intensity residential, LULC residential*, NLCD/LULC forested residential*, and urban/recreational grasses.
  - **Total undeveloped land**: the sum of grasslands/herbaceous, shrubland, LULC tundra*, deciduous forest, evergreen forest, mixed forest, woody wetlands, emergent herbaceous wetlands, open water, bare rock/sand/clay, and perennial ice/snow.

  * indicates new land-use classifications added in the enhanced version, NLCDe.

- Each site was assigned to one of 4 national land-use classes, depending on the amount of total agricultural, total urban, and total undeveloped land within the watershed, using the criteria listed in table 3–1. The mixed-land-use class was used for watersheds that have combinations of agricultural, urban, and undeveloped land that do not meet the criteria for the other 3 classes listed in table 3–1. Note that sites classified as Undeveloped may contain up to 25 percent agricultural land, and (or) 5 percent urban land in their watersheds, so they are not necessarily pristine, and the water quality at these sites may show some influences from developed land uses within the watershed.
- Ultimately, some sites (fewer than 5 percent) had their classifications adjusted if one or more land uses makes a disproportionately large or small contribution (relative to its percentage of land area in the watershed) to streamflow at the site because of water management practices or natural variations in precipitation and runoff. This is especially common in the arid west, where water resources are heavily managed. As an example, a site in Arizona with a watershed containing about 95 percent undeveloped, 5 percent agricultural, and <1 percent urban land initially was classified as Undeveloped. However, upstream of the sampling site, the water was diverted for irrigation and then returned to the stream, so 100 percent of the stream baseflow at the sampling site was irrigation return flow—therefore, this site was classified as a Mixed land use (agriculture and undeveloped) site.

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Fegeas, R.G., Claire, R.W., Guptill, S.C., Anderson, K.E., and Hallam, C.A., 1983, Land use and land cover digital data: U.S. Geological Survey Circular 895-E, 21 p.

Nakagaki, Naomi, and Wolock, D.M., 2005, Estimation of agricultural pesticide use in drainage basins using land cover maps and county pesticide data: U.S. Geological Survey Open-File Report 2005-1188.

Price, C.V.; Nakagaki, Naomi; Hitt, K.J.; and Clawges, R.M.; 2003, Mining GIRAS—improving on a national treasure of land use data, *in* Proceedings of the 23rd ESRI International Users Conference, July 7–11, 2003: Redlands, Calif.

U.S. Geological Survey, 1998, Land use and land cover digital data from 1:250,000- and 1:100,000-scale maps.

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Vogelmann, J.E.; Howard, S.M.; Yang, Limin; Larson, C.R.; Wylie, B.K.; and Van Driel, Nick; 2001, Completion of the 1990's national land cover dataset for the conterminous United States from Landsat Thematic Mapper data and ancillary data sources: Photogrammetric Engineering and Remote Sensing, v. 67, p. 650–662.

Information on sampling sites and their characteristics (including land use) is presented in Appendix 5.

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Table 5-1. The most common unique mixtures of pesticides and degradates found in stream water and ground water illustrate the diversity and complexity of mixtures that occur in agricultural and urban areas. The three mixtures detected most frequently for each number of compounds are shown for each land use, with all detections included, regardless of concentration. These most common unique mixtures serve as examples, rather than as a comprehensive compilation of all the most important mixtures, because other mixtures occurred almost as frequently.

Mixture	Frequency of detection (percentage of time for streams, or samples for ground water)			
	Streams		Ground water	
	Urban	Agricultural	Urban	Agricultural
2-compound mixtures				
Atrazine Prometon	79	50	15	10
Prometon Simazine	75	41	10	7
Atrazine Simazine	74	64	17	18
Atrazine Metolachlor	55	77	8	15
Atrazine Deethylatrazine	53	77	26	39
Deethylatrazine Simazine	49	57	15	17
Deethylatrazine Metolachlor	42	69	7	14
3-compound mixtures				
Atrazine Prometon Simazine	68	41	9	7
Atrazine Diazinon Prometon	60	10	1	0
Atrazine Diazinon Simazine	59	16	1	0
Diazinon Prometon Simazine	59	9	1	0
Atrazine Deethylatrazine Prometon	50	48	12	9
Atrazine Deethylatrazine Simazine	48	57	15	16
Atrazine Metolachlor Simazine	48	57	6	7
Atrazine Deethylatrazine Metolachlor	41	69	7	14
4-compound mixtures				
Atrazine Diazinon Prometon Simazine	53	9	1	0
Atrazine Deethylatrazine Prometon Simazine	46	39	8	7
Atrazine Metolachlor Prometon Simazine	43	38	4	4
Atrazine Deethylatrazine Metolachlor Prometon	39	45	5	6
Atrazine Deethylatrazine Metolachlor Simazine	37	52	5	7
Alachlor Atrazine Deethylatrazine Metolachlor	14	42	0	2
5-compound mixtures				
Atrazine Carbaryl Diazinon Prometon Simazine	36	2	0	0
Atrazine Deethylatrazine Diazinon Prometon Simazine	35	8	1	0
Atrazine Deethylatrazine Metolachlor Prometon Simazine	35	37	4	4
Atrazine Diazinon Metolachlor Prometon Simazine	35	8	0	0
Atrazine Deethylatrazine Prometon Simazine Tebuthiuron	28	16	2	1
Atrazine Deethylatrazine Metolachlor Simazine Tebuthiuron	22	19	2	1
Alachlor Atrazine Deethylatrazine Metolachlor Prometon	13	33	0	1
Alachlor Atrazine Deethylatrazine Metolachlor Simazine	13	33	0	1
Alachlor Atrazine Deethylatrazine Prometon Simazine	12	26	0	1
Atrazine Cyanazine Deethylatrazine Metolachlor Simazine	5	33	1	1

How the table was made:

This table shows the three most frequently detected unique pesticide mixtures in stream water (percentage of time) or ground water (percentage of samples) from agricultural or urban areas versus the number of pesticide compounds in the mixtures. Only the 25 most commonly detected pesticide compounds in water (see figure 4-2) were considered when identifying unique mixtures.

A unique mixture is defined in this report as a combination of two or more pesticide compounds, regardless of the presence of other compounds that may occur in the same sample (Squillace and others, 2002, p. 1924-1925). For example, a sample containing compounds A, B, and C contains four unique mixtures—AB, AC, BC, and ABC.

The "total detection frequency" threshold (detections at any concentration--some as low as 0.001 micrograms per liter) was used for this table. Six of the 25 most commonly detected pesticides (bentazon, bromacil, carbaryl, 2,4-D, diuron, and norflurazon) cannot be reliably detected when present at concentrations less than 0.1 micrograms per liter. The term "cannot be reliably detected" refers to the inability of the analytical method to detect low concentrations of pesticides when present in water samples. All reported detections of pesticides by NAWQA, regardless of concentration, are "reliable" in that they are conclusively identified by retention time and spectral characteristics. The expected effect of the unreliable detection of these six pesticide compounds when present at concentrations less than 0.1 micrograms per liter for table 5-1 is underestimation of the contribution of bentazon, bromacil, carbaryl, 2,4-D, diuron, and norflurazon to unique mixtures.

Two criteria related to missing values were used in the analysis of mixtures for table 5-1: (1) water samples must have data for at least 80 percent (16 of 20) of the most commonly detected compounds analyzed by gas chromatography/mass spectrometry (GCMS) and must have data for at least 80 percent (4 of 5) of the most commonly detected compounds analyzed by high performance liquid chromatography (HPLC), (2) missing data for individual pesticide compounds in samples that met the criteria provided in (1) were considered nondetections for the purposes of this figure. Analytical methods for pesticides in water are identified in Appendix 1A.

Approximately one third of the stream-water and ground-water sites did not have pesticides analyzed by HPLC. As a consequence, the mixture analysis is based on a smaller number of sites and samples than some of the other topics presented in this report. The expected effect of the missing pesticides described in (2) above for table 5-1 is indeterminate. Only the most frequently detected pesticides are identified in the table. Missing values for frequently detected pesticides would cause underestimation of the frequency of detection of unique mixtures that contain that pesticide and, consequently, may alter the order of the three most frequently detected unique mixtures.

Samples were pooled by sampling medium and land use for analysis. Multiple samples per site (over a 1-year period) were collected to characterize pesticides in stream water, whereas a single sample per well was used to characterize pesticides in ground water.

- For ground water, and for each of the two national land-use classes shown in the table, calculate the number of unique mixtures in each sample:

  Count the number of pesticides detected (d) in each sample. The number of mixtures composed of n pesticides is:

  $$d! / n! (d - n)!$$

  where n ranges from 2 to d (Walpole and Myers, 1978, p. 13). The total number of unique mixtures in a sample is the sum of the numbers of unique mixtures calculated for

each n from 2 through d.

A computer program was written to identify the specific pesticide compounds that compose each unique mixture in the sample. The frequency of detection for each unique mixture was determined by dividing the number of samples that contain the unique mixture by the total number of samples in the land-use class. For each land-use class, the three most frequently detected unique mixtures were selected for each n value (the number of pesticide compounds in the mixture) from two through five. In some cases the four most frequently detected unique mixtures were selected to account for ties for third place.

- Stream-water samples were collected more frequently during the pesticide-use season than at other times of the year. Consequently, time-weighted estimates are provided in table 5-1 for stream-water samples to eliminate the bias caused by more frequent sample collection during the pesticide-use season. Time weighting stream-water samples yields an estimate of the percentage of time a unique mixture was detected.

  Because of the vast number of unique mixtures, a time-weighting approach based on site-months (rather than sample weights) was used. Unique mixtures in individual stream-water samples were identified using similar procedures as those described above for ground-water samples. The unique mixtures for each sample were pooled by site and month and only the first occurrence of a unique mixture in a site-month was retained for analysis. The frequency of detection of each unique mixture was calculated for each of the national land-use classes, by dividing the number of site-months that contain the unique mixture by the total number of site-months in the land-use class. Mixtures for months without stream-water samples were estimated by assigning the mixtures from the sample nearest in time to the month with missing samples. For each land use class, the three most frequently detected unique mixtures were selected for each n value (the number of pesticide compounds in the mixture) from two through five. In some cases the four most frequently detected unique mixtures were selected to account for ties for third place.

The table was prepared by listing the three (or four, if ties) most frequently detected unique mixtures for mixtures for n values from two through five, by media and land-use class. Listing only the three most frequently detected mixtures would result in a table with empty cells for some unique mixtures that were not detected frequently in another media or land use. Therefore, the empty cells in the table were filled with the calculated frequency of detection for the appropriate mixture, media, and land use. Data in the table are sorted by the number of pesticide compounds in the mixture, the frequency of detection in urban streams, and the frequency of detection in agricultural streams. Frequency of detection was rounded to the one's place for presentation in the table.

References cited:

Squillace, P.J., Scott, J.C., Moran, M.J., Nolan, B.T., and Kolpin, D.W., 2002, VOCs, pesticides, nitrate, and their mixtures in groundwater used for drinking water in the United States: Environmental Science & Technology, v. 36, no. 9, p. 1923-1930.

Walpole, R.E., and Myers, R.H., 1978, Probability and statistics for engineers and scientists (2d ed.): New York, MacMillan, 580 p.

Pesticide names and analytical methods are presented in Appendix 1.

Information on sampling sites and their characteristics is presented in Appendix 5.

Downloadable concentration data are presented in Appendix 6.

Additional information on analytical approach is presented in Appendix 8.

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Table 5-2. The most common unique mixtures of organochlorine pesticide compounds found in fish tissue were dominated by compounds derived from commercial formulations of DDT, DDD, and chlordane, as well as dieldrin. The mixtures detected most frequently for each number of compounds are shown for each land use. These most common mixtures serve as examples, rather than having unique importance, because many other mixtures occur almost as frequently.

Mixture	Frequency of detection (percentage of samples) Fish tissue	
	Urban streams	Agricultural streams
2-compound mixtures		
p,p'-DDE *trans*-Nonachlor	72	49
cis-Chlordane *p,p'*-DDE	72	37
cis-Chlordane *trans*-Nonachlor	72	35
p,p'-DDD *p,p'*-DDE	64	59
Dieldrin *p,p'*-DDE	53	59
3-compound mixtures		
cis-Chlordane *p,p'*-DDE *trans*-Nonachlor	68	35
cis-Chlordane *p,p'*-DDD *p,p'*-DDE	60	28
cis-Chlordane *p,p'*-DDD *trans*-Nonachlor	57	27
p,p'-DDD *p,p'*-DDE *trans*-Nonachlor	57	37
Dieldrin *p,p'*-DDE *trans*-Nonachlor	53	42
Dieldrin *p,p'*-DDD *p,p'*-DDE	40	47
4-compound mixtures		
cis-Chlordane *p,p'*-DDD *p,p'*-DDE *trans*-Nonachlor	56	27
cis-Chlordane *p,p'*-DDE *trans*-Chlordane *trans*-Nonachlor	51	25
cis-Chlordane *p,p'*-DDE *p,p'*-DDT *trans*-Nonachlor	51	9
cis-Chlordane Dieldrin *p,p'*-DDE *trans*-Nonachlor	50	33
cis-Chlordane Dieldrin *p,p'*-DDD *p,p'*-DDE	40	27
Dieldrin *p,p'*-DDD *p,p'*-DDE *trans*-Nonachlor	40	34
5-compound mixtures		
cis-Chlordane *p,p'*-DDD *p,p'*-DDE *trans*-Chlordane *trans*-Nonachlor	46	19
cis-Chlordane *p,p'*-DDD *p,p'*-DDE *p,p'*-DDT *trans*-Nonachlor	44	9
cis-Chlordane Dieldrin *p,p'*-DDE *trans*-Chlordane *trans*-Nonachlor	43	24
cis-Chlordane Dieldrin *p,p'*-DDD *p,p'*-DDE *trans*-Nonachlor	40	26
cis-Chlordane *cis*-Nonachlor Dieldrin *p,p'*-DDE *trans*-Nonachlor	39	23

How the table was made:

This table shows the three most frequently detected unique pesticide mixtures in whole-fish tissue (percentage of samples) from agricultural or urban areas versus the number of pesticide compounds in the mixtures. Only the 15 most commonly detected pesticide compounds in water (see figure 4-4) were considered when identifying unique mixtures.

A unique mixture is defined in this report as a combination of two or more pesticide compounds, regardless of the presence of other compounds that may occur in the same sample (Squillace and othe 2002, p. 1924-1925). For example, a sample containing compounds A, B, and C contains four unique mixtures—AB, AC, BC, and ABC.

The "total detection frequency" threshold (detections at any concentration—some as low as 0.8 micrograms per kilogram) was used for this table. All 15 of the most commonly detected pesticide compounds in fish tissue can be detected when present at or above 5 micrograms per kilogram (µg/kg) wet weight. (Occasionally, concentrations below these levels may be observed—however, the method cannot reliably (consistently) detect lower concentrations, which may result in underestimation of the number of samples in which these compounds occur at concentrations less than 5 µg/kg.)

Fish samples with raised reporting levels (that is, reported as not detected above a specified concentration that is greater than the 5 µg/kg reporting level, such as <10 µg/kg) are treated as missing data. Missing data for individual pesticide compounds were considered nondetections for the purposes of this figure.

Samples were pooled by land use for analysis. Each site is represented by one whole-fish sample (each a composite of 5–8 individual whole fish of the same species). For each of the two national land-use classes shown in the table:

- The number of unique mixtures in each sample is calculated as follows: Count the number of pesticide compounds detected (d) in each sample. The number of mixtures composed of n pesticides is:

  $$d! / n! (d - n)!$$

  where n ranges from 2 to d (Walpole and Myers, 1978, p. 13). Then, the total number of unique mixtures in a sample is the sum of the numbers of unique mixtures calculated for each value of n from 2 through d.

- A computer program was written to identify the specific pesticide compounds that compose each unique mixture in the sample. The frequency of detection for each unique mixture was determined by dividing the number of samples that contain the unique mixture by the total number of samples in the land-use class. Then, for each land-use class, the three most frequently detected unique mixtures were selected for each value of n (the number of pesticide compounds in the mixture) from 2 through 5. In some cases the four most frequently detected unique mixtures were selected to account for ties for third place.

The table was prepared by listing the three (or four, if ties) most frequently detected unique mixtures for each value of n (the number of pesticide compounds in the mixture) from 2 through 5, by land-use class. Listing only the three most frequently detected mixtures would result in a table with empty cells for some unique mixtures that were not detected frequently in another land use. Therefore, the empty cells in the table were filled with the calculated frequency of detection for the appropriate mixture and land use. Data in the table are sorted by the number of pesticide compounds in the mixture, the frequency of detection in urban streams, and the frequency of occurrence in agricultural streams. Frequency of detection was rounded to the one's place for presentation in the table.

References cited:

Squillace, P.J., Scott, J.C., Moran, M.J., Nolan, B.T., and Kolpin, D.W., 2002, VOCs, pesticides, nitrate, and their mixtures in groundwater used for drinking water in the United States: Environmental Science &

Technology, v. 36, no. 9, p. 1923-1930.

Walpole, R.E., and Myers, R.H., 1978, Probability and statistics for engineers and scientists (2d ed.): New York, MacMillan, 580 p.

Pesticide names and analytical reporting levels are presented in Appendix 1.

Information on sampling sites and their characteristics is presented in Appendix 5.

Downloadable concentration data are presented in Appendix 6.

Additional information on analytical approach is presented in Appendix 8.

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Table 6-1. Most wells sampled for agricultural and urban land-use studies were shallow observation wells that are not used for drinking water, but about 20 percent of wells sampled in agricultural areas were domestic wells. Most wells sampled for the major aquifer studies are used for drinking water; about 18 percent were public-supply wells, and 71 percent were domestic wells. Overall, about 1 percent of all domestic and public-supply wells had concentrations of a pesticide greater than a human-health benchmark.

Type of ground-water study	Public-supply wells		Domestic wells		Observation wells	
	Number sampled	Percentage of samples exceeding a benchmark	Number sampled	Percentage of samples exceeding a benchmark	Number sampled	Percentage of samples exceedin a benchmark
Agricultural land use	1	0.0	406	1.2	1,005	1.1
Urban land use	9	11	17	18	835	4.4
Major aquifers	354	2.0	1,933	0.5	453	2.0

How this table was made:

This table shows the number of public-supply, domestic, and observation wells sampled for agricultural and urban land-use studies and major-aquifer studies and the percentage of those samples for which one or more pesticide compounds were detected at concentrations that exceeded a drinking-water benchmark. Of the 83 pesticide compounds analyzed in water, 47 have drinking-water benchmarks.

Approximately one-third of the samples did not have pesticides analyzed by one of the two principal analytical methods used for the national assessment. The missing method, high performance liquid chromatography (HPLC), accounts for 36 of the 83 pesticides analyzed in water for the national assessment and 20 of the 47 pesticides with a drinking-water benchmark. The missing data were assumed to be nondetections. The expected effect of the missing HPLC analyses for table 6-1 is underestimation of the percentage of samples with an exceedance.

All wells in the public-supply and domestic categories are public-supply or domestic wells, respectively. The observation wells category includes (but is not limited to) wells used for monitoring, livestock, recreation, irrigation, institutions, industry, commercial properties, and aquaculture.

A single sample per well was used to characterize pesticides in ground water.

- For each of the three ground-water study and well types, the percentage of wells with one or more

exceedances of a drinking-water benchmark was calculated as follows:

(n / N) * 100

Where N is the number of samples with pesticide analyses and n is the number of wells with one or more exceedances of a drinking water benchmark. The percentage was rounded to the tenth's place.

Pesticide names and analytical methods are presented in Appendix 1.

Information on sampling sites and their characteristics is presented in Appendix 5.

Downloadable concentration data are presented in Appendix 6.

Additional information on analytical approach is presented in Appendix 8.

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Appendix 1. Pesticide compounds analyzed in NAWQA samples

Appendix 1A. Pesticide compounds analyzed in NAWQA water samples

Appendix 1B. Pesticide compounds analyzed in NAWQA bed-sediment or whole-fish samples

Appendix 1—Pesticide compounds analyzed in NAWQA samples.

Table A. Pesticide compounds analyzed in NAWQA water samples.

[Pesticide compounds include pesticides, degradates, and manufacturing by-products. Pesticide compounds are grouped by pesticide class. Common synonyms are listed in parentheses in column 1. The cited references are listed by number at the end of Appendix 1. CAS, Chemical Abstracts Service; GCMS, gas chromatography/mass spectrometry; HPLC, high performance liquid chromatography; Parameter code, the number used to identify a pesticide in the U.S. Geological Survey National Water Information System and the U.S. Environmental Protection Agency Data Storage and Retrieval System; µg/L, micrograms per liter.]

Pesticide compound (synonym)	Type of pesticide compound (parent pesticide, if degradate)	CAS number	Parameter code	Analytical method	Long-term method detection level [1] (µg/L)
Amides					
Acetochlor	Herbicide	34256-82-1	49260	GCMS	0.003
Alachlor	Herbicide	15972-60-8	46342	GCMS	0.002
2,6-Diethylaniline	Degradate (Alachlor)	579-66-8	82660	GCMS	0.003
Metolachlor	Herbicide	51218-45-2	39415	GCMS	0.006
Napropamide	Herbicide	15299-99-7	82684	GCMS	0.003
Pronamide (Propyzamide)	Herbicide	23950-58-5	82676	GCMS	0.002
Propachlor	Herbicide	1918-16-7	04024	GCMS	0.005
Propanil	Herbicide	709-98-8	82679	GCMS	0.005
Carbamates					
Aldicarb	Insecticide	116-06-3	49312	HPLC	0.100
Aldicarb sulfone	Degradate (Aldicarb)	1646-88-4	49313	HPLC	0.100
Aldicarb sulfoxide	Degradate (Aldicarb)	1646-87-3	49314	HPLC	0.140
Butylate	Herbicide	2008-41-5	04028	GCMS	0.001
Carbaryl	Insecticide	63-25-2	82680	GCMS	0.021
Carbofuran	Insecticide	1563-66-2	82674	GCMS	0.010
EPTC	Herbicide	759-94-4	82668	GCMS	0.001
3-Hydroxycarbofuran	Degradate (Carbofuran)	16655-82-6	49308	HPLC	0.050
Methiocarb	Insecticide	2032-65-7	38501	HPLC	0.030
Methomyl	Insecticide	16752-77-5	49296	HPLC	0.240
Molinate	Herbicide	2212-67-1	82671	GCMS	0.001
Oxamyl	Insecticide	23135-22-0	38866	HPLC	0.080
Pebulate	Herbicide	1114-71-2	82669	GCMS	0.002
Propham	Herbicide	122-42-9	49236	HPLC	0.110
Propoxur (Baygon)	Insecticide	114-26-1	38538	HPLC	0.060
Thiobencarb	Herbicide	28249-77-6	82681	GCMS	0.002
Triallate	Herbicide	2303-17-5	82678	GCMS	0.001
Chlorobenzoic acid esters					
Dacthal (DCPA) [2]	Herbicide	1861-32-1	82682	GCMS	0.002
Dacthal monoacid	Degradate (Dacthal)	887-54-7	49304	HPLC	0.040
Chlorophenoxy acids					
2,4-D	Herbicide	94-75-7	39732	HPLC	0.080
2,4-DB	Herbicide	94-82-6	38746	HPLC	0.130
Dichlorprop	Herbicide	120-36-5	49302	HPLC	0.060

A011957

Table A. Pesticide compounds analyzed in NAWQA water samples.—Continued

[Pesticide compounds include pesticides, degradates, and manufacturing by-products. Pesticide compounds are grouped by pesticide class. Common synonyms are listed in parentheses in column 1. The cited references are listed by number at the end of Appendix 1. CAS, Chemical Abstracts Service; GCMS, gas chromatography/mass spectrometry; HPLC, high performance liquid chromatography; Parameter code, the number used to identify a pesticide in the U.S. Geological Survey National Water Information System and the U.S. Environmental Protection Agency Data Storage and Retrieval System; µg/L, micrograms per liter.]

Pesticide compound (synonym)	Type of pesticide compound (parent pesticide, if degradate)	CAS number	Parameter code	Analytical method	Long-term method detection level [1] (µg/L)
MCPA	Herbicide	94-74-6	38482	HPLC	0.100
MCPB	Herbicide	94-81-5	38487	HPLC	0.130
2,4,5-T	Herbicide	93-76-5	39742	HPLC	0.040
2,4,5-TP (Silvex)	Herbicide	93-72-1	39762	HPLC	0.030
		Dinitroanilines			
Benfluralin	Herbicide	1861-40-1	82673	GCMS	0.005
Ethalfluralin	Herbicide	55283-68-6	82663	GCMS	0.005
Oryzalin	Herbicide	19044-88-3	49292	HPLC	0.140
Pendimethalin	Herbicide	40487-42-1	82683	GCMS	0.011
Trifluralin	Herbicide	1582-09-8	82661	GCMS	0.005
		Miscellaneous			
Bentazon	Herbicide	25057-89-0	38711	HPLC	0.030
Norflurazon	Herbicide	27314-13-2	49293	HPLC	0.021
		Miscellaneous acids			
Acifluorfen	Herbicide	50594-66-6	49315	HPLC	0.040
Chloramben methyl ester	Herbicide	7286-84-2	61188	HPLC	0.110
Clopyralid	Herbicide	1702-17-6	49305	HPLC	0.210
Dicamba	Herbicide	1918-00-9	38442	HPLC	0.050
Picloram	Herbicide	1918-02-1	49291	HPLC	0.040
		Nitrophenols			
Dinoseb	Herbicide	88-85-7	49301	HPLC	0.040
DNOC	Herbicide	534-52-1	49299	HPLC	0.130
		Organochlorines			
Chlorothalonil	Fungicide	1897-45-6	49306	HPLC	0.070
p,p'-DDE	Degradate (*p,p'*-DDT)	72-55-9	34653	GCMS	0.001
Dichlobenil	Herbicide	1194-65-6	49303	HPLC	0.050
Dieldrin	Insecticide, Degradate (Aldrin)	60-57-1	39381	GCMS	0.002
alpha-HCH	Degradate (*gamma*-HCH), By-product in technical lindane [3]	319-84-6	34253	GCMS	0.002
gamma-HCH (Lindane)	Insecticide	58-89-9	39341	GCMS	0.002
Triclopyr	Herbicide	55335-06-3	49235	HPLC	0.040
		Organophosphates			
Azinphos-methyl (Guthion)	Insecticide	86-50-0	82686	GCMS	0.020
Chlorpyrifos	Insecticide	2921-88-2	38933	GCMS	0.003
Diazinon	Insecticide	333-41-5	39572	GCMS	0.003

A011958

Table A. Pesticide compounds analyzed in NAWQA water samples.—Continued

[Pesticide compounds include pesticides, degradates, and manufacturing by-products. Pesticide compounds are grouped by pesticide class. Common synonyms are listed in parentheses in column 1. The cited references are listed by number at the end of Appendix 1. CAS, Chemical Abstracts Service; GCMS, gas chromatography/mass spectrometry; HPLC, high performance liquid chromatography; Parameter code, the number used to identify a pesticide in the U.S. Geological Survey National Water Information System and the U.S. Environmental Protection Agency Data Storage and Retrieval System; µg/L, micrograms per liter.]

Pesticide compound (synonym)	Type of pesticide compound (parent pesticide, if degradate)	CAS number	Parameter code	Analytical method	Long-term method detection level [1] (µg/L)
Disulfoton	Insecticide	298-04-4	82677	GCMS	0.011
Ethoprop (Ethoprophos)	Insecticide	13194-48-4	82672	GCMS	0.002
Fonofos	Insecticide	944-22-9	04095	GCMS	0.001
Malathion	Insecticide	121-75-5	39532	GCMS	0.014
Parathion (Ethyl parathion)	Insecticide	56-38-2	39542	GCMS	0.005
Parathion-methyl (Methyl parathion)	Insecticide	298-00-0	82667	GCMS	0.003
Phorate	Insecticide	298-02-2	82664	GCMS	0.006
Terbufos	Insecticide	13071-79-9	82675	GCMS	0.009
		Phenols			
Bromoxynil	Herbicide	1689-84-5	49311	HPLC	0.030
		Pyrethroids			
cis-Permethrin [2]	Insecticide	54774-45-7	82687	GCMS	0.003
		Sulfite esters			
Propargite	Acaricide	2312-35-8	82685	GCMS	0.011
		Triazines			
Atrazine	Herbicide	1912-24-9	39632	GCMS	0.004
Cyanazine	Herbicide	21725-46-2	04041	GCMS	0.009
Deethylatrazine	Degradate (Atrazine)	6190-65-4	04040	GCMS	0.003
Metribuzin	Herbicide	21087-64-9	82630	GCMS	0.003
Prometon	Herbicide	1610-18-0	04037	GCMS	0.007
Simazine	Herbicide	122-34-9	04035	GCMS	0.006
		Uracils			
Bromacil	Herbicide	314-40-9	04029	HPLC	0.040
Terbacil	Herbicide	5902-51-2	82665	GCMS	0.017
		Ureas			
Diuron	Herbicide	330-54-1	49300	HPLC	0.060
Fenuron	Herbicide	101-42-8	49297	HPLC	0.030
Fluometuron	Herbicide	2164-17-2	38811	HPLC	0.030
Linuron	Herbicide	330-55-2	82666	GCMS	0.018
Neburon	Herbicide	555-37-3	49294	HPLC	0.030
Tebuthiuron	Herbicide	34014-18-1	82670	GCMS	0.008

[1] The long-term method detection level (reference 1) is calculated annually. The value reported in the table is the maximum long-term method detection level for the period 1992–2001.

[2] This pesticide also can be considered an organochlorine pesticide because it is an organic pesticide with multiple chlorine substituents.

[3] Prior to 1977, *alpha*-HCH was a manufacturing by-product in technical lindane, which is a mixture of several isomers of hexachlorocyclohexane (reference 2).

A011959

Table B. Pesticide compounds analyzed in NAWQA bed-sediment or whole-fish samples.

[Pesticide compounds include pesticides, degradates, and manufacturing by-products. Pesticide compounds are grouped by pesticide class. Common synonyms are listed in parentheses in column 1. The cited references are listed by number at the end of Appendix 1. CAS, Chemical Abstracts Service; Parameter code, the number used to identify a pesticide in the U.S. Geological Survey National Water Information System and the U.S. Environmental Protection Agency Data Storage and Retrieval System; µg/kg dw, micrograms per kilogram dry weight; µg/kg ww, micrograms per kilogram wet weight; —, not analyzed.]

Pesticide compound (synonym)	Type of pesticide compound (parent pesticide, if degradate)	CAS number	Bed sediment		Whole fish	
			Parameter code	Reporting level (µg/kg dw)	Parameter code	Reporting level (µg/kg ww)
Chlorobenzoic acid esters						
Dacthal (DCPA) [1]	Herbicide	1861-32-1	49324	5	49378	5
Organochlorines						
Aldrin	Insecticide, Component of total dieldrin [2]	309-00-2	49319	1	49353	5
cis-Chlordane	Insecticide, Component of total chlordane [3]	5103-71-9	49320	1	49380	5
trans-Chlordane	Insecticide, Component of total chlordane [3]	5103-74-2	49321	1	49379	5
Chloroneb	Insecticide	2675-77-6	49322	5	—	—
o,p'-DDD	Degradate (*o,p'*-DDT), Component of total DDT [4]	53-19-0	49325	1	49374	5
p,p'-DDD (*p,p'*-TDE)	Insecticide, Degradate (*p,p'*-DDT), Component of total DDT [4]	72-45-8	49326	1	49375	5
o,p'-DDE	Degradate (*o,p'*-DDT), Component of total DDT [4]	3424-82-6	49327	1	49373	5
p,p'-DDE	Degradate (*p,p'*-DDT), Component of total DDT [4]	72-55-9	49328	1	49372	5
o,p'-DDT	By-product in technical DDT, Component of total DDT [4]	789-02-6	49329	2	49377	5
p,p'-DDT	Insecticide, Component of total DDT [4]	50-29-3	49330	2	49376	5
Dieldrin	Insecticide, Degradate (Aldrin), Component of total dieldrin [2]	60-57-1	49331	1	49371	5
Endosulfan I (*alpha*-Endosulfan)	Insecticide	959-98-8	49332	1	—	—
Endrin	Insecticide	72-20-8	49335	1	49370	5
alpha-HCH	Degradate (*gamma*-HCH), By-product in technical lindane, Component of total HCH [5]	319-84-6	49338	1	49366	5
beta-HCH	By-product in technical lindane, Component of total HCH [5]	319-85-7	49339	1	49365	5
gamma-HCH (Lindane)	Insecticide, Component of total HCH [5]	58-89-9	49345	1	49363	5
delta-HCH	Degradate (*gamma*-HCH), By-product in technical lindane, Component of total HCH [5]	319-86-8	—	—	49364	5
Heptachlor	Insecticide, Component of total heptachlor [6]	76-44-8	49341	1	49369	5
Heptachlor epoxide	Degradate (Heptachlor), Component of total heptachlor [6]	1024-57-3	49342	1	49368	5
Hexachlorobenzene	Insecticide	118-74-1	49343	1	49367	5
Isodrin	Insecticide	465-73-6	49344	1	—	—
o,p'-Methoxychlor	Insecticide, Component of total methoxychlor [7]	30667-99-3	49347	5	49362	5
p,p'-Methoxychlor	Insecticide, Component of total methoxychlor [7]	72-43-5	49346	5	49361	5
Mirex	Insecticide	2385-85-5	49348	1	49360	5
cis-Nonachlor	By-product in technical chlordane, Component of total chlordane [3]	5103-73-1	49316	1	49359	5

A011960

Table B. Pesticide compounds analyzed in NAWQA bed-sediment or whole-fish samples.—Continued

[Pesticide compounds include pesticides, degradates, and manufacturing by-products. Pesticide compounds are grouped by pesticide class. Common synonyms are listed in parentheses in column 1. The cited references are listed by number at the end of Appendix 1. CAS, Chemical Abstracts Service; Parameter code, the number used to identify a pesticide in the U.S. Geological Survey National Water Information System and the U.S. Environmental Protection Agency Data Storage and Retrieval System; µg/kg dw, micrograms per kilogram dry weight; µg/kg ww, micrograms per kilogram wet weight; —, not analyzed.]

Pesticide compound (synonym)	Type of pesticide compound (parent pesticide, if degradate)	CAS number	Bed sediment		Whole fish	
			Parameter code	Reporting level (µg/kg dw)	Parameter code	Reporting level (µg/kg ww)
trans-Nonachlor	By-product in technical chlordane, Component of total chlordane [3]	39765-80-5	49317	1	49358	5
Oxychlordane	Degradate (Chlordane), Component of total chlordane [3]	27304-13-8	49318	1	49357	5
Pentachloroanisole	Degradate (Pentachlorophenol)	1825-21-4	49460	1	49356	5
Toxaphene	Insecticide, Technical mixture	8001-35-2	49351	200	49355	200
	Pyrethroids					
cis-Permethrin [1]	Insecticide, Component of total permethrin [8]	52774-45-7	49349	5	—	—
trans-Permethrin [1]	Insecticide, Component of total permethrin [8]	51877-74-8	49350	5	—	—

[1] This pesticide also can be considered an organochlorine pesticide because it is an organic pesticide with multiple chlorine substituents.

[2] The pesticide group "total dieldrin" refers to the summed concentrations of aldrin and dieldrin.

[3] The pesticide group "total chlordane" refers to the summed concentrations of *cis*-chlordane, *trans*-chlordane, *cis*-nonachlor, *trans*-nonachlor, and oxychlordane. Chlordane was applied as a technical-grade mixture of over 140 compounds, including nonachlor isomers and other manufacturing by-products.

[4] The pesticide group "total DDT" refers to the summed concentrations of *o,p'*-DDT, *p,p'*-DDT, *o,p'*-DDD, *p,p'*-DDD, *o,p'*-DDE, and *p,p'*-DDE. Technical DDT contained *p,p'*-DDT (the active ingredient) and *o,p'*-DDT (a manufacturing by-product).

[5] The pesticide group "total HCH" refers to the summed concentrations of *alpha*-HCH, *beta*-HCH, *gamma*-HCH, and *delta*-HCH. Technical lindane is a mixture of several isomers of hexachlorocyclohexane; *gamma*-HCH is the active ingredient, and the other isomers are manufacturing by-products. In 1977, USEPA cancelled inclusion of *alpha*- and *beta*-HCH in technical-grade lindane (reference 2).

[6] The pesticide group "total heptachlor" refers to the summed concentrations of heptachlor and heptachlor epoxide.

[7] The pesticide group "total methoxychlor" refers to the summed concentrations of *o,p'*-methoxychlor and *p,p'*-methoxychlor.

[8] The pesticide group "total permethrin" refers to the summed concentrations of *cis*-permethrin and *trans*-permethrin.

References—Appendix 1

1. Oblinger Childress, C.J., Foreman, W.T., Conner, B.F., and Maloney, T.J., 1999, New reporting procedures based on long-term method detection levels and some considerations of interpretations of water-quality data provided by the U.S. Geological Survey National Water Quality Laboratory: U.S. Geological Survey Open-File Report 99-193, 19 p.

2. U.S. Environmental Protection Agency, 1992, National study of chemical residues in fish: U.S. Environmental Protection Agency, Office of Science and Technology, EPA-823-R-92-008b, v. 2, variously paged.

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The Quality of Our Nation's Waters

Pesticides in the Nation's Streams and Ground Water, 1992-2001

Appendix 2 - Properties affecting the transport and fate of selected pesticide compounds.

[Pesticide compounds selected are those detected most frequently in NAWQA samples (see figs. 4-2 and 4-4), as well as several that were detected infrequently, despite extensive use. All values measured at (or estimated for) 25°C, except for those shown in *italics*. Unless noted otherwise, (1) values for octanol-water partition coefficient (K_{ow}, dimensionless), soil organic carbon-water partition coefficient (K_{oc}), water solubility (S_w) and Henry's law constant (K_H) are from Mackay and others (1997); (2) transformation half-lives in soil and water were measured in the laboratory (rather than in the field) at neutral pH in the dark, and obtained from the U.S. Department of Agriculture (2005); and (3) all are recommended values selected by the compilation authors when more than one value was available from the literature. Compounds are listed in the same order as in figures 4-2 and 4-4. Numbers of significant figures are identical to those given in original sources. kJ/mol, kilojoule per mole; mg/L, milligram per liter; mL/g, milliliter per gram; NA, data not available from any of the references consulted; Pa•m^3/mol, pascal-cubic meter per mole; >, greater than.]

Compound	log K_{ow}	log K_{oc} (K_{oc} in mL/g)	S_w (mg/L)	log K_H (K_H in Pa•m^3/mol)	Half-life for transformation (days)	
					In aerobic soil	In water
Agricultural herbicides and degradates detected most frequently in water						
Atrazine	2.75	2.00	30	-3.54	146	[1]742
Deethylatrazine (DEA)	[2]1.3	[3]1.90	[4]2700	[5]-4.12	[6]170	NA
Metolachlor	3.13	2.26	430	-2.63	26	[7]410
Cyanazine	2.22	2.3	171	-6.52	[8]17	[9]>200
Alachlor	2.8	2.23	240	-2.7	[10]20.4	[11]640
Acetochlor	[12]3.0	[13]2.38	[12,14]*223*	[12,15]*-2.15*	[13,15]*14*	[16]2300
Metribuzin	[14,17]*1.60*	1.72	[14,17]*1,000*	[17,18]-5.31	172	[9]>200
Bentazon	[19]2.80	[20]1.54	[14,17]*500*	[21]*-3.7*	[22]35	[23]*>200*
EPTC	3.2		370			

		2.3		0.00988	[24]7	[9]>200
Trifluralin	5.34	4.14	[25]0.5	1.00	169	[26]>32
Molinate	3.21	1.92	970	-0.839	[27]21	[9]>200
Norflurazon	[17]2.45	[17]2.55	[17]34	[17]-4.46	130	[9]>200
Urban herbicides detected most frequently in water						
Simazine	2.18	2.11	5	-3.46	[8]91	[28]>32
Prometon	2.99	2.54	750	-4.05	932	[9]>200
Tebuthiuron	[8]1.79	[17]2.1	[29]2400	[17]-4.88	1050	[30]>2700
2,4-D	2.81	[17]1.68	890	-3.61	[31]2.3	[7]732
Diuron	2.78	2.6	40	-3.17	372	>500
Dacthal (DCPA)	[32]4.28	[17]3.75	[17]0.5	[17]-0.66	[33]16	[9]>200
Bromacil	2.11	1.86	815	-4.89	275	[34]>30
Insecticides detected most frequently in water						
Diazinon	3.3	2.76	60	-1.39	39	140
Chlorpyrifos	4.92	3.78	0.73	0.0374	30.5	29
Carbofuran	2.32	2.02	351	-4.30	11	[35]289
Carbaryl	2.36	2.36	120	-4.35	17	11
Malathion	2.8	3.26	145	-2.64	<1	[36]6.3
Dieldrin[37]	5.20	4.08	0.17	0.0492	NA	3830
Organochlorine pesticide compounds detected most frequently in bed sediment and fish tissue						
p,p'-DDE	5.7	5.0	0.04	0.900	NA	[38]*>44,000*
p,p'-DDD	5.5	5.0	0.05	-0.194	NA	[39]10,000
p,p'-DDT	6.19	5.4	0.0055	0.37	NA	[40]*5000*
o,p'-DDE	5.8	[8]5.58	0.1	0.405	NA	NA
o,p'-DDD	6.0	[8]5.36	[25]0.10	[41]-2.7	NA	[39]NA
o,p'-DDT	[42]NA	[42]NA	0.026	-0.460	NA	NA
cis-Chlordane	6.0	5.5	0.056	-0.466	NA	[43]>7.2x10[7]
trans-Chlordane	6.0	5.5	0.056	-0.582	NA	[44]>10,000
Nonachlor	[45]5.66	[45]4.86	[45]0.06	[45]-1.69	NA	NA
Oxychlordane	[46]2.6	[46]2.48	[46]200	[46]-1.52	NA	NA
Dieldrin[37]	5.20	4.08	0.17	0.0492	NA	3830
Heptachlor epoxide	5.0	4.0	0.35	[46]0.51	NA	NA
Pentachloroanisole	[46]5.66	[46]4.62	[46]0.2	[46]2.91	NA	NA
Hexachlorobenzene	[32]5.31	[17]4.7	[32]0.0062	[47]1.69	NA	[48]>26,000
Chlorothalonil	2.64	3.2	0.6	1.77	NA	[9]>200

Dicamba	2.21	[17]1.11	4500	-3.66	[49]28	[9]>200
Parathion-methyl (Methyl parathion)	3.0	3.7	25	-1.68	[50]3.3	41
Pendimethalin	[17]5.2	[17]4.13	[17]0.275	[17]0.0899	1300	[9]>200
Terbufos	4.48	2.70	5	0.39	5	1.9

[1]Measured by Khan (1978) in a solution containing 0.5 g/L fulvic acid.

[2]Computed from K_{oc} value using K_{ow}-vs.-K_{oc} regression for "triazines" from Sabljić and others (1995).

[3]K_{oc} value measured on a clay loam soil (1.3% organic carbon) by Seybold and Mersie (1996), the study—among those having measured K_{oc} for both DEA and atrazine—reporting the K_{oc} value for atrazine (140 mL/g) that was closest to the value selected for atrazine (100 mL/g) by Mackay and others (1997).

[4]Value from Ciba-Geigy, Ltd., cited by Bayless (2001)

[5]Estimated by (1) computing estimates of K_H for both DEA and atrazine ($K_{H,est}[DEA]$ and $K_{H,est}[atr]$, respectively) using the bond-contribution method of Meylan and Howard (1991); and (2) scaling from the value measured for atrazine ($K_{H,meas}[atr]$) using the following equation:

$$K_H[DEA] \approx K_{H,meas}[atr] * \left(\frac{K_{H,est}[DEA]}{K_{H,est}[atr]} \right)$$

[6]Measured by Kruger and others (1997) in the aerobic soil (sandy clay loam, 0.6% organic carbon) for which the half-life for atrazine reported by the authors and adjusted to 25°C (191 d) was most similar to the value selected by the U.S. Department of Agriculture (2005) for atrazine at 25°C (146 d). Half-lives for both atrazine and DEA in soil were adjusted to 25°C from 24°C using an activation energy of 48.4 kJ/mol, measured by Baer and Calvet (1999) for atrazine disappearance in an aerobic silt loam (1.1% organic carbon).

[7]Rate extrapolated to 25°C using data reported by Cavalier and others (1991) for disappearance of the pesticide in ground-water samples (pH = 7.4-7.6) at 15 and 22°C, based on the experiment with the highest initial pesticide concentration (and thus maximum analytical sensitivity).

[8]Sole value reported by the U.S. Department of Agriculture (2005) database authors, but not "selected."

[9]Classified as "stable" with respect to hydrolysis (U.S. Department of Agriculture, 2005), meaning that the compound exhibits "less than 10% reaction after 30 days at 25°C" (Cheryl Sutton, U.S. Environmental Protection Agency Office of Pesticide Programs, Environmental Fate and Effects Division, personal communication, 1/4/05).

[10]Half-life interpolated to 25°C from rates of alachlor disappearance from a sandy loam soil (0.7% organic carbon) at 10, 20 and 30°C reported by Zimdahl and Clark (1982).

[11]Rate extrapolated to 25°C from data reported by Cavalier and others (1991) for alachlor disappearance in ground water (pH = 7.4-7.6) at 15 and 22°C, based on the experiment with the highest initial alachlor concentration (and thus maximum analytical sensitivity). Value consistent with half-life estimate of ">100 d" at 20°C in deionized water reported by Gan and others (2002).

[12]Source: U.S. Environmental Protection Agency (1994).

[13]Median value among those reported by U.S. Environmental Protection Agency (1994).

[14]Measured at 20°C.

[15]Temperature of measurement not given.

[16]Source: Zheng and Ye (2001), cited by Carlson (2003). Consistent with half-life of ">100 d" at 20°C in deionized water reported by Gan and others (2002).

[17]Source: U.S. Department of Agriculture (2005).

[18]Adjusted from value measured at 20°C to 25°C using equation provided by Mackay and others (2000), and an enthalpy of vaporization (ΔH_v) of 46.8 kJ/mol, based on K_H data from 197 compounds (Staudinger and Roberts, 2001).

[19]Source: Sabljić and others (1995). Form of molecule (salt vs. benzothiadiazine) not given.

[20]Measured using the sodium salt of bentazon, rather than the benzothiadiazine form (U.S. Department of Agriculture, 2005).

[21]Computed from dimensionless value given by Tiktak (1999). Temperature of measurement not given, but similarity of value to that computed from vapor pressure and solubility (both obtained from EXTOXNET) suggests that it may have been 20°C.

[22]Median value among 19 measurements of bentazon disappearance rates in a variety of soils (pH= 6.1-7.7) over a temperature range of 20-23°C (Huber and Otto, 1994; Thorstensen and Lode, 2001), after adjusting all values to 25°C using an activation energy of 90 kJ/mol for bentazon disappearance, measured for a sandy soil with 4.90% organic carbon (Tiktak, 1999).

[23]Statement by Huber and Otto (1994) that "hydrolytically, bentazon is nearly stable...at pH...7" presumed to be equivalent to U.S. Environmental Protection Agency's definition of "stable" (see footnote 9), although temperature of measurement not given.

[24]"[H]alf-life in moist loam soil at 21 to 27°C is approximately one week" (Mackay and others, 1997).

[25]According to Mackay and others (1997), "the reported values for this quantity vary considerably [0.05 - 40 mg/L for trifluralin; 0.10 - 0.24 mg/L for *o,p'*-DDD]; whereas this selected value represents the best judgement of the authors...it may be subject to large error."

[26]Computed from rate constant (maximum value) provided by U.S. Department of Agriculture (2005).

[27]According to Mackay and others (1997), "half-life is approximately 3 weeks in moist loam soils at 21-C."

[28]For biodegradation in pond water. Source: Tucker and Boyd (1981), cited by Mackay and others (1997).

[29]Arithmetic mean of the two values reported by U.S. Department of Agriculture (2005), neither of which was "selected."

[30]Estimated from assumption that "no hydrolysis in 64 days" at 51°C and pH 3, 6 and 9 (U.S. Department of Agriculture, 2005) implies less than 5% reaction. Extrapolated to 25°C using the minimum activation energy (E_a) for the transformation in soil of methabenzthiazuron (35.6 kJ/mol), the urea herbicide most similar in structure to tebuthiuron among those for which E_a values appear to be available (FOCUS, 1997). (No E_a values appear to be available for the disappearance of either methabenzthiazuron or tebuthiuron in water.)

[31]Average of values computed for two soils, based on data reported by Veeh and others (1996).

[32]Source: Syracuse Research Corporation CHEMFATE Database.

[33]Source: Wettasinghe and Tinsley (1993).

[34]Transformation rate given for pH 5 and 9 only (U.S. Department of Agriculture, 2005).

[35]Transformation rate measured at pH 6.2 (U.S. Department of Agriculture, 2005).

[36]Value measured at pH 7, rather than the pH (5) at which the value recommended by the U.S. Department of Agriculture (2005) was measured.

[37]Dieldrin is both an insecticide and a product of aldrin transformation (Nowell and others, 1999), and was one of the pesticide compounds detected most frequently in bed sediments, as well as in water.

[38]Reaction rate measured in 5% acetonitrile solution, extrapolated to 27°C from higher temperatures, and interpolated to pH 5 by Wolfe and others (1977).

[39]No distinction made between *o,p'* and *p,p'* isomers for this parameter by the U.S. Department of Agriculture (2005), but reported half-life was identical to that provided by Ellington and others (1987a) for *p,p'*-DDD, suggesting that the U.S. Department of Agriculture (2005) value was for the *p,p'* isomer only.

[40]Reaction rate measured in 5% acetonitrile solution, extrapolated to 27°C from higher temperatures, and interpolated to pH 7 by Wolfe and others (1977).

[41]Source: Suntio and others (1988).

[42]Available estimation methods appear inadequate for distinguishing between *ortho* and *para* isomers.

[43]Source: Ellington and others (1987a).

[44]Estimated from assumption that "zero degradation...during five days" at 85°C and pH 7 (Ellington and others, 1987b) implies less than 10% reaction (Ellington and others, 1988). Extrapolated to 25°C using the activation energy for the transformation of γ-HCH in borate buffer at pH 9 (84.6 kJ/mol), reported by Ngabe and others (1993).

[45]Source: Nowell and others (1999). No distinction made between *cis* and *trans* isomers.

[46]Source: Nowell and others (1999).

[47]Computed for 25°C using regression equation from Staudinger and Roberts (2001).

[48]Estimated from assumption that "zero hydrolysis observed after 13 days at 85°C and pH 7 (Ellington and others, 1987b) implies less than 10% reaction (Ellington and others, 1988). Extrapolated to 25°C using the activation energy for the transformation of γ-HCH in borate buffer at pH 9 (84.6 kJ/mol), reported by Ngabe and others (1993).

[49]Interpolated to 25°C from data for a clay soil (1.5% organic matter) by Comfort and others (1992).

[50]Extrapolated to 25°C from value measured at 30°C in a silt loam soil (organic carbon content not given) by Lichtenstein and Schulz (1964) after 12 days of reaction (the longest reaction period examined by the authors), using the activation energy (E_a) measured by Lartiges and Garrigues (1995) for methyl parathion disappearance in unfiltered river water at pH 7.3 (26 kJ/mol). (No E_a values appear to be available for methyl parathion disappearance from aerobic soil.)

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NAWQA Pesticide National Synthesis Project

Publications - CIRC 1291

The Quality of Our Nation's Waters

Pesticides in the Nation's Streams and Ground Water, 1992-2001

U.S. Geological Survey Circular 1291

Appendix 3. Water-quality benchmarks for pesticide compounds analyzed in NAWQA samples

Appendix 3A. Water-quality benchmarks for pesticide compounds analyzed in NAWQA water samples [downloadable excel file]

Appendix 3B. Water-quality benchmarks for pesticide compounds analyzed in NAWQA bed-sediment or whole-fish samples [downloadable excel file]

Appendix 3C. Pesticide compounds analyzed by NAWQA that do not have water-quality benchmarks. [downloadable excel file]

Appendix 3D. References—Appendix 3

Appendix 3A. Water-quality benchmarks for pesticide compounds analyzed in NAWQA water samples

[For pesticide compounds in water, benchmarks are for protection of human health and aquatic life. Common synonyms are listed in parentheses in column 1. Cited references are listed in Appendix 3D. Environmental concentration, the measured or calculated concentration statistic that is appropriate for comparison with the benchmark; CRC(10^{-6}), 10^{-6} cancer risk concentration; EC_{50}, 50 percent effect concentration; EFED, Environmental Fate and Effects Division (within EPA's Office of Pesticide Programs); HA-L, lifetime health advisory; IRED, Interim Reregistration Eligibility Decision; IRIS, Integrated Risk Information System database; LC_{50}, 50 percent lethal concentration; LOC, level of concern; MCL, maximum contaminant level; NOAEC, no-observed-adverse-effects concentration; OPP, Office of Pesticide Programs; RED, Reregistration Eligibility Decision; USEPA, U.S. Environmental Protection Agency; µg/L, microgram per liter; >, greater than; <, less than;—, no benchmark available.]

Pesticide compound (synonym)	Human health benchmarks (µg/L)		Aquatic life benchmarks (µg/L)									
	Derived from USEPA drinking-water standards and guidelines (Office of Water)		Derived from USEPA ambient water-quality criteria for aquatic life (Office of Water)		Derived from USEPA Reregistration Eligibility Decisions and ecological risk assessments (Office of Pesticide Programs)							
	Value[1]	Type	Acute[2]	Chronic[2]	Acute fish[3]	Chronic fish[4]	Acute invertebrates[5]	Chronic invertebrates[6]	Acute nonvascular plants[7]	Acute vascular plants[8]	Chronic aquatic community[9]	OPP references
Environmental concentration:	Time-weighted annual mean		Each individual sample	4-day moving average	Each individual sample	60-day average	Each individual sample	21-day average	Each individual sample	Each individual sample	60-day average	
Amides												
Alachlor	2	MCL	—	—	900	187	1,600	110	1.64	—	—	USEPA (1998a)
Metolachlor	100	HA-L	—	—	1,950	780	12,550	—	—	—	—	USEPA (1995a)
Napropamide	—	—	—	—	3,200	—	7,150	—	3,400	—	—	USEPA (2005a)
Pronamide (Propyzamide)	50	HA-L	—	—	36,000	—	[10] 2,800	—	760	—	—	USEPA (1994a)
Propachlor	90	HA-L	—	—	85	—	395	—	13.5	—	—	USEPA (1998b)
Propanil	—	—	—	—	1,150	9.1	600	86.0	16	110	—	USEPA (2003a)
Carbamates												
Aldicarb[11]	3	MCL (stayed)	—	—	26	0.46	10	1.0	[10] 50,000	—	—	USEPA (2005b)
Aldicarb sulfone[11]	2	MCL (stayed)	—	—	21,000	—	140	—	—	—	—	USEPA (2005b)
Aldicarb sulfoxide[11]	4	MCL (stayed)	—	—	3,570	—	21.5	—	—	—	—	USEPA (2005b)
Butylate	400	HA-L	—	—	105	[12] 210	5,950	—	—	—	—	USEPA (1993)

Appendix 3A. Water-quality benchmarks for pesticide compounds analyzed in NAWQA water samples

[For pesticide compounds in water, benchmarks are for protection of human health and aquatic life. Common synonyms are listed in parentheses in column 1. Cited references are listed in Appendix 3D. Environmental concentration, the measured or calculated concentration statistic that is appropriate for comparison with the benchmark; CRC(10^{-6}), 10^{-6} cancer risk concentration; EC_{50}, 50 percent effect concentration; EFED, Environmental Fate and Effects Division (within EPA's Office of Pesticide Programs); HA-L, lifetime health advisory; IRED, Interim Reregistration Eligibility Decision; IRIS, Integrated Risk Information System database; LC_{50}, 50 percent lethal concentration; LOC, level of concern; MCL, maximum contaminant level; NOAEC, no-observed-adverse-effects concentration; OPP, Office of Pesticide Programs; RED, Reregistration Eligibility Decision; USEPA, U.S. Environmental Protection Agency; µg/L, microgram per liter; >, greater than; <, less than;—, no benchmark available.]

Pesticide compound (synonym)	**Human health benchmarks (µg/L)**		**Aquatic life benchmarks (µg/L)**									
	Derived from USEPA drinking-water standards and guidelines (Office of Water)		Derived from USEPA ambient water-quality criteria for aquatic life (Office of Water)		Derived from USEPA Reregistration Eligibility Decisions and ecological risk assessments (Office of Pesticide Programs)							
	Value[1]	Type	Acute[2]	Chronic[2]	Acute fish[3]	Chronic fish[4]	Acute invertebrates[5]	Chronic invertebrates[6]	Acute nonvascular plants[7]	Acute vascular plants[8]	Chronic aquatic community[9]	OPP references
Environmental concentration:	Time-weighted annual mean		Each individual sample	4-day moving average	Each individual sample	60-day average	Each individual sample	21-day average	Each individual sample	Each individual sample	60-day average	
Carbaryl	700	HA-L	—	—	[13] 125	[13] 210	2.55	1.5	1,100	—	—	USEPA (2003b, 2004c)
Carbofuran	40	MCL	—	—	44	5.7	1.115	0.75	—	—	—	USEPA (2005c)
EPTC	—	—	—	—	7,000	—	3,250	—	1,360	5,600	—	USEPA (1999a)
Methiocarb	—	—	—	—	218	50	3.5	0.10	—	—	—	USEPA (1994b)
Methomyl	200	HA-L	—	—	265	57	4.4	[10] 0.4	—	—	—	USEPA (1998c)
Molinate	—	—	—	—	105	[12] 210	170	[12] 340	220	3,300	—	USEPA (2001a)
Oxamyl	200	MCL	—	—	2,100	770	90	[12] 180	—	—	—	USEPA (1999b)
Pebulate	—	—	—	—	3,150	—	3,315	—	230	1,800	—	USEPA (1999c)
Propham	100	HA-L	—	—	—	—	—	—	—	—	—	—
Propoxur (Baygon)	3	HA-L	—	—	1,850	—	5.5	—	—	—	—	USEPA (1997a)
Thiobencarb	—	—	—	—	280	—	50	1.0	17	770	—	USEPA (1997b)
Triallate	—	—	—	—	600	38	45.5	13	120	—	—	USEPA (2000a)
Chlorobenzoic acid esters												
Dacthal (DCPA)[14]	70	HA-L	—	—	15,000	—	13,500	—	[10] 11,000	[10] 11,000	—	USEPA (1998d)

Appendix 3A. Water-quality benchmarks for pesticide compounds analyzed in NAWQA water samples

[For pesticide compounds in water, benchmarks are for protection of human health and aquatic life. Common synonyms are listed in parentheses in column 1. Cited references are listed in Appendix 3D. Environmental concentration, the measured or calculated concentration statistic that is appropriate for comparison with the benchmark; CRC(10^{-6}), 10^{-6} cancer risk concentration; EC_{50}, 50 percent effect concentration; EFED, Environmental Fate and Effects Division (within EPA's Office of Pesticide Programs); HA-L, lifetime health advisory; IRED, Interim Reregistration Eligibility Decision; IRIS, Integrated Risk Information System database; LC_{50}, 50 percent lethal concentration; LOC, level of concern; MCL, maximum contaminant level; NOAEC, no-observed-adverse-effects concentration; OPP, Office of Pesticide Programs; RED, Reregistration Eligibility Decision; USEPA, U.S. Environmental Protection Agency; µg/L, microgram per liter; >, greater than; <, less than; —, no benchmark available.]

Pesticide compound (synonym)	**Human health benchmarks (µg/L)**		**Aquatic life benchmarks (µg/L)**									
	Derived from USEPA drinking-water standards and guidelines (Office of Water)		Derived from USEPA ambient water-quality criteria for aquatic life (Office of Water)		Derived from USEPA Reregistration Eligibility Decisions and ecological risk assessments (Office of Pesticide Programs)							
	Value[1]	Type	Acute[2]	Chronic[2]	Acute fish[3]	Chronic fish[4]	Acute invertebrates[5]	Chronic invertebrates[6]	Acute nonvascular plants[7]	Acute vascular plants[8]	Chronic aquatic community[9]	OPP references
Environmental concentration:	Time-weighted annual mean		Each individual sample	4-day moving average	Each individual sample	60-day average	Each individual sample	21-day average	Each individual sample	Each individual sample	60-day average	
Chlorophenoxy acids												
2,4-D	70	MCL	—	—	[15] 50,500	[15] 14,200	[15] 12,500	[15] 16,400	[15] 3,880	[15] 299.2	—	USEPA (2004d)
2,4-DB	—	—	—	—	[15] 1,000	—	[15] 7,500	—	[15] 932	—	—	USEPA (2004e)
MCPA	4	HA-L	—	—	[15] 380	[15] 12,000	[15] 90	[15] 11,000	[15] 160	[15] 20	—	USEPA (2004f)
2,4,5-T	70	HA-L	—	—	—	—	—	—	—	—	—	—
2,4,5-TP (Silvex)	50	MCL	—	—	—	—	—	—	—	—	—	—
Dinitroanilines												
Benfluralin	—	—	—	—	15.85	1.9	1,090	[16] 15.5	[10] 100	—	—	USEPA (2004g)
Ethalfluralin	—	—	—	—	16	0.4	30	24	25	—	—	USEPA (1995b)
Oryzalin	—	—	—	—	1,440	220	700	—	42	15.4	—	USEPA (1994c)
Pendimethalin	—	—	—	—	69	6.3	140	14.5	5.4	12.5	—	USEPA (1997c)
Trifluralin	5	HA-L, CRC(10^{-6})	—	—	20.5	1.14	280	2.4	7.52	43.5	—	USEPA (1996a)
Miscellaneous												
Bentazon	200	HA-L	—	—	[10] 50,000	—	[10] 50,000	—	4,500	5,350	—	USEPA (1994d)
Norflurazon	—	—	—	—	4,050	770	[10] 7,500	1,000	13	86	—	USEPA (1996b)

Appendix 3A. Water-quality benchmarks for pesticide compounds analyzed in NAWQA water samples

[For pesticide compounds in water, benchmarks are for protection of human health and aquatic life. Common synonyms are listed in parentheses in column 1. Cited references are listed in Appendix 3D. Environmental concentration, the measured or calculated concentration statistic that is appropriate for comparison with the benchmark; CRC(10^{-6}), 10^{-6} cancer risk concentration; EC_{50}, 50 percent effect concentration; EFED, Environmental Fate and Effects Division (within EPA's Office of Pesticide Programs); HA-L, lifetime health advisory; IRED, Interim Reregistration Eligibility Decision; IRIS, Integrated Risk Information System database; LC_{50}, 50 percent lethal concentration; LOC, level of concern; MCL, maximum contaminant level; NOAEC, no-observed-adverse-effects concentration; OPP, Office of Pesticide Programs; RED, Reregistration Eligibility Decision; USEPA, U.S. Environmental Protection Agency; µg/L, microgram per liter; >, greater than; <, less than;—, no benchmark available.]

Pesticide compound (synonym)	**Human health benchmarks (µg/L)**		**Aquatic life benchmarks (µg/L)**									
	Derived from USEPA drinking-water standards and guidelines (Office of Water)		Derived from USEPA ambient water-quality criteria for aquatic life (Office of Water)		Derived from USEPA Reregistration Eligibility Decisions and ecological risk assessments (Office of Pesticide Programs)							
	Value[1]	Type	Acute[2]	Chronic[2]	Acute fish[3]	Chronic fish[4]	Acute invertebrates[5]	Chronic invertebrates[6]	Acute nonvascular plants[7]	Acute vascular plants[8]	Chronic aquatic community[9]	OPP references
Environmental concentration:	Time-weighted annual mean		Each individual sample	4-day moving average	Each individual sample	60-day average	Each individual sample	21-day average	Each individual sample	Each individual sample	60-day average	
Miscellaneous acids												
Acifluorfen	1	CRC(10^{-6})	—	—	15,500	[17] 1,500	14,050	—	[10] 265,000	378,000	—	USEPA (2000b)
Dicamba	200	HA-L	—	—	—	—	—	—	—	—	—	—
Picloram	500	MCL	—	—	6,500	550	34,150	11,800	4,900	—	—	USEPA (1995c)
Nitrophenols												
Dinoseb	7	MCL	—	—	—	—	—	—	—	—	—	—
Organochlorines												
Chlorothalonil	1.5	CRC(10^{-6})	—	—	11.5	3	34	39	190	—	—	USEPA (1999d)
p,p'-DDE	[18] 0.1	CRC(10^{-6})	[19] 1.1	[19,20] 0.001	—	—	—	—	—	—	—	—
Dichlobenil	—	—	—	—	2,465	[17] 330	1,850	560	1,000	30	—	USEPA (1998e)
Dieldrin	0.002	CRC(10^{-6})	0.24	0.056	—	—	—	—	—	—	—	—
alpha-HCH	[18] 0.006	CRC(10^{-6})	—	—	—	—	—	—	—	—	—	—
gamma-HCH (Lindane)	0.2	MCL	0.95	—	0.85	[12] 1.7	0.5	[12] 1	—	—	—	USEPA (2001b)
Triclopyr	—	—	—	—	[21] 180	[10,21] 104,000	[21] 850	[21] 80,700	[21] 100	[21] 880	—	USEPA (1998f)

Appendix 3A. Water-quality benchmarks for pesticide compounds analyzed in NAWQA water samples

[For pesticide compounds in water, benchmarks are for protection of human health and aquatic life. Common synonyms are listed in parentheses in column 1. Cited references are listed in Appendix 3D. Environmental concentration, the measured or calculated concentration statistic that is appropriate for comparison with the benchmark; CRC(10^{-6}), 10^{-6} cancer risk concentration; EC_{50}, 50 percent effect concentration; EFED, Environmental Fate and Effects Division (within EPA's Office of Pesticide Programs); HA-L, lifetime health advisory; IRED, Interim Reregistration Eligibility Decision; IRIS, Integrated Risk Information System database; LC_{50}, 50 percent lethal concentration; LOC, level of concern; MCL, maximum contaminant level; NOAEC, no-observed-adverse-effects concentration; OPP, Office of Pesticide Programs; RED, Reregistration Eligibility Decision; USEPA, U.S. Environmental Protection Agency; µg/L, microgram per liter; >, greater than; <, less than;—, no benchmark available.]

Pesticide compound (synonym)	Human health benchmarks (µg/L)		Aquatic life benchmarks (µg/L)									
	Derived from USEPA drinking-water standards and guidelines (Office of Water)		Derived from USEPA ambient water-quality criteria for aquatic life (Office of Water)		Derived from USEPA Reregistration Eligibility Decisions and ecological risk assessments (Office of Pesticide Programs)							
	Value[1]	Type	Acute[2]	Chronic[2]	Acute fish[3]	Chronic fish[4]	Acute invertebrates[5]	Chronic invertebrates[6]	Acute nonvascular plants[7]	Acute vascular plants[8]	Chronic aquatic community[9]	OPP references
Environmental concentration:	Time-weighted annual mean		Each individual sample	4-day moving average	Each individual sample	60-day average	Each individual sample	21-day average	Each individual sample	Each individual sample	60-day average	
Organophosphates												
Azinphos-methyl (Guthion)	—	—	—	0.01	0.18	[12] 0.36	0.08	[12] 0.16	—	—	—	USEPA (2005e)
Chlorpyrifos	20	HA-L	0.083	0.041	0.9	0.57	0.05	0.04	140	—	—	USEPA (2000c, 2002)
Diazinon	0.6	HA-L	—	—	45	[17] 0.55	[13,22] 0.1	[13] 0.17	3,700	—	—	USEPA (2000d, 2004h)
Disulfoton	0.3	HA-L	—	—	19.5	[12] 39	1.95	0.037	—	—	—	USEPA (2000e)
Ethoprop (Ethoprophos)	—	—	—	—	150	24	22	0.8	8,400	—	—	USEPA (1999e)
Fonofos	10	HA-L	—	—	—	—	—	—	—	—	—	—
Malathion	100	HA-L	—	0.1	2	[12] 4	0.25	0.06	—	—	—	USEPA (2000f)
Parathion (Ethyl parathion)	—	—	0.065	0.013	9	[16] 0.19	0.02	0.002	—	—	—	USEPA (1999f)
Parathion-methyl (Methyl parathion)	2	HA-L	—	—	500	[17] 80	0.07	0.02	5,300	—	—	USEPA (2003c)

Appendix 3A. Water-quality benchmarks for pesticide compounds analyzed in NAWQA water samples

[For pesticide compounds in water, benchmarks are for protection of human health and aquatic life. Common synonyms are listed in parentheses in column 1. Cited references are listed in Appendix 3D. Environmental concentration, the measured or calculated concentration statistic that is appropriate for comparison with the benchmark; CRC(10^{-6}), 10^{-6} cancer risk concentration; EC_{50}, 50 percent effect concentration; EFED, Environmental Fate and Effects Division (within EPA's Office of Pesticide Programs); HA-L, lifetime health advisory; IRED, Interim Reregistration Eligibility Decision; IRIS, Integrated Risk Information System database; LC_{50}, 50 percent lethal concentration; LOC, level of concern; MCL, maximum contaminant level; NOAEC, no-observed-adverse-effects concentration; OPP, Office of Pesticide Programs; RED, Reregistration Eligibility Decision; USEPA, U.S. Environmental Protection Agency; µg/L, microgram per liter; >, greater than; <, less than;—, no benchmark available.]

Pesticide compound (synonym)	**Human health benchmarks (µg/L)**		**Aquatic life benchmarks (µg/L)**									
	Derived from USEPA drinking-water standards and guidelines (Office of Water)		Derived from USEPA ambient water-quality criteria for aquatic life (Office of Water)		Derived from USEPA Reregistration Eligibility Decisions and ecological risk assessments (Office of Pesticide Programs)							
	Value[1]	Type	Acute[2]	Chronic[2]	Acute fish[3]	Chronic fish[4]	Acute invertebrates[5]	Chronic invertebrates[6]	Acute nonvascular plants[7]	Acute vascular plants[8]	Chronic aquatic community[9]	OPP references
Environmental concentration:	Time-weighted annual mean		Each individual sample	4-day moving average	Each individual sample	60-day average	Each individual sample	21-day average	Each individual sample	Each individual sample	60-day average	
Phorate	—	—	—	—	0.5	[12] 1	0.30	0.21	1,300	—	—	USEPA (1998g, 1999g)
Terbufos	0.9	HA-L	—	—	0.385	[12] 0.77	0.1	0.030	—	—	—	USEPA (1999h)
Phenols												
Bromoxynil	—	—	—	—	11.5	9	5.5	2.5	51	219	—	USEPA (1998h)
Pyrethroids												
cis-Permethrin[14]	—	—	—	—	[23] 0.395	[23] 0.30	[13,23] 0.0195	[13,23] 0.039	—	—	—	USEPA (2005f)
Sulfite esters												
Propargite	—	—	—	—	[13] 15.5	[13] 16	37	9	19.4	75,000	—	USEPA (2000g)
Triazines												
Atrazine	3	MCL	—	—	2,650	62	360	62	32	18	17.5	USEPA (2003d, 2003e)
Cyanazine	1	HA-L	—	—	—	—	—	—	—	—	—	—
Metribuzin	200	HA-L	—	—	21,000	3,000	2,100	1,290	8.7	130	—	USEPA (1998i)
Prometon	100	HA-L	—	—	—	—	—	—	—	—	—	—
Simazine	4	MCL	—	—	3,200	960	500	[12] 1,000	36	140	—	USEPA (2005g, 2005h)

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Appendix 3A. Water-quality benchmarks for pesticide compounds analyzed in NAWQA water samples

[For pesticide compounds in water, benchmarks are for protection of human health and aquatic life. Common synonyms are listed in parentheses in column 1. Cited references are listed in Appendix 3D. Environmental concentration, the measured or calculated concentration statistic that is appropriate for comparison with the benchmark; CRC(10^{-6}), 10^{-6} cancer risk concentration; EC_{50}, 50 percent effect concentration; EFED, Environmental Fate and Effects Division (within EPA's Office of Pesticide Programs); HA-L, lifetime health advisory; IRED, Interim Reregistration Eligibility Decision; IRIS, Integrated Risk Information System database; LC_{50}, 50 percent lethal concentration; LOC, level of concern; MCL, maximum contaminant level; NOAEC, no-observed-adverse-effects concentration; OPP, Office of Pesticide Programs; RED, Reregistration Eligibility Decision; USEPA, U.S. Environmental Protection Agency; µg/L, microgram per liter; >, greater than; <, less than;—, no benchmark available.]

Pesticide compound (synonym)	Human health benchmarks (µg/L)		Aquatic life benchmarks (µg/L)									
	Derived from USEPA drinking-water standards and guidelines (Office of Water)		Derived from USEPA ambient water-quality criteria for aquatic life (Office of Water)		Derived from USEPA Reregistration Eligibility Decisions and ecological risk assessments (Office of Pesticide Programs)							
	Value[1]	Type	Acute[2]	Chronic[2]	Acute fish[3]	Chronic fish[4]	Acute invertebrates[5]	Chronic invertebrates[6]	Acute nonvascular plants[7]	Acute vascular plants[8]	Chronic aquatic community[9]	OPP references
Environmental concentration:	Time-weighted annual mean		Each individual sample	4-day moving average	Each individual sample	60-day average	Each individual sample	21-day average	Each individual sample	Each individual sample	60-day average	
Uracils												
Bromacil	90	HA-L	—	—	18,000	—	60,500	—	6.8	--	—	USEPA (1996c)
Terbacil	90	HA-L	—	—	23,100	—	31,500	—	11	140	—	USEPA (1998j)
Ureas												
Diuron	10	HA-L	—	—	355	26	80	[12] 160	2.4	--	—	USEPA (2003f)
Fluometuron	90	HA-L	—	—	320	—	110	—	30	220	—	USEPA (2005i)
Linuron	—	—	—	—	1,500	[17] 42	60	[12] 120	67	—	—	USEPA (1995d)
Tebuthiuron	500	HA-L	—	—	53,000	9,300	148,500	21,800	50	135	—	USEPA (1994e)

[1] From USEPA (2004a), unless noted otherwise

[2] From USEPA (2004b)

[3] Benchmark = Toxicity value x LOC. For acute fish, toxicity value is generally the lowest 96-hour LC_{50} in a standardized test (usually with rainbow trout, fathead minnow, or bluegill), and the LOC is 0.5.

[4] Benchmark = Toxicity value x LOC. For chronic fish, toxicity value is usually the lowest NOEAC from a life-cycle or early life stage test (usually with rainbow trout or fathead minnow), and the LOC is 1.

[5] Benchmark = Toxicity value x LOC. For acute invertebrate, toxicity value is usually the lowest 48- or 96-hour EC_{50} or LC_{50} in a standardized test (usually with midge, scud, or daphnids), and the LOC is 0.5.

Appendix 3A. Water-quality benchmarks for pesticide compounds analyzed in NAWQA water samples

[For pesticide compounds in water, benchmarks are for protection of human health and aquatic life. Common synonyms are listed in parentheses in column 1. Cited references are listed in Appendix 3D. Environmental concentration, the measured or calculated concentration statistic that is appropriate for comparison with the benchmark; CRC(10^{-6}), 10^{-6} cancer risk concentration; EC_{50}, 50 percent effect concentration; EFED, Environmental Fate and Effects Division (within EPA's Office of Pesticide Programs); HA-L, lifetime health advisory; IRED, Interim Reregistration Eligibility Decision; IRIS, Integrated Risk Information System database; LC_{50}, 50 percent lethal concentration; LOC, level of concern; MCL, maximum contaminant level; NOAEC, no-observed-adverse-effects concentration; OPP, Office of Pesticide Programs; RED, Reregistration Eligibility Decision; USEPA, U.S. Environmental Protection Agency; µg/L, microgram per liter; >, greater than; <, less than;—, no benchmark available.]

Pesticide compound (synonym)	**Human health benchmarks (µg/L)**		**Aquatic life benchmarks (µg/L)**									
	Derived from USEPA drinking-water standards and guidelines (Office of Water)		Derived from USEPA ambient water-quality criteria for aquatic life (Office of Water)		Derived from USEPA Reregistration Eligibility Decisions and ecological risk assessments (Office of Pesticide Programs)							
	Value[1]	Type	Acute[2]	Chronic[2]	Acute fish[3]	Chronic fish[4]	Acute invertebrates[5]	Chronic invertebrates[6]	Acute nonvascular plants[7]	Acute vascular plants[8]	Chronic aquatic community[9]	OPP references
Environmental concentration:	Time-weighted annual mean		Each individual sample	4-day moving average	Each individual sample	60-day average	Each individual sample	21-day average	Each individual sample	Each individual sample	60-day average	

[6] Benchmark = Toxicity value x LOC. For chronic invertebrates, toxicity value is usually the lowest NOAEC from a life-cycle test with invertebrates (usually with midge, scud, or daphnids), and the LOC is 1.

[7] Benchmark = Toxicity value x LOC. For acute nonvascular plants, toxicity value is usually a short-term (less than 10 days) EC_{50} (usually with green algae or diatoms), and the LOC is 1.

[8] Benchmark = Toxicity value x LOC. For acute vascular plants, toxicity value is usually a short-term (less than 10 days) EC50 (usually with duckweed) and the LOC is 1.

[9] Exceedance of this benchmark concentration, as an average for any 60 day period, could cause community-level effects on aquatic plants (based on changes in plant community diversity as predicted by the Comprehensive Aquatic Systems Model), and indirect effects on fish and aquatic invertebrates from disturbance of the aquatic plant community.

[10] Because the underlying toxicity value is a "greater-than" value (such as >265,000), this benchmark may overestimate toxicity.

[11] This MCL is under administrative stay of the effective date. For any combination of 2 or more of these 3 chemicals (aldicarb, aldicarb sulfoxide, and aldicarb sulfone), the summed concentration should not exceed 7 µg/L because of similar mode of action.

[12] The chronic benchmark is based on the acute toxicity value (which was lower than the lowest available chronic toxicity value), and therefore may underestimate chronic toxicity.

[13] Although the underlying acute toxicity value is greater than or equal to the chronic toxicity value, the acute benchmark is lower than the chronic benchmark because acute and chronic toxicity values were multipled by LOC values of 0.5 and 1, respectively.

[14] This pesticide also can be considered an organochlorine pesticide, because it is an organic compound with one or more chlorine substituents.

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Appendix 3A. Water-quality benchmarks for pesticide compounds analyzed in NAWQA water samples

[For pesticide compounds in water, benchmarks are for protection of human health and aquatic life. Common synonyms are listed in parentheses in column 1. Cited references are listed in Appendix 3D. Environmental concentration, the measured or calculated concentration statistic that is appropriate for comparison with the benchmark; CRC(10^{-6}), 10^{-6} cancer risk concentration; EC_{50}, 50 percent effect concentration; EFED, Environmental Fate and Effects Division (within EPA's Office of Pesticide Programs); HA-L, lifetime health advisory; IRED, Interim Reregistration Eligibility Decision; IRIS, Integrated Risk Information System database; LC_{50}, 50 percent lethal concentration; LOC, level of concern; MCL, maximum contaminant level; NOAEC, no-observed-adverse-effects concentration; OPP, Office of Pesticide Programs; RED, Reregistration Eligibility Decision; USEPA, U.S. Environmental Protection Agency; µg/L, microgram per liter; >, greater than; <, less than;—, no benchmark available.]

Pesticide compound (synonym)	**Human health benchmarks (µg/L)**		**Aquatic life benchmarks (µg/L)**									
	Derived from USEPA drinking-water standards and guidelines (Office of Water)		Derived from USEPA ambient water-quality criteria for aquatic life (Office of Water)		Derived from USEPA Reregistration Eligibility Decisions and ecological risk assessments (Office of Pesticide Programs)							
	Value[1]	Type	Acute[2]	Chronic[2]	Acute fish[3]	Chronic fish[4]	Acute invertebrates[5]	Chronic invertebrates[6]	Acute nonvascular plants[7]	Acute vascular plants[8]	Chronic aquatic community[9]	OPP references
Environmental concentration:	Time-weighted annual mean		Each individual sample	4-day moving average	Each individual sample	60-day average	Each individual sample	21-day average	Each individual sample	Each individual sample	60-day average	

[15] Original toxicity values are in micrograms of acid equivalents per liter. For 2,4-D and 2,4-DB, the toxicity values selected were the lowest available values for the acid or salt forms. For MCPA, acute toxicity values were the lowest for the acid, salt or ester forms, and chronic toxicity values were the lowest of the acid and salt forms. (Selection was consistent with risk quotients in the cited USEPA references.)

[16] This benchmark has greater uncertainty than usual because of methods used or conditions in the underlying toxicity study.

[17] Because the underlying toxicity value is a "less-than" value (such as <1,500), this benchmark may underestimate toxicity.

[18] From USEPA (2005d)

[19] Benchmark applies to total DDT, so comparison with measured *p,p'*-DDE concentration may underestimate potential effects.

[20] Sporadic contamination by *p,p'*-DDE was measured in 2.9 percent of quality-control (QC) samples (field blanks) collected by NAWQA sampling teams. The median detected *p,p'*-DDE concentration in the QC samples for streams was 0.0014 µg/L, which exceeds the chronic aquatic-life criterion (0.001 µg/L). Of the 26 QC samples in which *p,p'*-DDE was detected, concentrations were greater than 0.002 µg/L in only 5 samples (less than 1 percent of all QC samples). To account for possible incidental contamination of stream-water samples by *p,p'*-DDE, exceedance of the chronic aquatic-life criterion was determined after subtracting 0.002 µg/L from the measured *p,p'*-DDE concentration. Given that *p,p'*-DDE is detected more frequently in stream-water samples (5.5 percent) than in QC samples (2.9 percent), and that the magnitude of contamination in QC samples usually (81 percent of contaminated QC samples) is less than the 0.002 µg/L correction factor, the expected overall effect of this compensation is to underestimate the true frequency of exceedance of the 0.001 µg/L chronic aquatic-life criterion by *p,p'*-DDE. (Also see footnote 19).

[21] The acute toxicity values were the lowest of the acid, salt or ester forms, and the chronic toxicity values were the lowest of the acid and salt forms of triclopyr. (Selection was consistent with risk quotients in the cited USEPA reference.)

Appendix 3A. Water-quality benchmarks for pesticide compounds analyzed in NAWQA water samples

[For pesticide compounds in water, benchmarks are for protection of human health and aquatic life. Common synonyms are listed in parentheses in column 1. Cited references are listed in Appendix 3D. Environmental concentration, the measured or calculated concentration statistic that is appropriate for comparison with the benchmark; CRC(10^{-6}), 10^{-6} cancer risk concentration; EC_{50}, 50 percent effect concentration; EFED, Environmental Fate and Effects Division (within EPA's Office of Pesticide Programs); HA-L, lifetime health advisory; IRED, Interim Reregistration Eligibility Decision; IRIS, Integrated Risk Information System database; LC_{50}, 50 percent lethal concentration; LOC, level of concern; MCL, maximum contaminant level; NOAEC, no-observed-adverse-effects concentration; OPP, Office of Pesticide Programs; RED, Reregistration Eligibility Decision; USEPA, U.S. Environmental Protection Agency; µg/L, microgram per liter; >, greater than; <, less than;—, no benchmark available.]

Pesticide compound (synonym)	**Human health benchmarks (µg/L)**		**Aquatic life benchmarks (µg/L)**									
	Derived from USEPA drinking-water standards and guidelines (Office of Water)		Derived from USEPA ambient water-quality criteria for aquatic life (Office of Water)		Derived from USEPA Reregistration Eligibility Decisions and ecological risk assessments (Office of Pesticide Programs)							
	Value[1]	Type	Acute[2]	Chronic[2]	Acute fish[3]	Chronic fish[4]	Acute invertebrates[5]	Chronic invertebrates[6]	Acute nonvascular plants[7]	Acute vascular plants[8]	Chronic aquatic community[9]	OPP references
Environmental concentration:	Time-weighted annual mean		Each individual sample	4-day moving average	Each individual sample	60-day average	Each individual sample	21-day average	Each individual sample	Each individual sample	60-day average	

[22] During public comment on draft ambient water-quality criteria that are under development by USEPA, public comment noted an atypical distribution of the acute toxicity data for diazinon. If data from the second most sensitive study were used (USEPA, 2000 risk assessment), rather than the most sensitive study, then the benchmark would change from 0.1 to 0.4 µg/L.

[23] Toxicity values and benchmarks apply to permethrin. Because NAWQA measures only the *cis* isomer of permethrin in water, comparison with benchmarks may underestimate potential toxicity.

Appendix 3B. Water-quality benchmarks for pesticide compounds analyzed in NAWQA bed-sediment and (or) whole-fish samples

[For pesticide compounds in bed sediment and whole-fish tissue, benchmarks are for protection of aquatic life and fish-eating wildlife, respectively. Common synonyms are listed in parentheses in column 1. Cited references are listed in Appendix 3D. $Benchmark_{High}$, highest value in the range of wildlife benchmarks available for a given pesticide compound or group; $Benchmark_{Low}$, lowest value in the range of wildlife benchmarks available for a given pesticide compound or group; C_f, concentration in food; Eisler-PC, proposed criterion from Contaminant Hazard Review series by R. Eisler and colleagues; ESB, equilibrium partitioning sediment benchmark; FFC, fish flesh criterion (noncancer value); NOAEL-ECF, no-observed-adverse-effects level equivalent concentration in food; TEC, threshold effect concentration; TRG, tissue residue guideline; USEPA, U.S. Environmental Protection Agency; µg/g, microgram per gram; µg/kg dw, microgram per kilogram dry weight; µg/kg ww, microgram per kilogram wet weight;—, no benchmark available.]

Pesticide compound (synonym)	Bed sediment benchmarks for protection of benthic aquatic organisms		Whole-fish benchmarks for protection of fish-eating wildlife			
	Consensus-based threshold effect concentration (TEC) (µg/kg dw) [1]	USEPA equilibrium partitioning sediment benchmark (ESB) (µg/g of sediment organic carbon) [1]	$Benchmark_{Low}$ value (µg/kg ww) [2]	Type of $Benchmark_{Low}$	$Benchmark_{High}$ value (µg/kg ww) [2]	Type of $Benchmark_{High}$
Organochlorines						
Aldrin	—	—	813	NOAEL-equivalent concentration in food	813	NOAEL-equivalent concentration in food
Total chlordane [3]	3.24	—	300	Eisler proposed criterion	4,200	NOAEL-equivalent concentration in food
o,p′ + *p,p′*-DDD [4]	4.88	—	see [5]	—	see [5]	—
o,p′ + *p,p′*-DDE [4]	3.16	—	see [5]	—	see [5]	—
o,p′ + *p,p′*-DDT [4]	4.16	—	see [5]	—	see [5]	—
Total DDT [5]	5.28	—	6	NOAEL-equivalent concentration in food	200	New York FFC
Dieldrin	1.90	12	81	NOAEL-equivalent concentration in food	[6] 120	New York FFC
Endosulfan I	—	0.29	—	—	—	—
Endrin	2.22	5.4	20	NOAEL-equivalent concentration in food	25	New York FFC
beta-HCH	—	—	1,630	NOAEL-equivalent concentration in food	1,630	NOAEL-equivalent concentration in food
gamma-HCH	2.37	0.37	3,950	NOAEL-equivalent concentration in food	3,950	NOAEL-equivalent concentration in food
Total HCH [7]	—	—	70	NOAEL-equivalent concentration in food	100	New York FFC
Heptachlor	—	—	529	NOAEL-equivalent concentration in food	529	NOAEL-equivalent concentration in food

Appendix 3B. Water-quality benchmarks for pesticide compounds analyzed in NAWQA bed-sediment and (or) whole-fish samples

[For pesticide compounds in bed sediment and whole-fish tissue, benchmarks are for protection of aquatic life and fish-eating wildlife, respectively. Common synonyms are listed in parentheses in column 1. Cited references are listed in Appendix 3D. $Benchmark_{High}$, highest value in the range of wildlife benchmarks available for a given pesticide compound or group; $Benchmark_{Low}$, lowest value in the range of wildlife benchmarks available for a given pesticide compound or group; C_f, concentration in food; Eisler-PC, proposed criterion from Contaminant Hazard Review series by R. Eisler and colleagues; ESB, equilibrium partitioning sediment benchmark; FFC, fish flesh criterion (noncancer value); NOAEL-ECF, no-observed-adverse-effects level equivalent concentration in food; TEC, threshold effect concentration; TRG, tissue residue guideline; USEPA, U.S. Environmental Protection Agency; µg/g, microgram per gram; µg/kg dw, microgram per kilogram dry weight; µg/kg ww, microgram per kilogram wet weight;—, no benchmark available.]

Pesticide compound (synonym)	Bed sediment benchmarks for protection of benthic aquatic organisms		Whole-fish benchmarks for protection of fish-eating wildlife			
	Consensus-based threshold effect concentration (TEC) (µg/kg dw) [1]	USEPA equilibrium partitioning sediment benchmark (ESB) (µg/g of sediment organic carbon) [1]	$Benchmark_{Low}$ value (µg/kg ww) [2]	Type of $Benchmark_{Low}$	$Benchmark_{High}$ value (µg/kg ww) [2]	Type of $Benchmark_{High}$
Heptachlor epoxide	2.47	—	see ([8])	—	see ([8])	—
Total heptachlor [8]	—	—	200	New York FFC	529	NOAEL-equivalent concentration in food
Hexachlorobenzene	—	—	330	New York FFC	330	New York FFC
Total methoxychlor [9]	—	1.9	16,300	NOAEL-equivalent concentration in food	16,300	NOAEL-equivalent concentration in food
Mirex	—	—	330	New York FFC	330	New York FFC
Toxaphene	—	10	6.3	Canadian TRG	32,500	NOAEL-equivalent concentration in food

[1] TECs are from MacDonald and others (2000). ESBs are from USEPA (2003g, 2003h, 2003i).

[2] $Benchmark_{Low}$ and $Benchmark_{High}$ refer to the range of benchmark values from the following four sources: Oak Ridge NOAEL-equivalent concentrations in food (the lowest C_f value for piscivorous wildlife species from Sample and others, 1996); New York fish flesh criteria—noncancer values (Newell and others, 1987); Canadian tissue residue guidelines (Canadian Council of Ministers of the Environment, 1999a, 1999b); proposed criteria from the U.S. Fish and Wildlife Service's report series, Contaminant Hazard Reviews (Eisler and Jacknow, 1985; Eisler 1990).

[3] Sum of *cis*- and *trans*-chlordane, *cis*- and *trans*-nonachlor, and oxychlordane.

[4] Benchmark applies to the sum of these two compounds

[5] Sum of the concentrations of *o,p´* and *p,p´* isomers of DDD, DDE, and DDT.

[6] The benchmark is for total dieldrin (sum of aldrin plus dieldrin). However, this benchmark is considered applicable to dieldrin concentration data because only one fish sample contained any aldrin (10 µg/kg), and in that sample both aldrin and dieldrin (43 µg/kg) were well below all benchmarks.

[7] Sum of the concentrations of *alpha*, *beta*, *gamma*, and *delta*-HCH.

[8] Sum of the concentrations of heptachlor and heptachlor epoxide.

[9] Sum of the concentrations of *o,p´* and *p,p´* isomers of methoxychlor.

Appendix 3C. Pesticide compounds analyzed by NAWQA that do not have water-quality benchmarks

[Common synonyms are listed in parentheses after the pesticide name. Degradates are indicated by a D in brackets.]

Pesticide compounds measured in water			Pesticide compounds measured in bed sediment	Pesticide compounds measured in whole fish
Pesticide compounds that do not have human-health benchmarks		Pesticide compounds that do not have aquatic-life benchmarks	Pesticide compounds that do not have aquatic-life benchmarks	Pesticide compounds that do not have benchmarks for fish-eating wildlife
Acetochlor	Linuron	Acetochlor	Aldrin	Dacthal (DCPA)
Azinphos-methyl (Guthion)	MCPB	Chloramben methyl ester	Chloroneb	Pentachloroanisole [D]
Benfluralin	Methiocarb	Clopyralid	Dacthal (DCPA)	
Bromoxynil	Molinate	Cyanazine	*alpha*-HCH [D]	
Chloramben methyl ester	Napropamide	Dacthal mono-acid [D]	*beta*-HCH	
Clopyralid	Neburon	Deethylatrazine [D]	Heptachlor	
Dacthal mono-acid [D]	Norflurazon	Dicamba	Hexachlorobenzene	
2,4-DB	Oryzalin	Dichlorprop	Isodrin	
Deethylatrazine [D]	Parathion (Ethyl parathion)	2,6-Diethylaniline [D]	Mirex	
Dichlobenil	Pebulate	Dinoseb	Pentachloroanisole [D]	
Dichlorprop	Pendimethalin	DNOC	*cis*-Permethrin	
2,6-Diethylaniline [D]	*cis*-Permethrin	Fenuron	*trans*-Permethrin	
DNOC	Phorate	Fonofos		
EPTC	Propanil	*alpha*-HCH		
Ethalfluralin	Propargite	3-Hydroxycarbofuran [D]		
Ethoprop (Ethoprophos)	Thiobencarb	MCPB		
Fenuron	Triallate	Neburon		
3-Hydroxycarbofuran [D]	Triclopyr	Prometon		
		Propham		
		2,4,5-T		
		2,4,5-TP (Silvex)		

CIRC1291

NAWQA Pesticide National Synthesis Project

Publications - CIRC 1291

The Quality of Our Nation's Waters

Pesticides in the Nation's Streams and Ground Water, 1992-2001

References – Appendix 3

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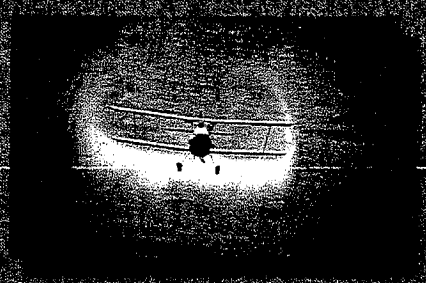
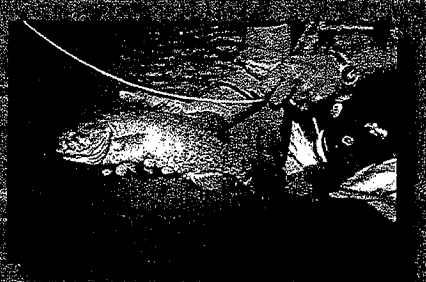
The Quality of Our Nation's Waters

Pesticides in the Nation's Streams and Ground Water, 1992–2001





National Water-Quality Assessment Program

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Pesticides in the Nation's Streams and Ground Water, 1992–2001

By Robert J. Gilliom, Jack E. Barbash, Charles G. Crawford, Pixie A. Hamilton, Jeffrey D. Martin, Naomi Nakagaki, Lisa H. Nowell, Jonathan C. Scott, Paul E. Stackelberg, Gail P. Thelin, and David M. Wolock

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U.S. Department of the Interior
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"The Heinz Center depends heavily on NAWQA data to support our periodic report: 'The State of the Nation's Ecosystems.' NAWQA data provide the foundation for our description of chemical contamination—including pesticides and other compounds—both nationally and among different land uses, and for tracking how contaminant levels change over time. We appreciate NAWQA's strong commitment to making its information and data readily accessible to meet our organization's needs and to address the Nation's water-resource information needs."

Robin O'Malley, Senior Fellow and Program Director,
The H. John Heinz III Center for Science, Economics and the Environment

"EPA has worked closely with the USGS NAWQA Program since it began in 1991, with the goal of advancing the scientific tools and data that are available to assess the potential risks posed by pesticides in surface water and ground water. Recently, EPA and USGS have collaborated in developing statistical models to predict concentrations of atrazine and other pesticides in streams around the country, including quantitative estimates of reliability. The models, developed by USGS from NAWQA data, increase EPA's capacity to estimate surface-water concentrations of pesticides. Model results are being used to identify locations where additional monitoring may be needed to evaluate the ecological condition of watersheds."

Elizabeth Behl, Chief of Environmental Risk Branch,
Office of Pesticide Programs,
U.S. Environmental Protection Agency

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National Water-Quality Assessment Program

The U.S. Geological Survey (USGS) is committed to serving the Nation with accurate and timely scientific information that helps enhance and protect the overall quality of life, and facilitates effective management of water, biological, energy, and mineral resources (*http://www.usgs.gov/*). Information on the quality of the Nation's water resources is of critical interest to the USGS because water quality is integrally linked to the long-term availability of water that is clean and safe for drinking and recreation and that is suitable for industry, irrigation, and habitat for fish and wildlife. Escalating population growth and increasing demands for multiple water uses make water availability, now measured in terms of quantity and quality, even more critical to the long-term sustainability of our communities and ecosystems.

The USGS implemented the National Water-Quality Assessment (NAWQA) Program (*http://water.usgs.gov/nawqa/*) to support national, regional, and local information needs and decisions related to water-quality management and policy. Shaped by and coordinated with ongoing efforts of other Federal, State, and local agencies, the NAWQA Program is designed to answer: What is the quality of our Nation's streams and ground water? How is the quality changing over time? How do natural features and human activities affect the quality of streams and ground water, and where are those effects most pronounced? By combining information on water chemistry, physical characteristics, stream habitat, and aquatic life, the NAWQA Program aims to provide science-based insights for current and emerging water issues and priorities. NAWQA results can contribute to informed decisions that result in practical and effective water-resource management and strategies that protect and restore water quality.

Since 1991, the NAWQA Program has implemented interdisciplinary assessments in 51 of the Nation's most important river basins and aquifers, referred to as Study Units, and the High Plains Regional Ground Water Study (see accompanying map and list of studies). Collectively, these areas account for more than 70 percent of total water use (excluding thermoelectric and hydropower) and more than 50 percent of the population's supply of drinking water. The areas are representative of the Nation's major hydrologic landscapes, priority ecological resources, and agricultural, urban, and natural sources of contamination.

Each assessment is guided by a nationally consistent study design and methods of sampling and analysis. The assessments thereby build local knowledge about water-quality issues and trends in a particular stream or aquifer while providing an understanding of how and why water quality varies regionally and nationally. The consistent, multi-scale approach helps to determine if certain types of water-quality issues are isolated or pervasive, and allows direct comparisons of how human activities and natural processes affect water quality and ecological health in the Nation's diverse geographic and environmental settings. Comprehensive assessments of pesticides, nutrients, volatile organic compounds, trace elements, and aquatic ecology are developed at the national scale through national data analysis and comparative analysis of the Study Unit findings.

The USGS places high value on the communication and dissemination of credible, timely, and relevant science so that the most recent and available knowledge about water resources can be applied in management and policy decisions. We hope this NAWQA publication will provide you the needed insights and information to meet your needs, and thereby foster increased awareness and involvement in the protection and restoration of our Nation's waters.

The NAWQA Program recognizes that a national assessment by a single program cannot address all water-resource issues of interest. External coordination at all levels is critical for a fully integrated understanding of watersheds and for cost-effective management, regulation, and conservation of our Nation's water resources. The Program, therefore, depends extensively on the advice, cooperation, and information from other Federal, State, interstate, Tribal, and local agencies, nongovernmental organizations, industry, academia, and other stakeholder groups. The assistance and suggestions of all are greatly appreciated.

Robert M. Hirsch
Associate Director, Water

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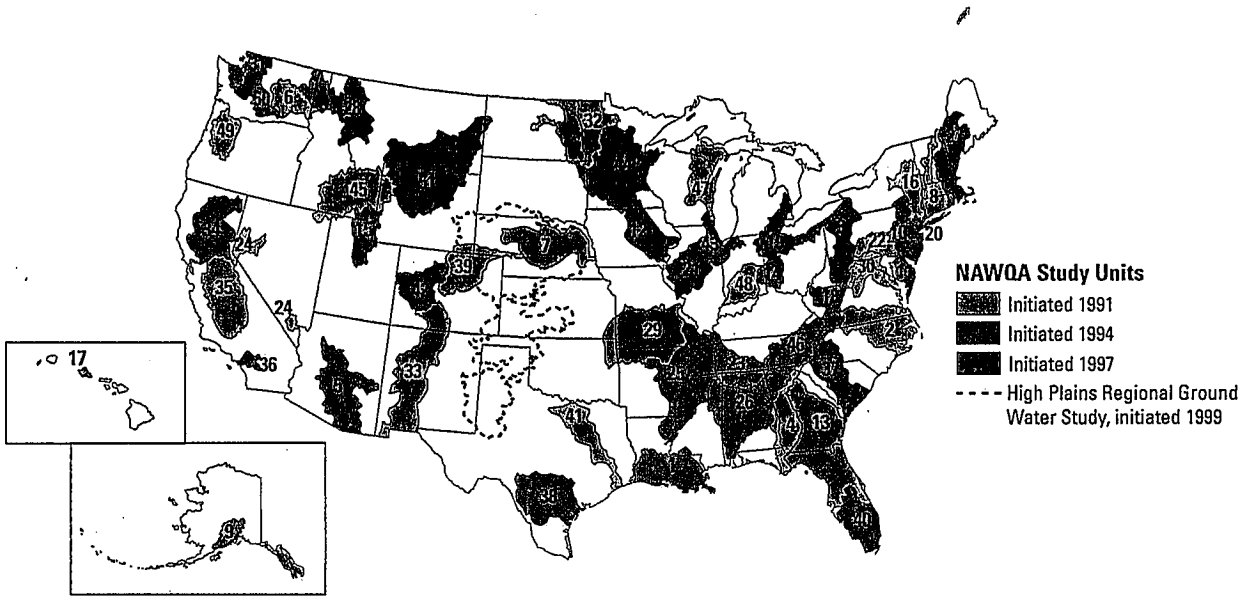

NAWQA Study Units

1 Acadian–Pontchartrain Drainages
2 Albemarle–Pamlico Drainage Basin
3 Allegheny and Monongahela River Basins
4 Apalachicola–Chattahoochee–Flint River Basin
5 Central Arizona Basins
6 Central Columbia Plateau
7 Central Nebraska Basins
8 Connecticut, Housatonic, and Thames River Basins
9 Cook Inlet Basin
10 Delaware River Basin
11 Delmarva Peninsula
12 Eastern Iowa Basins
13 Georgia–Florida Coastal Plain
14 Great and Little Miami River Basins
15 Great Salt Lake Basins
16 Hudson River Basin
17 Island of Oahu
18 Kanawha–New River Basins
19 Lake Erie–Lake Saint Clair Drainages
20 Long Island–New Jersey Coastal Drainages
21 Lower Illinois River Basin
22 Lower Susquehanna River Basin
23 Lower Tennessee River Basin
24 Las Vegas Valley Area and the Carson and Truckee River Basins
25 Mississippi Embayment
26 Mobile River Basin
27 New England Coastal Basins
28 Northern Rockies Intermontane Basins
29 Ozark Plateaus
30 Potomac River Basin
31 Puget Sound Basin
32 Red River of the North Basin
33 Rio Grande Valley
34 Sacramento River Basin
35 San Joaquin–Tulare Basins
36 Santa Ana Basin
37 Santee River Basin and Coastal Drainages
38 South-Central Texas
39 South Platte River Basin
40 Southern Florida
41 Trinity River Basin
42 Upper Colorado River Basin
43 Upper Illinois River Basin
44 Upper Mississippi River Basin
45 Upper Snake River Basin
46 Upper Tennessee River Basin
47 Western Lake Michigan Drainages
48 White River Basin
49 Willamette Basin
50 Yakima River Basin
51 Yellowstone River Basin

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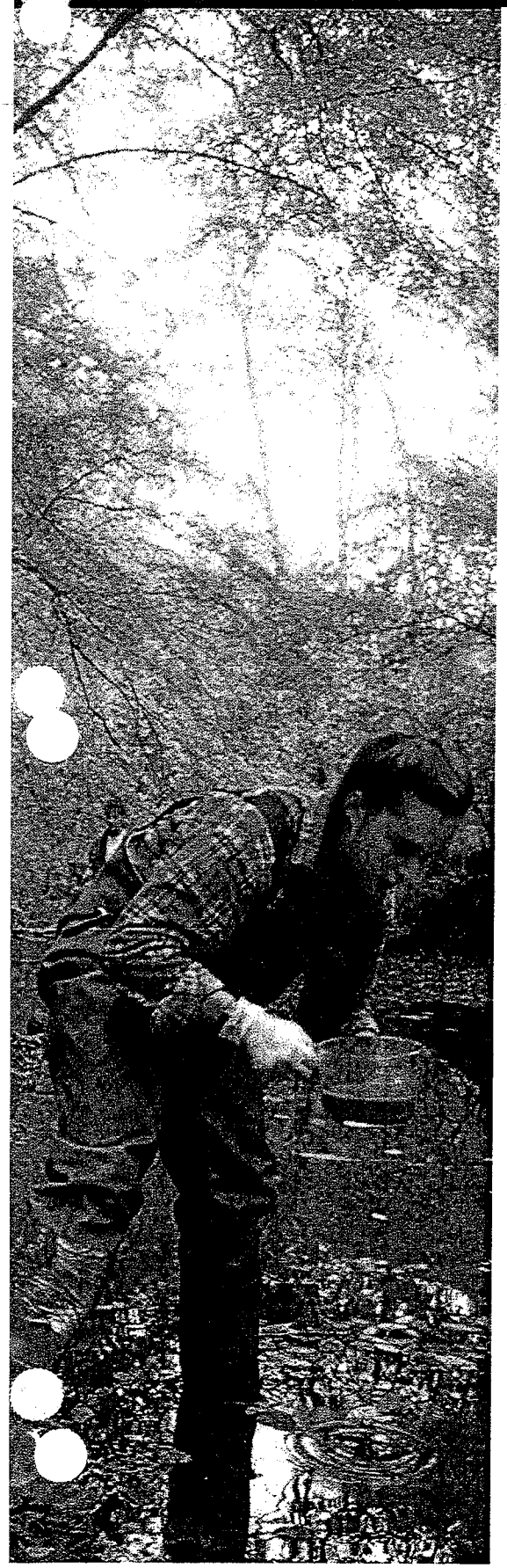
Introduction to this report and the NAWQA series

The Quality of Our Nation's Waters



This report is one of a series of publications, The Quality of Our Nation's Waters, that describe major findings of the NAWQA Program on water-quality issues of regional and national concern. This report presents evaluations of pesticides in streams and ground water based on findings for the first decadal cycle of NAWQA. "Pesticides in the Nation's Streams and Ground Water, 1992–2001" greatly expands the analysis of pesticides presented in "Nutrients and Pesticides," which was the first report in the series and was based on early results from 1992 to 1995. Other reports in this series cover additional water-quality constituents of concern, such as volatile organic compounds and trace elements, as well as physical and chemical effects on aquatic ecosystems. Each report builds toward a more comprehensive understanding of regional and national water resources.

The information in this series is intended primarily for those interested or involved in resource management, conservation, regulation, and policymaking at regional and national levels. In addition, the information might interest those at a local level who wish to know more about the general quality of streams and ground water in areas near where they live and how that quality compares with other areas across the Nation.

P. Patrick Leahy, Acting Director
U.S. Geological Survey

A011997

Contents

Chapter 1 is a broad overview of key national findings and their implications. Chapters 2 and 3 provide background on pesticides and how they were assessed by NAWQA. Together, Chapters 4 and 5 provide a detailed assessment of findings regarding the occurrence and behavior of pesticides in streams and ground water. Chapter 6 evaluates the occurrence and distribution of pesticides in terms of the potential for effects on human health, aquatic life, and wildlife. Chapters 7 and 8 examine two important topics with implications for the future—prediction of pesticide levels for unmonitored areas and emerging evidence of long-term trends.

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1 Overview of Findings and Implications

About 1 billion pounds of conventional pesticides are used each year in the United States to control weeds, insects, and other pests. The use of pesticides has resulted in a range of benefits, including increased food production and reduction of insect-borne disease, but also raises questions about possible adverse effects on the environment, including water quality. The NAWQA assessment of pesticides provides the most comprehensive national-scale analysis to date of pesticide occurrence and concentrations in streams and ground water. NAWQA results show where, when, and why specific pesticides occur in streams and ground water across the Nation, and yield science-based implications for assessing and managing the quality of our water resources.

Photograph by Rand Schaal

This chapter provides a broad overview of NAWQA findings about the occurrence and distribution of pesticides in the Nation's streams and ground water and summarizes the implications of these findings for water-quality assessment and management. Priorities for filling remaining information gaps also are addressed. Detailed discussions of each major topic are provided in subsequent chapters, including selected case studies of pesticide occurrence within individual NAWQA study units.

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Introduction—

New results confirm and expand findings from earlier NAWQA studies

This report is based on the National Water-Quality Assessment (NAWQA) Program's first decade of water-quality assessments, which were completed on a rotational schedule during 1992–2001 in 51 major hydrologic systems across the country, referred to as Study Units (see p. iv and v). Assessments were conducted using a nationally consistent approach in 20 Study Units during 1992–1995; in 16 Study Units during 1996–1998; and in 15 Study Units during 1998–2001.

Nationally, water samples for pesticide analysis were collected from 186 stream sites within the 51 Study Units, bed-sediment samples were collected from 1,052 stream sites, and fish samples were collected from 700 stream sites. Ground-water samples were collected from 5,047 wells. In this report, most data analyses for stream water are based on the single year of most intensive sampling; data analyses for bed sediment and fish tissue are based on one composite sample per site; and data analyses for ground water are based on one sample per well. Sampling sites for streams and ground water were selected to represent the specific agricultural, urban, undeveloped, and mixed-land-use settings of greatest significance to water resources in the primary hydrologic settings within each of the Study Units. Shallow ground water (generally less than 20 ft below the water table) was sampled in agricultural, urban, and undeveloped areas, whereas deeper ground water was sampled from wells that tap major aquifers, most of which are affected by a mixture of land uses and are important as potential sources of drinking water.

Most NAWQA water samples were analyzed for 75 pesticides and 8 pesticide degradates, including 20 of the 25 most heavily used herbicides and 16 of the 25 most heavily used insecticides, but few fungicides, fumigants, or other types of pesticides were analyzed. Degradates are new compounds formed by transformation of a pesticide by chemical, photochemical, or biological reactions. In addition, 32 organochlorine pesticide compounds were analyzed in bed sediment and (or) fish tissue—19 parent pesticides and 13 degradates and manufacturing by-products (hereinafter referred to as by-products). Most of the organochlorine pesticides are no longer used in the United States, but the parent compounds, degradates, or by-products may persist in the environment. Pesticide compounds analyzed are listed in Appendix 1.

This analysis of NAWQA results for 1992–2001 builds upon an initial national assessment of pesticides in streams and ground water that was based on results from NAWQA's first 20 Study Unit investigations (summarized in the first report of this series, U.S. Geological Survey, 1999). The more extensive data and expanded geographic coverage available for this report confirm and reinforce many of the previously reported findings, allow more detailed analyses of each topic, and support new analyses, such as the development of statistical models that extend the results from targeted NAWQA studies to areas of the Nation that have not been assessed. In addition, water-quality benchmarks for assessing the potential significance of pesticide concentrations to aquatic life and fish-eating wildlife have been substantially updated to incorporate the most recent values available from the U.S. Environmental Protection Agency (USEPA) and other sources.

NAWQA findings are summarized below for major topics, each of which is identified with the chapter in this report where more detailed results, explanations, and references are provided. Key implications are also summarized for each topic, focusing on the extension of study results to national assessment of water quality, applications to water-quality management, and needs for additional information.

The NAWQA approach and design are summarized in Chapter 3. Details on data-analysis methods, as well as all data used in this report, are available at *http://ca.water.usgs.gov/pnsp/pubs/circ1291/.*

Relation to Previous Studies

Over the past 50 years, a vast amount of research has been conducted to investigate the spatial and temporal distributions of pesticides and their degradates in the hydrologic system, the biological effects of these compounds, and the myriad chemical, physical, and biological processes that control their transport and fate in the environment. Much of this previous work was summarized in a NAWQA book series entitled "Pesticides in the Hydrologic System," which examined these issues in relation to pesticides in the atmosphere (Majewski and Capel, 1995), ground water (Barbash and Resek, 1996), surface water (Larson and others, 1997), and bed sediment and aquatic biota (Nowell and others, 1999). In addition, since this book series was published, there have been many more studies and new reviews of specific topics by scientists in government, academia, corporations, and other organizations. This report is not intended to be a comprehensive review of all of these topics, although investigations directly relevant to the findings discussed in this report are cited in the text. The focus of this report is on the summary and interpretation of NAWQA data collected during 1992–2001.

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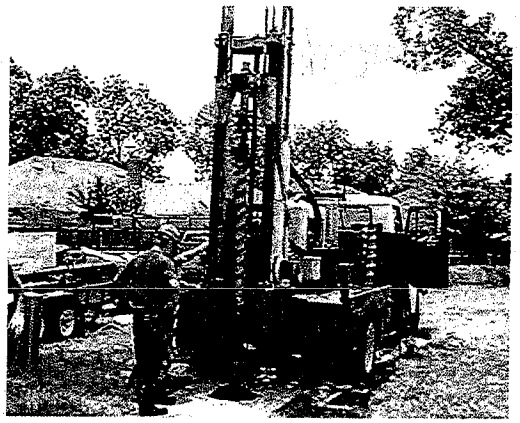
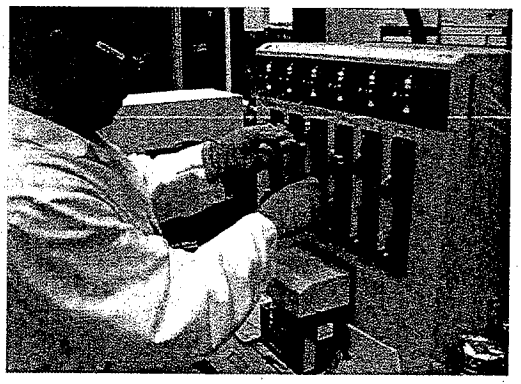
Unique Features of the NAWQA Approach

Water-quality assessments by NAWQA, which is a single program among many local, State, and Federal programs, were not designed to address all of the Nation's water-resource information needs and issues. Listed below are several characteristics and limitations of the NAWQA approach that are important to consider when interpreting the findings on pesticides presented in this report.

- NAWQA assessments characterized the quality of the available, untreated water resources, and not the quality of drinking water (as would be done by monitoring water from water-treatment plants or from household taps). By focusing on the quality of streams and ground water in their present condition (ambient water quality), NAWQA complements many Federal, State, and local drinking-water monitoring programs.
- NAWQA assessments did not focus on specific sites with known water-quality problems or narrowly defined "issues of the day," but rather on the condition of the total resource, including streams and ground water in a wide range of hydrologic and land-use settings across the country.
- NAWQA assessments of pesticides focused primarily on non-point sources resulting from applications for pest management in agricultural, urban, and other land-use settings, although some sites—particularly those downstream from major metropolitan areas—also may be influenced by point sources, such as discharges from wastewater treatment plants.
- NAWQA assessments targeted specific land-use settings that are most extensive or important to water quality in a wide range of hydrologic and environmental settings across the Nation. This targeted approach gives priority to understanding the most critical factors influencing water quality. Extension of results to national analysis, however, requires careful definition of each type of water resource and environmental setting for which conclusions are drawn and the use of statistical models to extrapolate results to resources that have not been measured.
- USGS analytical methods were designed to measure concentrations as low as economically and technically feasible. Studies of contaminant occurrence and behavior benefit from the most information possible at all concentration levels, and such data help to identify emerging issues and to track changes in concentrations over time. By this approach, however, pesticides were commonly detected at concentrations far below Federal or State standards and guidelines for protecting water quality. Detections of pesticides do not necessarily indicate that there are appreciable risks to human health, aquatic life, or wildlife, which must be assessed by comparing measured concentrations with those that may cause adverse effects.
- USGS methods for analyzing pesticides in water measured concentrations in filtered water samples and, thus, may underestimate concentrations of compounds that have strong affinities for suspended particles. The potential for underestimation is greater for stream water compared with ground water because of the generally greater amounts of suspended particles present in stream water—which are removed by filtration along with any pesticides contained in or on the particles.
- Pesticide compounds analyzed in water by NAWQA included many of the most heavily used herbicides and insecticides, but they included only a fraction of all pesticides currently in use and few of their degradates. NAWQA findings provide insights about what to expect for pesticides and degradates that were not measured, but must be considered as only a partial assessment of currently used pesticides.
- Organochlorine pesticide compounds analyzed by NAWQA in bed sediment and fish tissue are predominantly related to pesticides that were no longer in use by 1990. Of the pesticide compounds measured in bed sediment and fish tissue, only dacthal, endosulfan, lindane, methoxychlor, and permethrin were used during all or part of the study period.





NAWQA studies used nationally consistent methods for sample collection and laboratory analysis. Urban ground-water studies, for example, often required the installation of new observation wells to ensure comparable data among studies.

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Pesticide Occurrence—

Pesticides were frequently detected in streams and ground water (Chapter 4)

Pesticides or their degradates were detected in one or more water samples from every stream sampled. One or more pesticides or degradates were detected in water more than 90 percent of the time during the year in agricultural streams, urban streams, and mixed-land-use streams (fig. 1–1). This finding is based on a time-weighted analysis of results for 4,380 water samples, which adjusts results for variable sampling frequencies to avoid biases that may be caused by differences in sampling intensity among sites and seasons. Undeveloped streams had one or more detectable pesticides or degradates 65 percent of the time. The presence of pesticide compounds in predominantly undeveloped watersheds may result from past or present uses within the watershed for purposes such as forest management or maintenance of rights-of-way, uses associated with small areas of urban or agricultural land, or atmospheric transport from other areas.

Organochlorine pesticides (such as DDT) and their degradates and by-products were found in fish or bed-sediment samples from most streams in agricultural, urban, and mixed-land-use settings—and in more than half the fish samples from streams draining undeveloped watersheds (fig. 1–1). Most organochlorine pesticides had not been used in the United States for a number of years prior to the study period, but the continued occurrence of some historically used organochlorine pesticide compounds demonstrates their persistence in the environment.

Pesticides were less common in ground water than in streams (fig. 1–1). Nevertheless, more than half of the shallow wells sampled in agricultural and urban areas, and 33 percent of the deeper wells that tap major aquifers, which are influenced by a mixture of land uses, contained one or more pesticides or degradates.

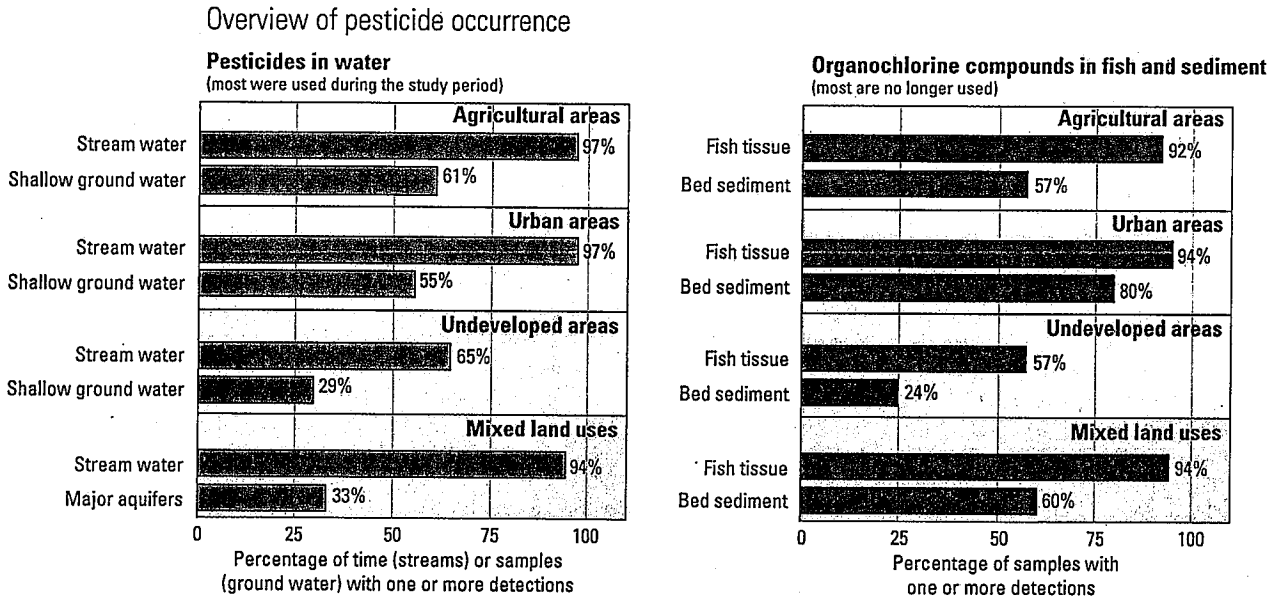

Figure 1–1. One or more pesticides or degradates were detected in water more than 90 percent of the time during the year in streams draining watersheds with agricultural, urban, and mixed land uses. In addition, some organochlorine pesticides that have not been used in the United States for many years were detected along with their degradates and by-products in most samples of whole fish or bed sediment from streams sampled in these land-use settings. Pesticides were less common in ground water, but were detected in more than 50 percent of wells sampled to assess shallow ground water in agricultural and urban areas.

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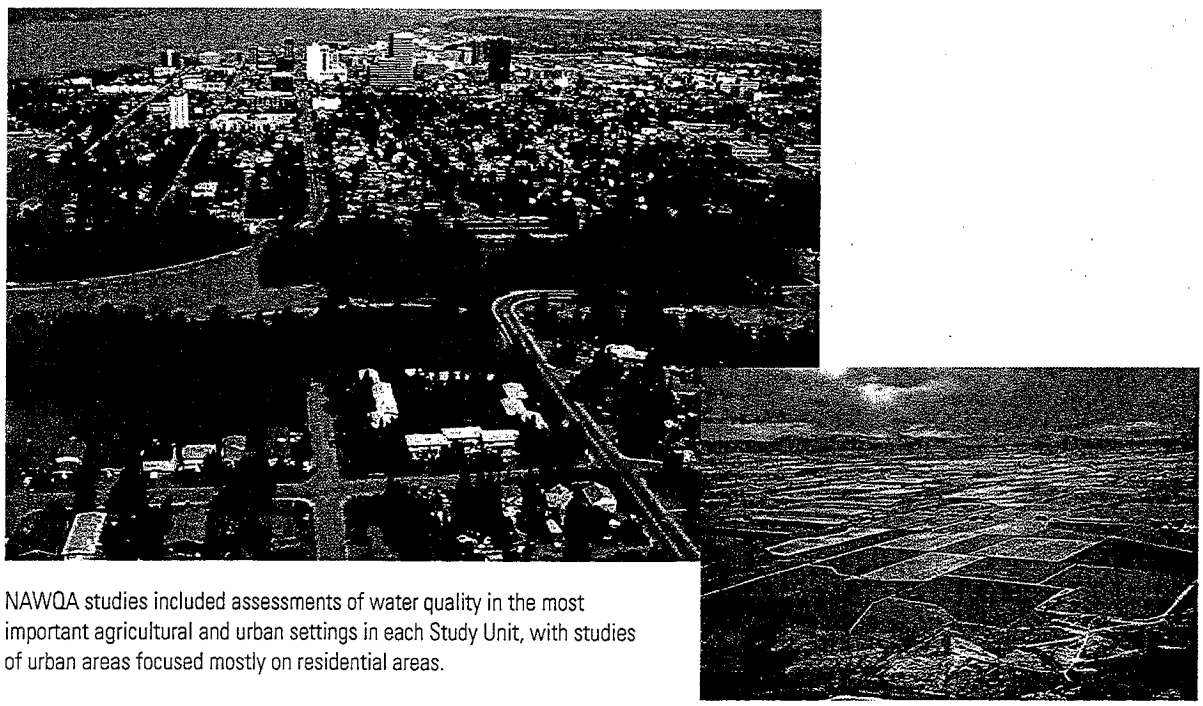
Implications

- Pesticides and degradates are likely to be present at detectable levels throughout most of the year in streams that have substantial agricultural or urban land use in their watersheds.
- Streams are more vulnerable to pesticide contamination than ground water in most hydrologic settings, as indicated by much more frequent detections in stream water.
- The frequent detection of pesticides and degradates in shallow wells in agricultural and urban areas indicates that ground water may merit special attention in these land-use settings. Shallow ground water is used in some areas for drinking water—and can also move downward into deeper aquifers. Early attention to potential ground-water contamination is warranted because the movement of ground water is usually slow and contamination is difficult to reverse.
- Pesticide occurrence in streams and ground water does not necessarily cause adverse effects on aquatic ecosystems or humans. The potential for effects can be assessed by comparing measured pesticide concentrations with water-quality benchmarks, which are based on the concentrations at which effects may occur.



NAWQA studies included assessments of water quality in the most important agricultural and urban settings in each Study Unit, with studies of urban areas focused mostly on residential areas.

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Potential Significance to Human Health—

Pesticides seldom occurred at concentrations greater than water-quality benchmarks for human health (Chapter 6)

A screening-level assessment of the potential significance of pesticides to human health was based on comparing measured concentrations in streams and ground water with water-quality benchmarks for human health. These human-health benchmarks were derived from standards and guidelines developed by USEPA for drinking water.

Although none of the NAWQA stream sites is located at actual drinking-water intakes, comparison of time-weighted annual mean concentrations to human-health benchmarks provides perspectives on (1) the likelihood that some current drinking-water intakes on streams may withdraw water with pesticide concentrations that exceed a benchmark, and (2) the potential long-term significance of pesticides to the quality of water that may be used as sources of drinking water in the future.

Annual mean concentrations of pesticides in streams studied by NAWQA were seldom greater than human-health benchmarks (fig. 1–2). No streams draining undeveloped land, and only one stream in a watershed with mixed land uses, had an annual mean concentration greater than a human-health benchmark. The annual mean concentrations of one or more pesticides exceeded a human-health benchmark in about 10 percent of the 83 agricultural streams and in about 7 percent of the 30 urban streams sampled by NAWQA. The 2 urban streams where benchmarks were exceeded are in Texas (diazinon) and Hawaii (dieldrin). Agricultural streams located in the Corn Belt (Illinois, Indiana, Iowa, Nebraska, Ohio, and parts of adjoining states) and Mississippi River Valley accounted for most concentrations that exceeded benchmarks, all involving atrazine (5 sites), cyanazine (4 sites), or dieldrin (2 sites). If, as examined in Chapter 6, the atrazine human-health benchmark were changed to values from the updated atrazine risk assessment (USEPA, 2003a), then there would be 2 sites rather than 5 sites with exceedances (although NAWQA did not measure 2 of the 3 degradates required for that benchmark).

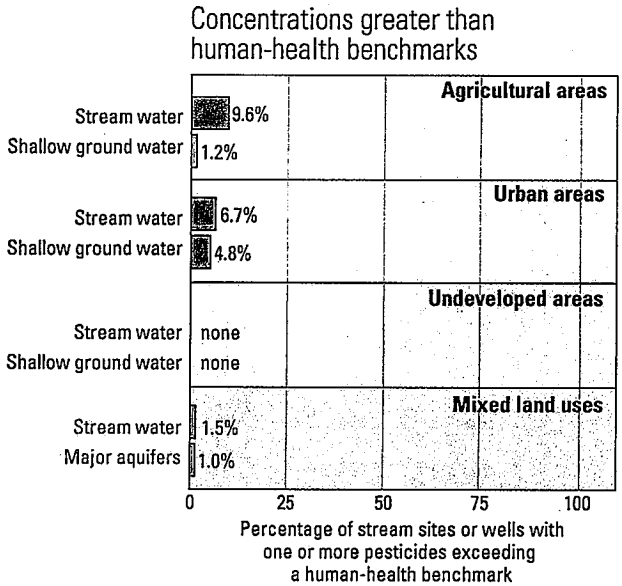

Figure 1–2. Concentrations of pesticides and degradates measured in streams and ground water usually were lower than human-health benchmarks for the pesticide compounds analyzed by NAWQA. Many of the wells sampled for ground-water studies, but none of the stream sites sampled, were sources of domestic or public water supplies during the study period.

Of pesticides accounting for most exceedances, atrazine use remains high, use of cyanazine has been reduced sharply since the mid-1990s (with corresponding decreases in stream concentrations; Chapter 8), and dieldrin and aldrin uses were discontinued before the 1992–2001 study period. Changes through the study period in the frequency of benchmark exceedances by atrazine and cyanazine were consistent with changes in agricultural use. As described in Chapter 6, the proportion of agricultural stream sites in the Corn Belt with atrazine concentrations that exeeded the human-health benchmark was greater for streams sampled during 1998–2000 than for streams sampled during either 1993–1994 or 1995–1997. In contrast, most sites where cyanazine exceeded its benchmark were sampled during 1993–1994, and no sites that were sampled during 1998–2000 had exceedances of the cyanazine benchmark.

For perspective on the relevance of NAWQA findings to drinking-water supplies, NAWQA land-use classifications for 1,679 public water-supply intakes that withdraw water from streams in the United States indicate that 55 percent of the intakes withdraw water from streams that drain watersheds with predominantly undeveloped land, 32 percent from streams with mixed land use, 12 percent from streams with agricultural land use, and 1 percent from streams with urban land use. Although the watershed land uses of NAWQA sites and water-supply intakes were

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classified in the same way, NAWQA sites tend to have more agricultural and urban land in their watersheds than do water-supply intakes in the same land-use categories.

Human-health benchmarks were exceeded less often in ground water than in streams (fig. 1–2). One or more pesticides exceeded a benchmark in about 1 percent of the 2,356 domestic wells and 364 public-supply wells sampled among studies in the three land-use settings and major aquifers. In contrast to the streams that were sampled, however, these wells are sources of drinking water—commonly without treatment in the case of domestic wells and with variable amounts and types of treatment for public-supply wells. Shallow ground water sampled in urban areas had the greatest proportion of wells with concentrations of one or more pesticides that were greater than a benchmark, including 1 of 9 public-supply wells, 3 of 17 domestic wells, and 37 of 835 observation wells, for a total of about 5 percent. About 1 percent of wells sampled in agricultural areas (shallow ground water) and in major aquifers had concentrations greater than one or more benchmarks. Wells with a concentration greater than a benchmark were scattered among 36 of the 187 ground-water studies. All concentrations greater than a benchmark were accounted for by dieldrin (72 wells), dinoseb (4), atrazine (4), lindane (2), and diazinon (1).

Implications

- Concentrations of pesticides measured in streams draining undeveloped and mixed-land-use watersheds indicate that public water-supply intakes on streams in these land-use settings, which compose about 87 percent of all intakes on the Nation's streams, are unlikely to withdraw water with concentrations that are greater than a human-health benchmark.
- The likelihood of pesticide concentrations exceeding a human-health benchmark in streams is greatest for those streams draining agricultural or urban watersheds, which account for about 12 and 1 percent, respectively, of public water-supply intakes on streams (based on NAWQA land-use classification). Such streams may warrant a priority for enhanced monitoring.
- The likelihood of pesticide concentrations exceeding a human-health benchmark in a public-supply well or domestic well is low on the basis of NAWQA results. About 1 percent of such wells sampled by NAWQA in all land-use settings had a pesticide concentration greater than a benchmark—most frequently dieldrin, which is no longer used.

Characteristics and Limitations of the Screening-Level Assessment of Potential Effects

The NAWQA screening-level assessment provides an initial perspective on the potential importance of pesticides to water quality in a national context by comparing measured concentrations with water-quality benchmarks. The screening-level assessment is not a substitute for risk assessment, which includes many more factors, such as additional avenues of exposure. The screening-level results are primarily intended to identify and prioritize needs for further investigation and have the following characteristics and limitations.

- Most benchmarks used in this report are estimates of no-effect levels, such that concentrations below the benchmarks are expected to have a low likelihood of adverse effects and concentrations above a benchmark have a greater likelihood of adverse effects, which generally increases with concentration.
- The presence of pesticides in streams or ground water at concentrations that exceed benchmarks does not indicate that adverse effects are certain to occur. Conversely, concentrations that are below benchmarks do not guarantee that adverse effects will not occur, but indicate that they are expected to be negligible (subject to limitations of measurements and benchmarks described below).
- The potential for adverse effects of pesticides on humans, aquatic life, and wildlife can only be partially addressed by NAWQA studies because chemical analyses did not include all pesticides and degradates. In addition, some compounds analyzed by NAWQA do not have benchmarks.
- Most benchmarks used in this report are based on toxicity tests of individual chemicals, whereas NAWQA results indicate that pesticides usually occur as mixtures. Comparisons to single-compound benchmarks may tend to underestimate the potential for adverse effects for some sites.
- Water-quality benchmarks for different pesticides and media are not always comparable because they have been derived by a number of different approaches, using a variety of types of toxicity values and test species.
- For some benchmarks, there is substantial uncertainty in underlying estimates of no-effect levels, depending on the methods used to derive them and the quantity and types of toxicity information on which they are based. This is especially true of fish-tissue benchmarks for the protection of fish-eating wildlife, for which there is no consensus on national-scale benchmarks or toxicity values.
- Estimates of pesticide exposure derived from NAWQA concentration measurements are also uncertain—particularly estimates of short-term exposure of aquatic organisms to pesticides in stream water. Generally, short-term average concentrations in stream water, such as 4-day values, are underestimated from NAWQA data.

A012005

Potential Significance to Aquatic Life and Wildlife—

Concentrations of pesticides were frequently greater than water-quality benchmarks for aquatic life and fish-eating wildlife (Chapter 6)

A screening-level perspective on the potential significance of pesticides to aquatic life and fish-eating wildlife was obtained by comparing concentrations measured in streams—including those in water, bed sediment, and whole fish—with water-quality benchmarks derived from guidelines established by USEPA, toxicity values from USEPA pesticide risk assessments, or selected guidelines from other sources.

Water—NAWQA findings for streams indicate that pesticides detected in water, most of which were in use during the study period, frequently exceeded aquatic-life benchmarks (fig. 1–3). Of 186 stream sites sampled nationwide:

- 57 percent of 83 agricultural streams had concentrations of at least one pesticide that exceeded one or more aquatic-life benchmarks at least one time during the year (68 percent of sites sampled during 1993–1994, 43 percent during 1995–1997, and 50 percent during 1998–2000).
- 83 percent of 30 urban streams had concentrations of at least one pesticide that exceeded one or more aquatic-life benchmarks at least one time during the year (90 percent of sites sampled during 1993–1994, 100 percent during 1995–1997, and 64 percent during 1998–2000).
- 42 percent of 65 mixed-land-use streams had concentrations of at least one pesticide that exceeded one or more aquatic-life benchmarks at least one time during the year (38 percent of sites sampled during 1993–1994, 40 percent during 1995–1997, and 46 percent during 1998–2000).

Streams in which concentrations of one or more pesticides exceeded an aquatic-life benchmark for water were distributed throughout the Nation in agricultural, urban, and mixed-land-use settings. In urban streams, most concentrations greater than a benchmark involved the insecticides diazinon (73 percent of sites), chlorpyrifos (37 percent), and malathion (30 percent). A potential revision of the acute invertebrate benchmark for diazinon from 0.1 micrograms per

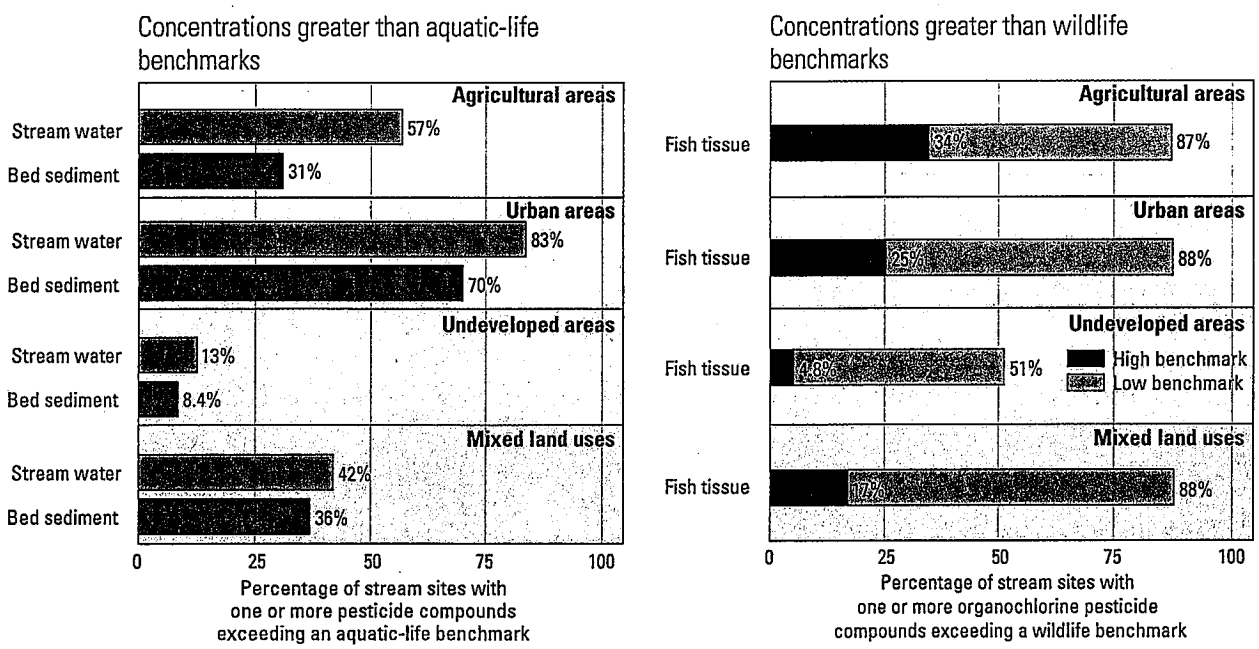

Figure 1–3. Pesticide concentrations measured in stream water and bed sediment frequently exceeded water-quality benchmarks for aquatic life. Concentrations of organochlorine pesticide compounds measured in whole-fish tissue were frequently greater than benchmarks for fish-eating wildlife, although the wide range of results for low and high benchmark values indicates relatively high uncertainty in the potential for effects, mainly because of uncertainty in the benchmark for total DDT.

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liter (µg/L) to 0.4 µg/L, as discussed in Chapter 6, would reduce the percentage of urban streams with exceedances by diazinon from 73 percent to 40 percent. As described in Chapter 6, all three of these insecticides exceeded aquatic-life benchmarks least frequently at urban sites sampled near the end of the study period (1998–2000), compared with sites sampled during 1993–1997. Agricultural and nonagricultural uses of diazinon and chlorpyrifos have been restricted to varying degrees since 2001, as discussed for diazinon in Chapter 8.

In agricultural streams, most concentrations greater than a benchmark involved chlorpyrifos (21 percent of sites), azinphos-methyl (19 percent), atrazine (18 percent), *p,p'*-DDE (16 percent), and alachlor (15 percent). Findings for agricultural streams in the Corn Belt indicate that alachlor exceedances declined through the study period, with none during 1998–2000; atrazine exceedances increased, with the most frequent for sites sampled during 1998–2000; and chlorpyrifos exceedances varied through the study period, but were most frequent during 1998–2000.

Generally, insecticides most commonly exceeded benchmarks that are based on acute or chronic effects on aquatic invertebrates, or those that are based on ambient water-quality criteria for aquatic life. Herbicides most commonly exceeded benchmarks that are based on acute or chronic effects on vascular or nonvascular plants. Because of the wide variability in the number, type, and degree of benchmark exceedances among sites and the complexity of translating exceedances of screening-level benchmarks into specific potential for effects, the screening-level results should be used as the starting point for further site-specific investigation.

Bed Sediment—Concentrations of organochlorine pesticide compounds measured in bed sediment were greater than one or more aquatic-life benchmarks at 70 percent of urban stream sites, 31 percent of agricultural sites, 36 percent of sites with mixed land use, and 8 percent of undeveloped sites (fig. 1–3). The geographic distribution of sites where aquatic-life benchmarks for bed sediment were exceeded is similar to findings for water in many respects, including urban streams throughout the country, and many agricultural and mixed-land-use streams in the Southeast, East, and irrigated areas of the West. In urban streams, aquatic-life benchmarks were most frequently exceeded by individual compounds in the DDT group or total DDT (58 percent of sites), total chlordane (57 percent), and dieldrin (26 percent). Compounds in the DDT group are derived from 2 parent pesticides, DDT and DDD, and include several degradates and by-products (DDD is also a degradate of DDT). Total DDT is the sum of the concentrations of six individual compounds. Total chlordane concentration is the sum of concentrations of the *cis* and *trans* isomers of chlordane and nonachlor, plus the chlordane degradate oxychlordane. In agricultural streams, aquatic-life benchmarks were exceeded most often by individual compounds in the DDT group or by total DDT (28 percent of sites) and by dieldrin (8 percent).

Fish Tissue—Comparisons of concentrations of organochlorine pesticide compounds measured in whole fish with benchmarks for fish-eating wildlife indicate a wide range of potential for effects, depending on the type of wildlife benchmark used (fig. 1–3). Because there is no consensus on tissue-based benchmark values for wildlife, measured concentrations were compared with both the high and low benchmark values from the range available for each compound. The high benchmark values for fish tissue were exceeded most frequently in streams in the populous Northeast; in high-use agricultural areas in the upper and lower Mississippi River Basin; in high-use irrigated agricultural areas, such as eastern Washington and the Central Valley of California; and in urban streams distributed throughout the country. In urban streams, low benchmarks were exceeded most often by total DDT (88 percent of sites), dieldrin (18 percent), and total chlordane (10 percent). In agricultural streams, low benchmarks were exceeded most often by total DDT (87 percent of sites), dieldrin (11 percent), and toxaphene (9 percent).

Implications

- The screening-level assessment indicates that the most widespread potential impact of pesticides on water quality is adverse effects on aquatic life and fish-eating wildlife, particularly in streams draining watersheds with substantial agricultural and urban areas.
- Assessment and management of potential effects on aquatic life and wildlife are complicated by the combined presence of (1) currently used pesticides and their degradates, and (2) organochlorine pesticide compounds derived from pesticides that, for the most part, had their uses cancelled prior to 1990.
- The widespread potential for adverse effects shown by the screening-level assessment—and the uncertainty in this potential because of the preliminary nature of the assessment and the complexity of pesticide exposure—indicate a continuing need to study the effects of pesticides on aquatic life and wildlife under the conditions of pesticide exposure that occur in the environment.

A012007

Frequently Detected Pesticides and Relations to Use—

Pesticides detected most frequently were among those used most heavily during the study period or in the past (Chapter 4)

The pesticides detected most frequently in streams and ground water were primarily those with the greatest use—either during the study period or in the past—and with the greatest mobility and (or) persistence in the hydrologic system (fig. 1–4).

The pesticides detected most frequently in stream water included: (1) five agricultural herbicides that were among the most heavily used during the study period—atrazine (and its degradate deethylatrazine), metolachlor, cyanazine, alachlor, and acetochlor; (2) five herbicides extensively used for nonagricultural purposes, particularly in urban areas—simazine, prometon, tebuthiuron, 2,4-D, and diuron; and (3) three of the most extensively used insecticides during the study period—diazinon, chlorpyrifos, and carbaryl (fig. 1–4). Simazine, prometon, diuron, 2,4-D, diazinon, and carbaryl, which are commonly used to control weeds, insects, and other pests in urban areas, were frequently found at relatively high levels in urban streams throughout the Nation. The use of individual pesticides often changes over time, and may have increased or decreased during or since the end of the study period. For example, the uses of diazinon and chlorpyrifos have been substantially restricted since 2001, and analysis of recent data for diazinon shows that concentrations in some streams have now declined as well.

The pesticide compounds detected most frequently in fish and bed sediment were historically used organochlorine pesticides, along with their degradates and by-products (fig. 1–4). Most organochlorine pesticides were heavily used during the 1950s and 1960s, but had their agricultural uses cancelled during the 1970s and remaining urban uses cancelled by the late 1980s. Some organochlorine compounds, however, persist in soils, sediment, and biota. Several compounds in the DDT group, chlordane compounds, dieldrin (from use of both dieldrin and aldrin), and heptachlor epoxide (degradate of heptachlor), were found most frequently. Although quantitative information on urban pesticide use is limited, the relatively high concentrations found in fish and bed sediment from urban streams indicate that historical use of these pesticides in urban areas was probably intensive.

Compared with streams, ground-water detections were dominated by fewer compounds—mainly those with relatively high mobility and persistence, which allows them to move greater distances to and within the ground-water flow system (fig. 1–4). The most prevalent pesticides in both agricultural and urban areas were the herbicides atrazine (and deethylatrazine), metolachlor, prometon, and simazine.

Implications

- The correlations of the pesticides found most frequently in streams and ground water with the amounts and characteristics of pesticides used can help managers to anticipate and prioritize the pesticides most likely to affect water quality in different land-use settings.
- For pesticides that are still being applied, reducing their use is likely to be an effective way to reduce their concentrations in the hydrologic system, particularly for streams (other approaches may also be effective).
- For organochlorine pesticide compounds derived from past use, management practices that control the erosion of soil may help to reduce their transport to streams.

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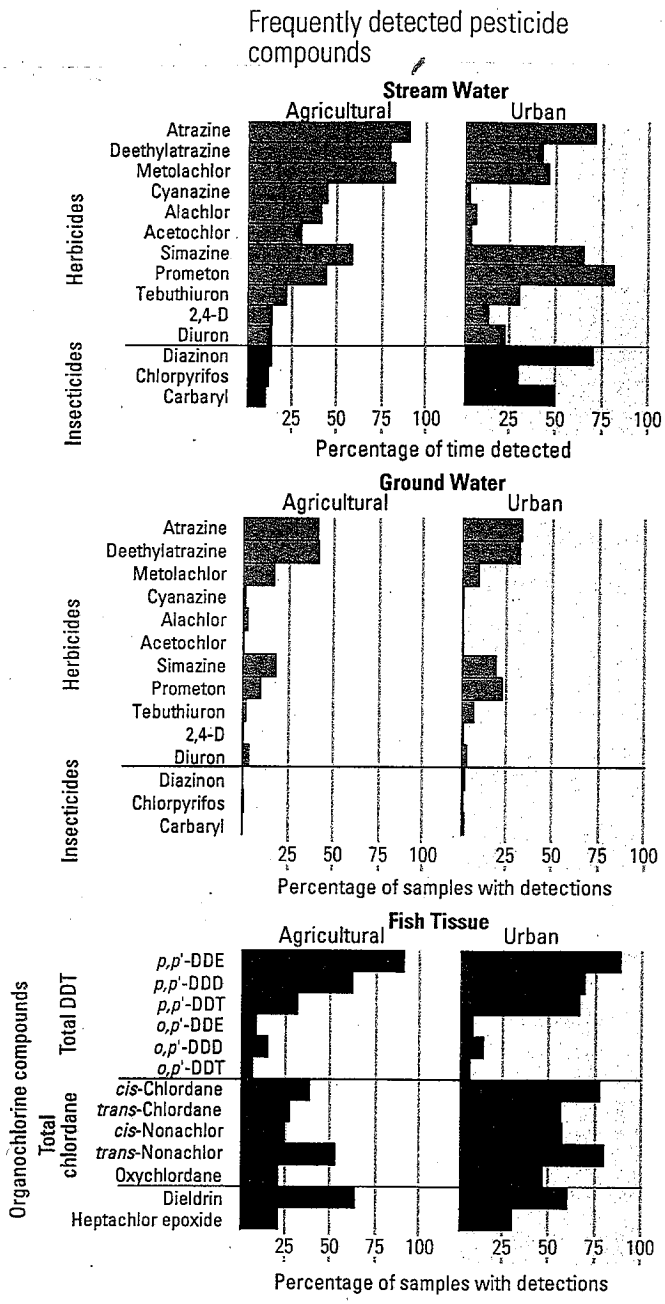
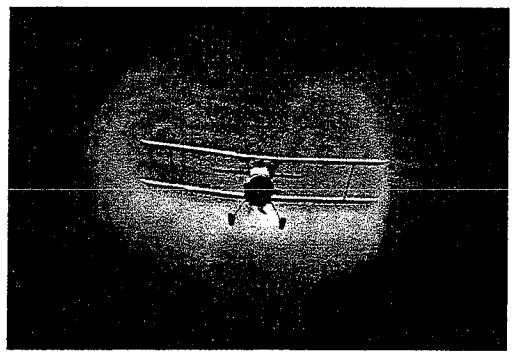


Figure 1–4. The pesticide compounds detected most frequently in streams and ground water in agricultural and urban areas were mainly those with the most extensive use—either during the study period or historically—and those with the greatest mobility and (or) persistence in the hydrologic system.



The most intensive pesticide applications are in agricultural and urban areas, including substantial use for home, lawn, and garden pest control in residential areas (photograph ©2003 Corbis [top]).

A012009

Geographic Patterns—

Patterns of pesticide occurrence in streams primarily followed the distribution of use, whereas patterns in ground water were more affected by management practices and natural susceptibility to contamination (Chapter 4)

The types and concentrations of pesticides found in agricultural streams primarily reflect the geographic distributions and intensity of use, along with additional influences by climate, soil characteristics, and water-management practices. For example, geographic patterns in stream concentrations of atrazine, metolachlor, simazine, acetochlor, 2,4-D, chlorpyrifos, and diazinon directly correlate with where they are used on crops. Some of the highest concentrations of atrazine were observed in streams within the Corn Belt and other areas where corn is a primary crop and where the herbicide is most heavily used (fig. 1–5). Total DDT was found at some of the highest concentrations in bed sediment and fish in parts of the Southeast, where DDT was historically used on cotton, tobacco, and peanuts, as well as in parts of California, Oregon, and Washington, where it was used extensively on orchards, potatoes, vegetables, and specialty crops. Dieldrin, on the other hand, was found most frequently and at some of the highest concentrations in the Corn Belt, where aldrin and dieldrin were extensively applied to corn.

The geographic distribution of pesticides in ground water also is influenced by the distributions of land use and pesticide use, but is more strongly affected by natural features, such as hydrogeology and soil characteristics, and by agricultural management practices, such as irrigation and drainage. For example, ground water is more susceptible to contamination in areas where the soil and unsaturated zone are more permeable than in areas where they are less permeable. A management practice that can influence pesticides in ground water is the use of subsurface tile-drain systems, which are buried networks of perforated pipes that collect shallow ground water for the purpose of lowering the water table and draining water-logged soils, as well as other subsurface drainage systems. These drain systems may reduce pesticide levels in underlying ground water by diverting shallow ground water to surface waters.

Detection frequencies of atrazine (fig. 1–6), metolachlor, and simazine generally were highest in ground water sampled in areas with permeable soils and geologic formations in parts of

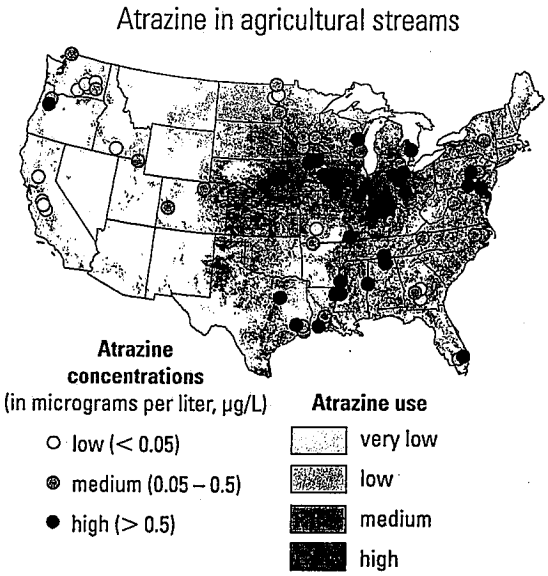


Figure 1–5. The concentrations of atrazine measured in agricultural streams correlated with the distribution of its use on crops—primarily corn. Some of the highest concentrations occurred in the corn-growing areas of Illinois, Indiana, Iowa, Nebraska, and Ohio.

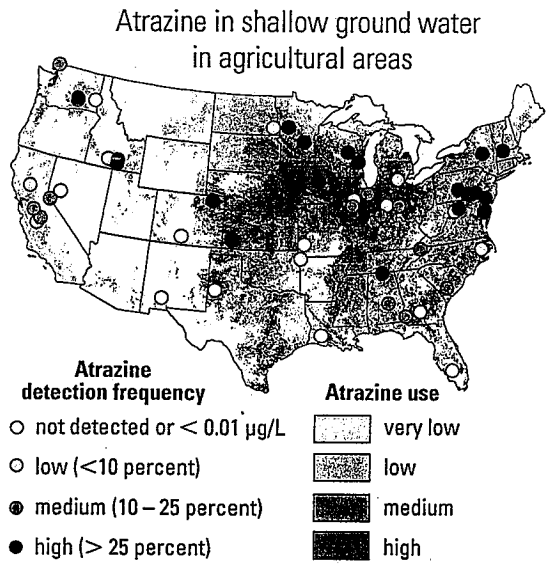


Figure 1–6. Atrazine was detected most frequently in shallow ground water in agricultural areas where soils and the underlying unsaturated zone are highly permeable and use is moderate to high, such as in parts of Iowa, Minnesota, Pennsylvania, and Wisconsin.

A012010

the country where these compounds are used for corn production—such as parts of Iowa, Minnesota, Pennsylvania, and Wisconsin. In contrast, these herbicides were found less frequently and at lower concentrations in ground water within many areas sampled in the central Corn Belt, despite some of the highest use in the Nation. This apparent anomaly, which has also been noted by other studies, is probably caused by the relatively impermeable soils and glacial till that cover much of this region, combined with the resulting widespread use of subsurface drainage systems. As observed for streams, each pesticide has a unique pattern and story regarding its occurrence in ground water, in large part resulting from its use on particular crops and its characteristic mobility and persistence. Pesticide properties more strongly control the occurrence of pesticides in ground water than in streams, however, because longer travel times in ground water and prolonged contact with soil and aquifer materials reduce concentrations of pesticides or degradates with low persistence or mobility.

Implications

- Pesticide occurrence in streams can be largely anticipated from the geographic distribution of land use, crops, and associated chemical use. Other factors, such as soil and runoff characteristics, also influence the amount and timing of the transport of pesticides to streams, but these factors are generally less important than the amount used in determining pesticide concentrations in streams.
- Compared with streams, natural features and management practices are more important considerations for anticipating the occurrence of pesticides in ground water. Ground water is most susceptible to contamination in areas where soils and the underlying unsaturated zone are most permeable and drainage practices do not divert recharge to surface waters.
- The entire hydrologic system and its complexities need to be considered in evaluating the potential for pesticide contamination of streams and ground water. Some hydrologic settings where ground water is least vulnerable to contamination are those where streams are most vulnerable, and vice versa. For example, subsurface drains may help protect deep ground water, but increase pesticide transport to streams.

Different pesticides are applied during different seasons in each region of the country. In the San Joaquin Valley, California, many orchards were sprayed with diazinon during the winter when they are dormant, whereas herbicides were applied to corn fields before and after spring planting throughout much of the Corn Belt (photograph by Dave Kim, California Department of Pesticide Regulation [left]).

A012011

Seasonal Patterns—

Pesticide concentrations in streams followed distinct seasonal patterns (Chapter 5)

Pesticide concentrations in stream water vary through the year, usually characterized by long periods with low or undetectable concentrations of most pesticides, punctuated by seasonal pulses of much higher concentrations. The timing and magnitude of seasonal pulses were correlated with the timing and intensity of pesticide applications, the frequency and magnitude of runoff from rainstorms or snowmelt, and the timing and distribution of land-management practices such as irrigation and artificial drainage. Concentrations in agricultural streams generally were highest during periods of runoff resulting from precipitation or irrigation that occurred soon after pesticide applications—a combination that causes seasonal patterns that are unique to each region. Spray drift and other modes of atmospheric transport can also be sources of pesticides to streams during high-use periods within an agricultural region. Most streams that drain farmland in the Corn Belt and other corn-growing areas, for example, had elevated concentrations of herbicides during spring runoff that followed applications (fig. 1–7). In contrast, agricultural streams in parts of the San Joaquin–Tulare Basin had high concentrations of diazinon during the winter, resulting from applications on dormant almond orchards followed by rainfall. Patterns also may vary because of differences in the timing of local water-management practices, such as irrigation and reservoir releases.

Implications

- Effective management of streams may require increased monitoring—including high-frequency sampling during seasons when intense pesticide use coincides with periods of high runoff—so that the periods with the highest pesticide concentrations are adequately characterized.
- Seasonal patterns in pesticide concentrations are important to consider in managing the quality of drinking water withdrawn from streams in agricultural and urban settings. Knowledge of seasonal patterns may help managers to adapt treatment strategies, or avoid or minimize withdrawals in favor of alternative sources of water, during high-concentration seasons.
- Seasonal patterns may result in adverse effects on aquatic life in some streams. Both acute and chronic aquatic-life benchmarks for water were most frequently exceeded during seasonal periods of high concentrations. Concentration pulses of some pesticides during sensitive stages of aquatic life cycles may have the greatest effects in some streams, and site-specific assessments may be required.

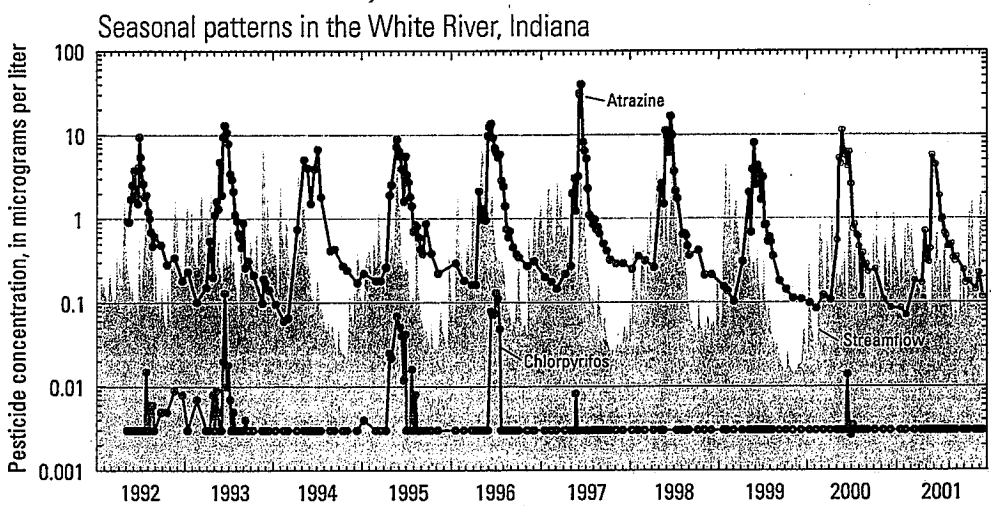


Figure 1–7. Atrazine concentrations in the White River, Indiana, were typical of streams throughout much of the Corn Belt, following similar seasonal patterns every year. Concentration pulses corresponded to the timing of runoff events and atrazine use on corn fields each spring. In contrast, seasonal patterns in concentrations of chlorpyrifos were more variable because of its more sporadic use.

A012012

Mixtures—

Pesticides were most commonly detected as mixtures of multiple pesticide compounds (Chapter 5)

Samples from streams in areas with substantial agricultural or urban land use almost always contained mixtures of multiple pesticides and degradates (fig. 1–8). More than 90 percent of the time, water from streams with agricultural, urban, or mixed-land-use watersheds had detections of 2 or more pesticides or degradates, and about 20 percent of the time they had detections of 10 or more. In addition, samples of fish tissue and bed sediment from most streams contained mixtures of historically used organochlorine pesticides and their degradates and by-products.

Mixtures were less common in ground water than in streams, which is consistent with the lower frequencies of detection for individual pesticide compounds. Nevertheless, 47 percent of shallow wells in agricultural areas and 37 percent of shallow wells in urban areas contained 2 or more detectable pesticides or degradates. Less than 1 percent had detections of 10 or more compounds.

The environmental significance of mixtures is ultimately determined by the specific combinations of individual compounds—known as "unique mixtures"—their concentrations and combined toxicity, and how often and where they occur. A unique mixture is a specific combination of 2 or more compounds, regardless of the presence of other compounds. Thus, a single sample with several pesticides contains many unique mixtures. Depending on the specific compounds, the toxicity of a mixture to a particular type of organism may result from additive effects among the compounds, independent effects, antagonistic effects (less than additive), or synergistic effects (greater than additive). Each of these toxicity models, except for the antagonistic model, usually results in a toxicity of the mixture that is greater than any of its individual components.

More than 6,000 unique 5-compound mixtures were found at least 2 percent of the time in agricultural streams (only 1 unique 5-compound mixture was found in ground water). Evaluating the potential significance of mixtures can be simplified, however, because many mixtures do not occur very often at high concentrations, and the most frequently occurring mixtures are composed of relatively few pesticides. For example, the number of unique 5-compound mixtures found in agricultural streams is less than 100 when only concentrations greater than 0.1 micrograms per liter (µg/L) are considered. More than 30 percent of all unique mixtures found in streams and ground water in agricultural and urban areas contained the herbicides atrazine (and deethylatrazine), metolachlor, simazine, and prometon. The insecticides diazinon, chlorpyrifos, carbaryl, and malathion were common in mixtures found in urban streams.

Implications

- Because of the widespread and common occurrence of pesticide mixtures, particularly in streams, the total combined toxicity of pesticides in water or other media often may be greater than that of any single pesticide compound that is present.
- Continued systematic assessment is needed of the potential toxicity of pesticide mixtures to humans, aquatic life, and wildlife. NAWQA information on the occurrence and characteristics of mixtures can help to target and prioritize toxicity assessments.

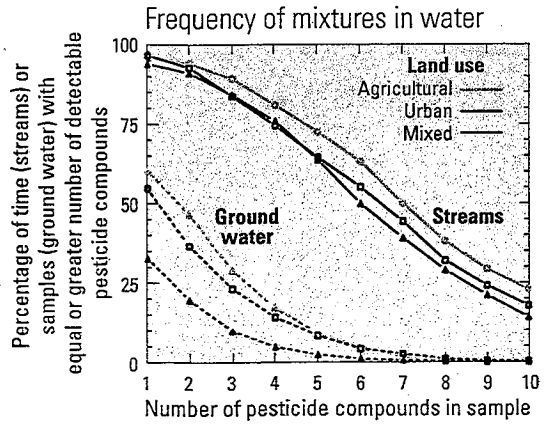


Figure 1–8. Pesticides commonly occurred in streams and ground water as mixtures. For example, agricultural stream samples contained 10 or more different pesticides or degradates more than 20 percent of the time.

A012013

Degradates—

Concentrations of degradates were often greater than concentrations of parent pesticides (Chapter 5)

Once released into the environment, pesticides undergo many types of transformation reactions that create degradates. Factors that govern the formation and distribution of degradates in the hydrologic system include the use and persistence of parent pesticides, the persistence and mobility of the degradates, and the physical, chemical, and biological conditions in the environment. In many cases, transformation results in the conversion of the parent compound to a compound that is less toxic, but some degradates have toxicities that are similar to, or greater than, that of their parent pesticide.

Some degradates were found more frequently and at higher concentrations than their parent pesticide. For example, DDT, which was first used more than 50 years ago and was discontinued about 20 years before this study began, was detected in fish from about 30 percent of agricultural streams sampled by NAWQA, whereas DDE, a more stable degradate of DDT, was detected in fish from 90 percent of sampled agricultural streams. Atrazine, the most heavily used herbicide in the Nation during the study period, was found together with one of its several degradates, deethylatrazine, in about 75 percent of stream samples and about 40 percent of ground-water samples collected in agricultural areas across the Nation. In the Eastern Iowa Basins, where NAWQA conducted special studies of herbicide degradates, an average of nearly 85 percent of the total mass of herbicide compounds in stream samples was composed of 10 degradates of the herbicides acetochlor, alachlor, atrazine, cyanazine, and metolachlor (fig. 1–9). The summed concentrations of degradates were more than 10 times higher than the summed concentrations of their parent compounds during much of the year, and the degradates accounted for the largest proportion of pesticide compounds that are transported by the Iowa River to the Mississippi River.

Degradates are particularly important in ground water, which moves relatively slowly through soils and aquifers, providing the extended time and conditions favorable for transformation of pesticides to their degradates. Ground water in the Delmarva Peninsula, for example, contained degradates of alachlor and metolachlor at median concentrations 10 times higher than those of the parent herbicides. Degradates in ground water can ultimately reach streams when ground-water discharge contributes to streamflow. In the Iowa River, substantial transport of herbicide degradates occurred during low streamflow conditions (fig. 1–9).

Implications

- Pesticide degradates should continue to be considered and accounted for in assessments of pesticide exposure and in evaluating the potential effects of pesticides on humans, aquatic life, and wildlife.
- Enhanced assessments of the occurrence and behavior of degradates in the hydrologic system require improved coverage of degradates in water-quality monitoring and continued research on pesticide transformations and transport in the hydrologic system. Enhanced assessments would supplement the toxicity testing of major degradates now required by USEPA as part of risk assessments for pesticide registration.

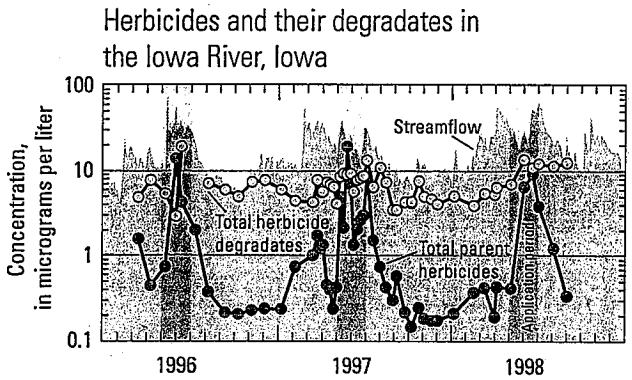


Figure 1–9. The total concentration of degradates commonly exceeded the total concentration of parent herbicides (acetochlor, alachlor, atrazine, cyanazine, and metolachlor) in the Iowa River.

A012014

Prediction—

Extensive data and improved understanding enable prediction of pesticide occurrence and concentrations for streams and ground water where they have not been measured (Chapter 7)

NAWQA data from 1992 to 2001 are sufficiently extensive to support statistical models that can be used to estimate the concentrations or occurrence of some pesticides in streams and ground water where they have not yet been assessed. Such spatial extrapolation is fundamental to extending NAWQA's targeted local and regional studies to a comprehensive national assessment. The statistical models were developed from measured pesticide concentrations, together with information on key factors and processes that affect pesticide occurrence, including pesticide use and land use, climate and soil characteristics, and other features.

The NAWQA approach to extrapolation for streams is illustrated by a model used to estimate concentrations of atrazine in stream water, specifically the likelihood that the annual average atrazine concentration in any particular stream in the Nation would exceed a human-health benchmark of 3 µg/L (fig. 1–10). The human-health benchmark used for atrazine is the USEPA drinking-water standard, or Maximum Contaminant Level (MCL). Predictions are for annual mean concentrations in untreated stream water (including consideration of predictive uncertainty), regardless of whether a stream is presently a source of drinking water. Atrazine concentrations were predicted to be highest in the Corn Belt and parts of the southern Mississippi River Valley, where use is high and natural features favor the transport of pesticides by runoff to streams. In these areas, many streams are estimated to have more than a 5-percent chance of having a mean annual concentration of atrazine that is greater than the benchmark (shown in red in figure 1–10). In other words, more than 1 out of 20 of these streams are predicted to have mean concentrations greater than the human-health benchmark, and thus, may not be suitable as sources of drinking water without the use of strategies to lower concentrations. Similar analyses can be developed for other probability criteria or concentration estimates.

Implications

- The development of national-scale predictive models with quantified reliability is increasingly possible for some pesticides, particularly for streams. Expanding this capability is a critical step for national water-quality assessment, as well as for cost-effective management of water resources, because both require more information (compounds, places, and times) than can be directly measured under current technology and budget constraints.
- Model estimates can be used to identify locations that have the greatest likelihood of water-quality problems and that are, therefore, the highest priority for additional monitoring.
- Future success with development and application of statistical models—as well as more complex simulation models—will depend upon continued, carefully targeted monitoring of pesticide concentrations in the hydrologic system, coupled with continued and improved collection of supporting data on pesticide use, natural features, and other explanatory factors needed to update and validate the models.

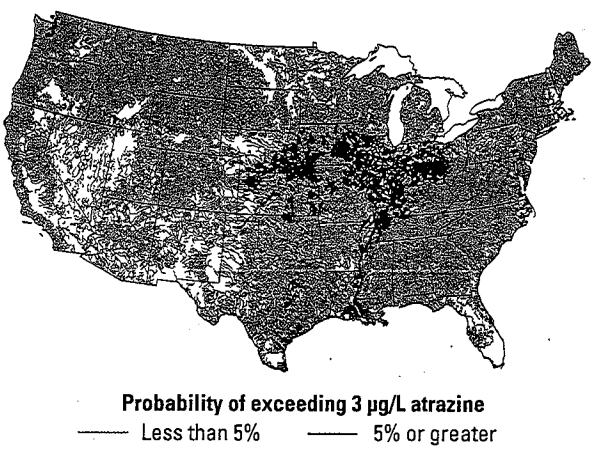


Figure 1–10. Streams predicted to have a 5 percent or greater chance of having annual mean atrazine concentrations that are higher than its human-health benchmark of 3 µg/L—USEPA's Maximum Contaminant Level for drinking water—are located throughout much of the Corn Belt and in other high-use areas such as the southern Mississippi River Valley. These estimates were based on 1997 atrazine use for agriculture and will change if use changes.

A012015

Trends—

A first look at trends shows examples of both decreasing and increasing levels of pesticides in streams and ground water (Chapter 8)

NAWQA results from 1992 to 2001 provide a framework for assessing whether pesticide levels in the Nation's streams and ground water are increasing or decreasing over time. For many pesticides and locations, it is too early to discern changes because historical data are insufficient to measure trends. Some trends, however, are already evident and others are just emerging.

The most complete story of trends in response to regulatory action and reduced pesticide use is the decline in concentrations of organochlorine pesticide compounds that followed reductions in use during the 1960s and bans on their uses in the 1970s and 1980s. For example, concentrations of total DDT in fish decreased rapidly from the 1960s through the 1970s, then more slowly during the 1980s and 1990s, as documented by data for 1969–1986 from the U.S. Fish and Wildlife Service (Schmitt and Bunck, 1995), and by data for the 1990s from NAWQA (fig. 1–11). The trends in concentrations of organochlorine compounds in fish, however, also show that responses to reductions in sources can take a long time for chemicals that are persistent in the environment.

More recent regional changes in corn herbicide use have resulted in corresponding trends in concentrations in Corn Belt streams. For example, in response to the partial replacement of alachlor by the new herbicide acetochlor in 1994, streams quickly—generally within 1 to 2 years—showed increasing acetochlor concentrations and decreasing alachlor concentrations. Findings show that concentrations of relatively mobile and short-lived pesticides in stream water will respond rapidly to changes in use—much more quickly than the less mobile and more persistent organochlorine compounds in fish tissue.

Ground water responds more slowly than streams to changes in pesticide use—taking years and even decades for changes in quality to occur. A persistent pesticide or degradate can remain in ground water long after its use has been discontinued because of the slow rates of ground-water flow and the resulting long residence time of water and contaminants in ground-water flow systems. This is evident from a number of studies in different parts of the country. For example, bromacil remained at detectable levels in ground water in parts of Florida for several years after it was no longer used. Similarly, dieldrin, which was no longer used during the study period, was still detectable at concentrations greater than its human-health benchmark in 72 wells sampled by NAWQA.

Continued NAWQA studies and monitoring will build on the baseline assessment established during the 1990s to assess trends in basins across the Nation. Assessment of trends is a primary objective during the second decade of the NAWQA Program when study areas are systematically reassessed and an increasing number of stream and ground-water sampling sites will have had 10 years of monitoring. Equally important, the NAWQA studies will continue to link changes in pesticide occurrence and concentrations over time with those factors that control the timing of trends, such as changes in pesticide use, land management, and natural factors.

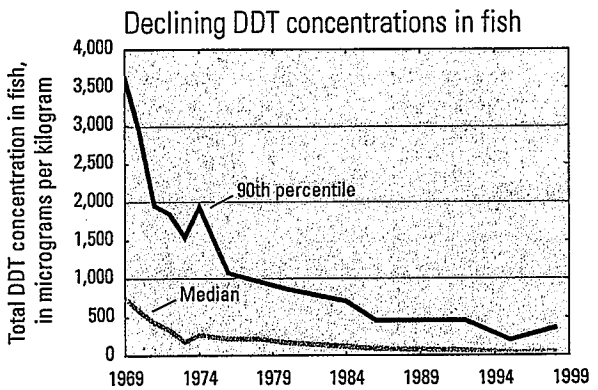


Figure 1–11. Total DDT concentrations in whole fish (wet weight) from rivers and streams throughout the Nation that drain watersheds with mixed land uses decreased rapidly from the 1960s through the 1970s, and then more slowly during the 1980s and 1990s.

Implications

- Increases or decreases in pesticide use can result in rapid corresponding changes in pesticide concentrations in stream water—generally within 1 to 2 years. In contrast, pesticide occurrence in ground water, and the occurrence of persistent compounds in aquatic organisms or sediment, may change slowly—sometimes taking decades to respond to changes in use.
- Long-term and consistent monitoring of pesticides in streams and ground water is essential for distinguishing actual trends from short-term fluctuations and for accurately tracking changes.
- Assessment of trends in stream-water concentrations of most currently used pesticides requires consistent annual data, with a particular focus on critical seasons of high use and transport. Assessment of trends in more persistent pesticides, such as organochlorine compounds in fish tissue, can rely on samples collected several years apart.
- Assessment of trends in concentrations of pesticides in ground water usually requires estimation of ground-water age and an understanding of the ground-water flow system because of the slow rate of ground-water flow and the uncertainty in flow paths.

A012016

Priorities for Filling Information Gaps

The NAWQA assessment provides the most comprehensive analysis to date of pesticides in streams and ground water at the national scale and serves as a foundation for improving water-resource assessment and management. Nevertheless, major gaps in critical information about pesticides still persist and continue to present challenges to scientists, managers, and policy makers. As present-day knowledge is brought to bear on decision making, there is a continuing need to improve the data and scientific understanding required for future decisions. Some of the most important steps needed to fill information gaps for pesticides are outlined below:

- **Improve tracking of pesticide use.** Existing data on pesticide use are sparse (infrequent, with coarse geographic coverage) for agricultural uses and virtually nonexistent for nonagricultural uses. Given the direct relations between pesticide use and occurrence, improvement in the extent, frequency, and quality of quantitative data on agricultural use—and development of comparable and reliable data sources for nonagricultural pesticide use—would have major benefits for assessment and management of pesticides in streams and ground water.

- **Add assessments of pesticides not yet studied.** Many important pesticides have not yet been assessed in the Nation's streams and ground water using a nationally consistent approach because of budget constraints and limitations of current analytical methods. These pesticides include most fungicides and fumigants in current use, as well as many new or increasingly used herbicides and insecticides, such as glyphosate and pyrethroid insecticides. Pesticides targeted for analysis need to be re-evaluated regularly as use changes over time and new pesticides are introduced.

- **Improve assessment and understanding of degradates.** Closely related to the gaps in pesticides that have been assessed, are the even greater gaps in information about the distribution of degradates in streams and ground water. Specific needs include the development of analytical capabilities for measurement of a broader suite of pesticide degradates, continued research on pesticide transformations and the implications for transport and persistence in the hydrologic system, and improved assessment of potential exposure to degradates and their potential to affect humans, aquatic life, and wildlife. This information is needed to supplement the information on the toxicity and environmental behavior of major degradates that is now developed as part of the pesticide registration process.

- **Evaluate toxicities of mixtures.** Existing standards and guidelines for exposure to individual pesticides may not address all potential effects because actual exposure is most often to mixtures of multiple pesticides and degradates. Additional research is needed regarding the toxicities of mixtures to humans, aquatic life, and wildlife.

- **Evaluate the performance of management practices.** Evaluations are needed for making direct links between management practices—such as irrigation methods, subsurface drains, integrated pest management, and retention of wetlands and buffers—and the concentrations and transport of pesticides in streams and ground water. Field-scale studies have shown that certain management practices can influence pesticides in streams and ground water, but the effectiveness of these practices has not been systematically assessed at regional and national scales.

- **Improve methods for prediction.** Successful assessment and management of the Nation's water quality requires a commitment not only to monitoring pesticides and their degradates in streams and ground water, but also to the continued development of predictive tools, such as statistical and simulation models. NAWQA assessments demonstrate that models can play an important role in the assessment of water quality and provide a cost-effective approach for extrapolating measured water-quality conditions to unsampled areas. Predictive capabilities are critical because the expense of monitoring prevents direct assessment of pesticides for all of the places and times required. Models, however, are successful only if they are developed and verified on the basis of measured data. Thus, the integration of monitoring and modeling, which is heavily emphasized in NAWQA's second decade of assessments, is critical to expanding and improving methods for prediction.

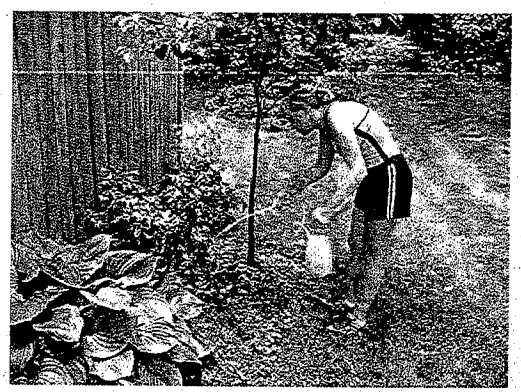
- **Sustain and expand long-term monitoring for trends.** Long-term, consistent data for assessing trends is essential for tracking water-quality response to changes in pesticide use and management practices, for providing early warning of unanticipated problems, and for updating and improving models. The second decade of NAWQA assessments will include long-term monitoring of a broad range of pesticides and degradates in water at a national network of selected sampling locations, but the geographic coverage and range of pesticides measured should be increased in cooperation with other agencies.

A012017

A012018

2 Pesticide Primer

Pesticides are used to control weeds, insects, and other pests in agricultural areas, urban areas, and a variety of other land-use settings. Once released into the environment, pesticides and their degradates can move through the hydrologic system to streams and ground water, where they may affect humans, aquatic life, or wildlife if concentrations occur at toxic levels. Many factors affect the transport and concentrations of pesticides in streams and ground water, including the intensity and distribution of their use; natural factors, such as climate and soil characteristics; and the physical and chemical properties of the pesticide compounds themselves.



This chapter provides a basic overview of the use of pesticides and the factors that control their transport and fate in streams and ground water, thus serving as a foundation for understanding the occurrence and significance of pesticides in the hydrologic system—topics that are examined in subsequent chapters.

A012019

Pesticides and Their Uses

A pesticide is any substance used to kill or control insects, weeds, fungi, rodents, bacteria, or other unwanted organisms. Pesticides provide a range of benefits, including increased food production and reduction of insect-borne disease, but their use also raises questions about possible adverse impacts on the environment, including potential effects on drinking-water sources and aquatic life.

All pesticide products contain one or more active ingredients, which are referred to as pesticides in this report. Most pesticide products also contain adjuvants, which are usually referred to as inert ingredients on product labels. Active ingredients specifically target the pest organism, whereas adjuvants are used to increase the effectiveness of the active ingredient. Adjuvants were not extensively assessed as part of NAWQA studies and are not addressed in this report, although some may have toxicological importance. As of 1997, about 900 pesticides were registered in the United States for use in more than 20,000 different pesticide products (Aspelin and Grube, 1999). New pesticides are introduced every year—for example, typically 10 to 20 new active ingredients were registered each year from 1967 to 1997 (Aspelin and Grube, 1999).

Conventional pesticides include four major groups: herbicides, insecticides, fungicides, and a mixed group of fumigants, nematicides and other pesticides. An average of almost 1 billion pounds (lb) of conventional pesticides was used each year in the United States during the 1992–2001 study period (fig. 2–1). NAWQA studies focused primarily on herbicides and insecticides, as described further in Chapter 3. In addition to conventional pesticides, about 4 billion lb of other registered pesticides are used each year, including chlorine disinfectants, wood preservatives, and other specialty products. These other types of pesticides were not included in NAWQA assessments.

Pesticide names used in this report are the scientific names of the active ingredients, such as atrazine and diazinon—rather than product names—in order to minimize confusion among the vast array of products and their names. For example, a 1994 analysis identified a total of 7,340 different product names associated with 386 commonly used pesticides—an average of 19 different product names per pesticide (Milne, 1995).

Pesticides are released into the environment primarily through their application to agricultural lands, such as croplands and orchards, and for nonagricultural pest control, such as on lawns and gardens, commercial areas, and rights-of-way. In 2001, agriculture accounted for 76 percent of total national use, with the remaining 24 percent being applied for a wide range of nonagricultural purposes (Kiely and others, 2004).

The nature and extent of pesticide use for agriculture in the United States has continually changed over the past 40 years. Total use for agriculture steadily increased from 1964 to 1980—from less than 400 million to more than 800 million pounds per year (lb/yr)—and then varied between about 700 and 800 million lb/yr from 1980 to 2001 (fig. 2–1). From 1980 to 2001, the use of herbicides and fungicides decreased

Trends in pesticide use

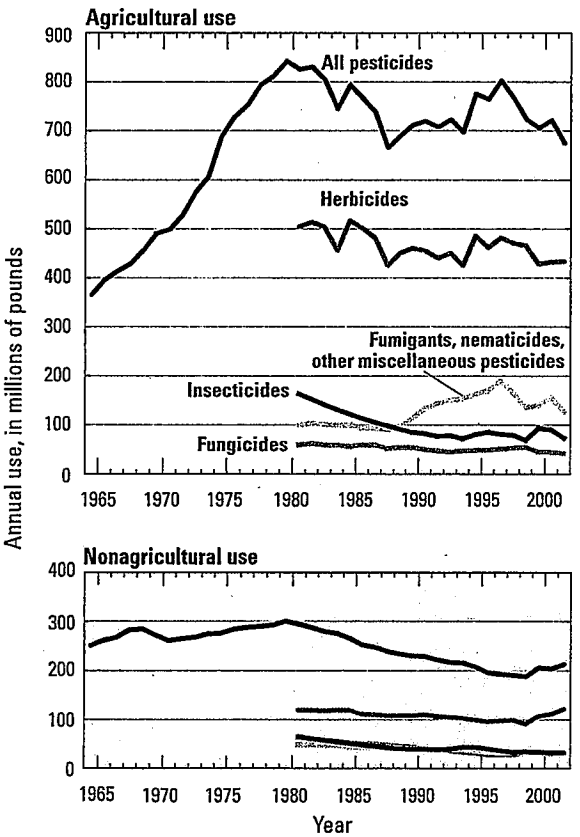


Figure 2–1. Total agricultural use of pesticides—more than half of which was accounted for by herbicides—increased from 1964 until about 1980 and then varied between about 700 and 800 million lb/yr until 2001. Nonagricultural use of pesticides, much of which occurs in urban settings, remained relatively steady from 1964 to 1979, gradually declined from 1979 to 1998, and then increased through 2001. (Data from Donaldson and others, 2002; and Kiely and others, 2004.)

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slightly, insecticide use decreased by about half, and the combined use of fumigants, nematicides, and other pesticides increased.

By comparison, nonagricultural use of pesticides remained relatively constant from 1964 to 1979, in the range of 250–300 million lb/yr, and then gradually decreased to about 190 million lb/yr by 1998. From 1998 to 2001, nonagricultural use increased, driven primarily by increases in the amounts of herbicides, insecticides, and fungicides applied for home and garden pest control (Kiely and others, 2004).

Trends in the use of individual pesticides applied for agricultural or nonagricultural purposes commonly vary from these overall patterns, depending on factors such as market conditions, regulatory actions, and the introduction of new pesticides or approaches (for example, genetically engineered crops or organic agriculture). Selected trends are discussed in Chapter 8 as part of an evaluation of changes in pesticide occurrence in streams and ground water.

Most agricultural use of conventional pesticides is accounted for by fewer than 100 active ingredients. In 1997, for example, 25 herbicides accounted for approximately 92 percent of total herbicide use, 25 insecticides accounted for 91 percent of total insecticide use, 25 fungicides accounted for 99 percent of total fungicide use, and 20 pesticides accounted for 100 percent of total fumigant and nematicide use (Gianessi and Marcelli, 2000). The national use of a pesticide, however, does not necessarily indicate the importance of its use in a particular area. For example, some pesticides are used in small quantities nationally (ranking them outside the top pesticides by weight), but are used intensively or frequently in certain areas. Pesticide use within a particular agricultural area is determined by many factors, including the types of weeds, insects, and other pests of concern, the potency and application rates of specific pesticides, climate, regulatory limits, and cost. These factors are closely related to the types of crops and the extent of their production. For example, more than 50 percent of all agricultural pesticide use in the Nation (by weight) is for pest control on only three crops—corn, soybeans, and cotton. Applications to corn alone account for about 30 percent of total pesticide use in the United States (fig. 2–2). Estimates of pesticide use for agricultural purposes are available for more than 200 pesticides by crop and county for all States except Alaska and Hawaii (Thelin and Gianessi, 2000; see *http://ca.water.usgs.gov/pnsp/*).

Pesticides are used for nonagricultural purposes in urban and suburban areas to control weeds, insects, and other pests around homes and gardens, in parks and golf courses, along roads and other rights-of-way, and in commercial and industrial areas. Pesticides are also used for nonagricultural purposes in undeveloped and agricultural areas to control weeds, insects and other pests along fence rows and roadsides, in parks, and around rural residences. Nationally, total nonagricultural use is estimated to exceed the amount applied to any single crop except for corn (fig. 2–2). Data on nonagricultural use of pesticides, however, are much more limited than those for agricultural use. The only current published national data on nonagricultural use of specific pesticides are for 10 of the pesticides most commonly applied in each of two nonagricultural market sectors: (1) home and garden use by homeowners, and (2) use for industrial,

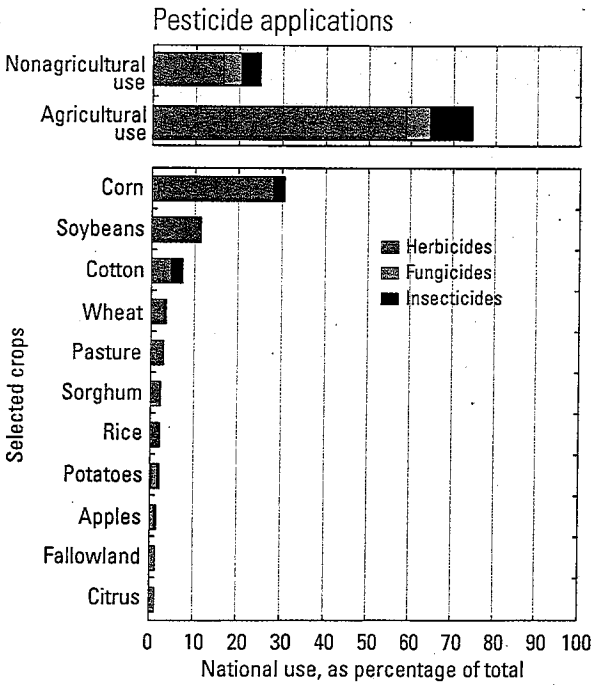

Figure 2–2. Agricultural use of pesticides in 2001 was about three times greater than nonagricultural use. However, nonagricultural uses, such as applications to control weeds and insects in urban and suburban areas, were second only to corn when compared with individual crops. (Pesticide use estimates for individual crops are for 1997 and are from Gianessi and Marcelli, 2000; use estimates for total agricultural and nonagricultural uses are for 2001 and are from Kiely and others, 2004.)

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commercial, and government applications (Kiely and others, 2004).

In addition to total use, the intensity of pesticide applications—expressed as the amount applied per unit of land area (such as pounds per acre)—also is an important consideration in assessing possible effects on water quality. For example, land devoted to corn production constitutes only about 8 percent of the total national area of agricultural and urban land uses, and yet pesticide applications to corn account for 30 percent of total national use. In contrast, pasture lands constitute about 50 percent of the total national area of agricultural and urban land, but account for only 4 percent of the total pesticide use. Collectively, urban areas across the Nation cover about the same area of land as corn (about 8 percent of the total agricultural and urban land area) and account for much of the 24 percent of total pesticide use that is attributed to nonagricultural purposes (Kiely and others, 2004). Estimates from the early 1990s indicate that the intensities of applications of herbicides to turf grass at sod farms, golf courses, and residences—and of applications of fungicides to turf at golf courses—are greater than the intensities of applications to most crops (Barbash and Resek, 1996). Available information indicates a relatively high intensity of nonagricultural use in urban areas.

The specific pesticides applied in a particular area differ by land use, crop type, and targeted pests. For example, during the 1992–2001 study period, certain pesticides, such as 2,4-D, diuron, diazinon, and chlorpyrifos, were more intensively used in urban and suburban areas across the Nation than in most agricultural settings. The types of crops largely determine which pesticides are applied in agricultural areas, resulting in distinct geographic patterns of use (fig. 2–3). The use of each pesticide during 1997 was estimated by combining the 1997 state-level use data reported by Gianessi and Marcelli (2000), with county crop acreages from the 1997 Census of Agriculture (U.S. Department of Agriculture, 1999), using methods described by Thelin and Gianessi (2000). Use intensity was mapped for agricultural land using land-cover data from the early 1990s (Vogelmann and others, 2001) as described by Nakagaki and Wolock (2005). For example, molinate is used only on rice, which is grown primarily in the lower Mississippi River Valley and in parts of Louisiana, Texas, and California. Diazinon, atrazine, and diuron also have their own unique patterns of application. Considering the combined use of all pesticides, the overall intensity of pesticide application for agriculture is greatest in the croplands of the Corn Belt, the Mississippi River Valley, Florida, the coastal plain of the Southeast and Mid-Atlantic states, and irrigated areas of the West.

Although the amounts and intensities of pesticide applications largely define the sources of pesticides to the environment in a particular location, the potential of a pesticide to affect water quality is also influenced by its sources and pathways in the hydrologic system, its chemical and physical properties (which determine mobility and persistence), and its toxicity to humans, aquatic life, and wildlife. A basic background on the influences of sources, transport pathways, and pesticide properties on the behavior of pesticides in hydrologic systems—and some of the potential implications for water quality—is summarized below and these factors are further explored in Chapters 4 and 5. The potential effects of pesticides on humans, aquatic life, and wildlife are examined in Chapter 6.

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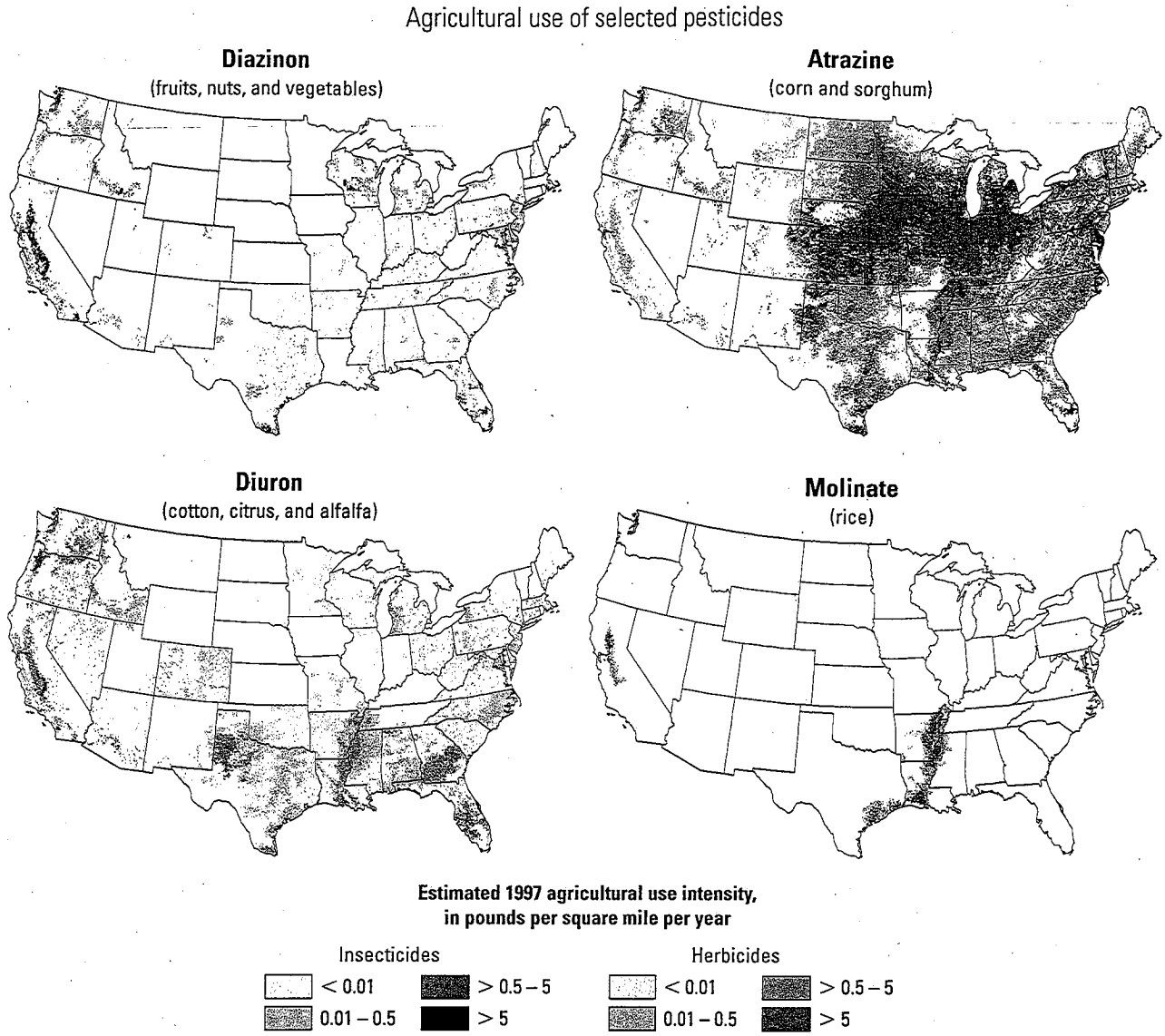

Figure 2–3. The geographic distribution of the use of each pesticide follows the distributions of crops and pests for which it is applied. Examples for the 1997 agricultural use of the insecticide diazinon and the herbicides atrazine, diuron, and molinate show four distinctly different geographic patterns of use. (Use intensity for 1997 was mapped for agricultural land using methods described on p. 24.)

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Sources and Pathways in the Hydrologic System

Pesticides, like most other water contaminants, enter the hydrologic system from point sources, which are associated with specific points of release, and from nonpoint sources, which are diffuse and widely dispersed. Nonpoint sources are the dominant sources of pesticides found in streams and ground water (fig. 2–4). Nonpoint sources include runoff to streams from agricultural and urban land, seepage to ground water in areas where pesticides are used, and deposition of pesticides from the atmosphere. Potential point sources of pesticides include pesticide manufacturing plants, mixing-and-loading facilities, spills, wastewater recharge facilities (wells or basins), waste disposal sites, and sewage treatment plants. Once pesticides and their degradates (new compounds formed by the transformation of a pesticide by chemical or biological reactions) reach the atmosphere, streams, or ground water, they move through the hydrologic system with air, water, or particles, depending on the chemical and physical properties of the compounds.

Atmosphere

The atmosphere is an important part of the hydrologic system in which pesticides can be transported substantial distances from where they are applied (for example, Goolsby and others, 1997; Cromwell and Thurman, 2000). In fact, atmospheric transport can be global and is thought to be responsible for the detection of long-lived organochlorine pesticides such as chlordane, DDT, and dieldrin in remote areas of Scandinavia and the Arctic—locations where these pesticides probably were never used (Majewski and Capel, 1995; Nowell and others, 1999; Hermanson and others, 2005).

Pesticides can be transported from the atmosphere to streams and ground water with precipitation or the deposition of particles. For example, studies in the Upper Tennessee River Basin showed that atrazine and metolachlor

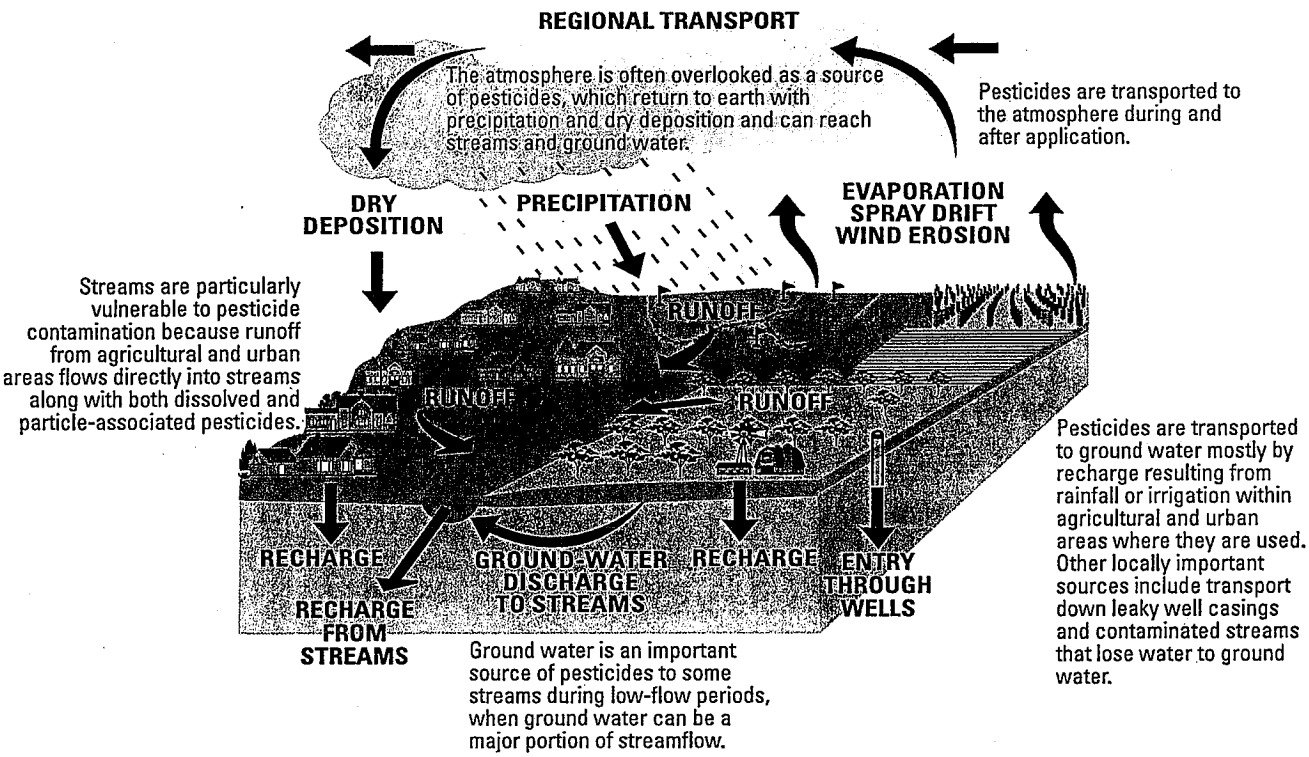

Figure 2–4. Pesticides are transported to streams and ground water primarily by runoff and recharge. Nonpoint sources of pesticides originating from areas where they were applied—rather than point sources such as wastewater discharges—are the most widespread causes of pesticide occurrence in streams and ground water. (Modified from Majewski and Capel, 1995.)

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were frequently detected in Clear Creek in the Obed National Wild and Scenic River watershed (fig. 2–5). Seasonal patterns of occurrence of these two compounds matched those in nearby agricultural streams, indicating an atmospheric source from agricultural areas (Hampson and others, 2000). Similarly, metolachlor, EPTC, and atrazine were detected in rainwater within the Minneapolis–St. Paul metropolitan area—where they had not been applied—also indicating that these pesticides had been transported from nearby agricultural areas (Andrews and others, 1998; Capel and others, 1998). All three pesticides were found in rainwater at concentrations that were usually higher than those measured in the ground water of the Minneapolis–St. Paul study area; thus, atmospheric inputs alone could have accounted for most of their occurrence in the ground water.

Streams

Pesticides are transported from land into streams primarily by runoff or drainage resulting from rainfall or irrigation. These event-generated inflows to streams can occur by surface runoff, shallow subsurface flow, or flow through drainage ditches and subsurface tile-drain systems. Some compounds, such as atrazine, readily dissolve in and move with water. Other compounds, such as chlorpyrifos, more strongly associate with soil particles and organic matter and are transported primarily with eroded soil, particularly during times of high runoff from precipitation or irrigation.

Transport to streams is controlled, in large part, by the timing of precipitation and associated runoff and drainage relative to pesticide applications (Leonard, 1990). For example, figure 2–6 shows elevated concentrations of atrazine in the White River during runoff events that occurred soon after spring applications in May and June, but lower concentrations in response to runoff events of comparable or greater magnitude at other times of the year when use was lower, such as in April or August. The phenomenon of high herbicide concentrations in spring runoff has been extensively documented, especially in the Midwest (for example, Thurman and others, 1991).

Pesticides also enter streams with inflowing ground water—which can be a continuous source of pesticides and degradates throughout the year in some areas (Squillace and others, 1993). For example, during baseflow conditions on the Delmarva Peninsula, Shedlock and others (1999) measured pesticide concentrations in streams that were similar to those found in nearby wells. Baseflow conditions occur during periods of minimal precipitation, when streamflow is dominated by ground-water discharge. Similarly, in Waikele Stream, which drains a watershed with mixed land use on the Island of Oahu, Hawaii, concentrations of the herbicides bromacil, atrazine, and diuron were highest during baseflow conditions (Anthony and others, 2004).

Once in a stream, a pesticide may transform, be taken up by aquatic organisms, attach

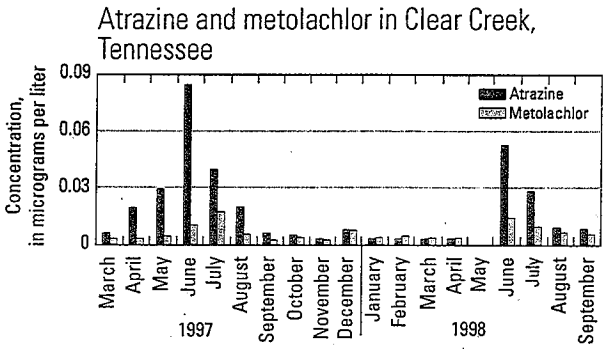

Figure 2–5. Atrazine and metolachlor were frequently detected in Clear Creek in the Obed National Wild and Scenic River watershed (Upper Tennessee River Basin). The seasonal patterns in concentrations followed those of applications in nearby agricultural areas, suggesting atmospheric transport (Hampson and others, 2000).

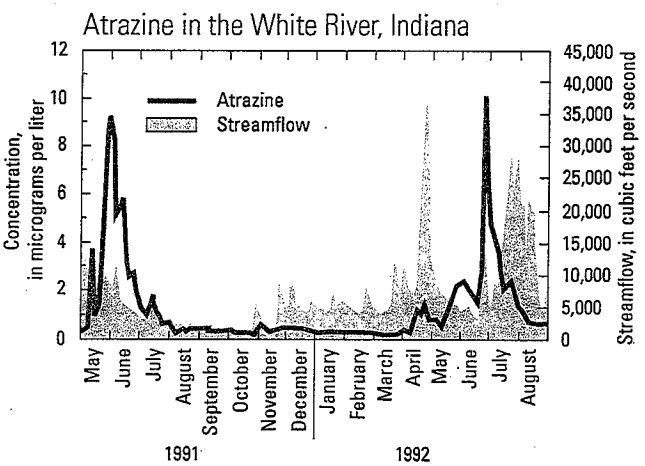

Figure 2–6. Atrazine concentrations in the White River (White River Basin) rose rapidly and peaked during the first runoff events that occurred soon after spring applications of atrazine in May and June. High runoff and streamflow either before or substantially after the high-use period typically did not result in similarly high concentrations (Carter and others, 1995).

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to suspended particles and be deposited in bed sediment, or volatilize to the atmosphere—all resulting in losses of the parent compound from stream water. Model calculations by Capel and others (2001) for 39 high-use pesticides indicated that transformations are the dominant cause of pesticide losses from streams, accounting for most of the predicted losses for 27 of the 39 compounds, compared with 4 pesticides lost mostly by volatilization, and 8 pesticides lost by multiple processes.

Ground Water

Pesticides reach ground water primarily in water that infiltrates the soil and passes through the underlying unsaturated zone to the water table. As with streams, most pesticide transport to ground water is driven by rainfall or irrigation when one or both result in ground-water recharge. Ground-water transport is different from transport in streams because only dissolved forms of pesticides and their degradates move substantial distances with ground water. Particle-bound compounds are largely retained by soil and aquifer materials. In addition, transport of pesticide compounds to and within ground water is much less predictable than transport in streams because the flow of ground water is considerably slower and more complex than the flow of stream water.

Pesticides and their degradates can move readily to ground water through mobile zones, such as cracks, worm holes, or permeable sediments, but a portion of pesticide compounds is retained in immobile zones within the subsurface where flow is minimal. Pesticide compounds that are retained in immobile zones can be released gradually to ground water by diffusion and subsequent leaching, sometimes long after application. Much as a soap-filled sponge must be repeatedly rinsed and wrung before all of the soap is removed, the soil acts as a reservoir from which pesticides and their degradates continue to leach after application. As a result, pesticides may be found in ground water much sooner than expected after application (because of rapid movement through mobile zones), as well as for extended periods afterward (because of gradual release from immobile zones).

Pesticides generally are detected most frequently in ground water where the permeability of the soil and the hydraulic conductivity of the aquifer are highest, allowing relatively rapid transport. Deep aquifers usually have less pesticide contamination than shallow ground water because: (1) it takes a long time—decades or more, in many cases—for water to move from the land surface to deep ground water (resulting in long residence times for ground water and any solutes it may contain); (2) long travel distances increase the likelihood that pesticides will transform or attach to aquifer materials; (3) protective, low-permeability deposits (which inhibit flow and transport) may be present between the land surface and deep aquifers; and (4) the mixing of water from complex flow paths over long distances and time periods tends to result in a mixture of land-use influences on the quality of deep ground waters, commonly including contributions from areas of undeveloped land.

Influence of Pesticide Properties on Environmental Behavior

The occurrence and transport of pesticides in the environment are strongly influenced by the chemical and physical properties that affect their persistence and partitioning. Persistence refers to the tendency of a compound to remain in its original chemical form in the environment. Partitioning is the process by which pesticides become distributed among different environmental media, such as water, sediment, biota, and air, generally resulting in higher concentrations in some media than in others.

Pesticides with high persistence remain in their original chemical form in the environment for long periods, whereas those with low persistence rapidly transform following their release. Transformations proceed at widely varying rates, depending on the structure of the compound and environmental conditions (Barbash, 2004). As a result, the persistence of a pesticide—which is commonly expressed in terms of a half-life for transformation (the amount of time that it takes for half of the compound to transform)—can vary from hours to decades. Some transformations of pesticides in the hydrologic system result in degradates whose chemical properties, toxicities, and ultimate fate are not well known, although much information on the properties of major degradates has begun to emerge in recent years as part of pesticide registration studies in the United States and Europe (Sinclair and Boxall, 2003). Generally, persistent pesticides or degradates may be transported for long distances or accumulate in soils, sediment, or biota. In some cases—as with several of the historically used organochlorine pesticides—both long-distance transport and accumulation have been observed.

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The tendency of a pesticide or degradate to partition into water, sediment, or other media determines where it is most likely to be detected in the environment, and how it is transported through the hydrologic system. Two of the parameters used most often to describe the partitioning of a compound among environmental media are (1) the Henry's law constant (K_H), which describes partitioning between air and water, and (2) the soil organic carbon-water partition coefficient (K_{oc}), which describes partitioning between water and the organic matter in soil or sediment. Values of K_H and K_{oc} for the pesticides and degradates that were detected most frequently in NAWQA studies are provided in Appendix 2. These values were compiled from a variety of sources, including the U.S. Environmental Protection Agency (USEPA) and the U.S. Department of Agriculture (USDA). A pesticide with a high K_H is volatile and thus, primarily tends to reside in and be transported by air. As a result, such compounds are rarely retained for long in streams or soil, but if they reach ground water, these compounds may remain for substantial periods of time because there is comparatively little exposure to the atmosphere. A pesticide with a high K_{oc} has a greater tendency to accumulate in soil or sediment than to remain dissolved in water. Because they associate more strongly with organic matter than with water, pesticides with high K_{oc} values are sometimes referred to as hydrophobic. Compounds with low K_{oc} values (which therefore tend to favor water over organic matter) are described as hydrophilic. As a result of their affinity for organic matter, the more persistent hydrophobic pesticides are likely to accumulate not only in soils and sediments, but also in fish, birds, mammals, and other biota (Nowell and others, 1999).

Understanding the factors that affect the persistence of a pesticide and its occurrence in different environmental media is key to evaluating and anticipating its potential effects on water quality. For example, atrazine, which moves readily with water and is relatively persistent, reached streams in 10 times greater proportions than EPTC, which is less persistent, more volatile, and, unlike atrazine, usually incorporated into the soil when applied. Nationally, an average of about 1 percent of the atrazine applied to the land in watersheds of sampled streams reached its associated stream outlet, as opposed to only about 0.1 percent for EPTC (fig. 2–7) (Larson and others, 1999; Capel and others, 2001). Similarly, NAWQA data from agricultural areas across the Nation indicate that pesticides with

Pesticides with high K_{OC} values attach to sediment particles and are transported during runoff events when suspended-sediment concentrations are high.

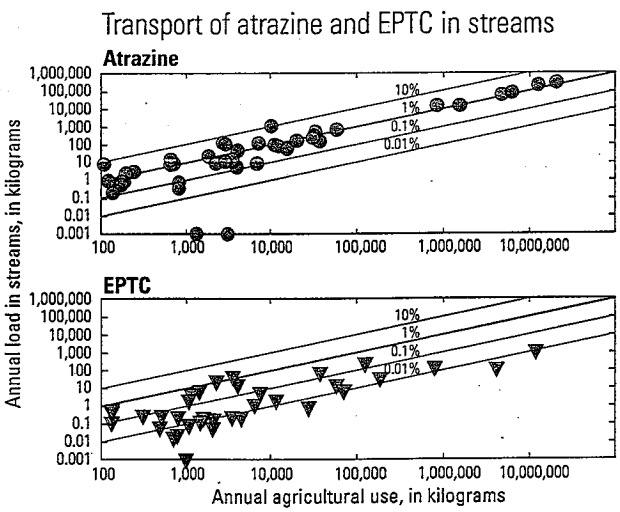

Figure 2–7. The annual transport of atrazine in streams was typically equivalent to about 1 percent of the amount applied in a particular watershed (percentages are shown by diagonal lines), whereas annual transport of EPTC in streams, which is less persistent and more volatile than atrazine, was less than 0.1 percent of annual use for more than half of the sites (Larson and others, 1999).

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greater persistence in soil are more likely to be detected in shallow ground water than compounds that are less persistent (Barbash and others, 1999). For example, within areas of relatively equal use, atrazine (soil half-life of 146 days) was detected in shallow ground water much more frequently than the less persistent metolachlor (soil half-life of 26 days) (fig. 2–8).

The effects of chemical and physical properties on the environmental behavior of pesticides were also illustrated by the differences between hydrophobic and hydrophilic pesticides in their transport within streams of the Yakima River Basin. Hydrophobic pesticides ($K_{oc} \geq 300$ milliliters per gram, mL/g) were found to be most readily transported in basins dominated by rill irrigation—a management practice that involves distributing large volumes of water across the land surface, and which often causes soil erosion (fig. 2–9). In contrast, annual loads of hydrophilic pesticides ($K_{oc} < 300$ mL/g) were not affected by the extent of rill irrigation because the compounds are, for the most part, transported in the water rather than in suspended sediment (Fuhrer and others, 2004).

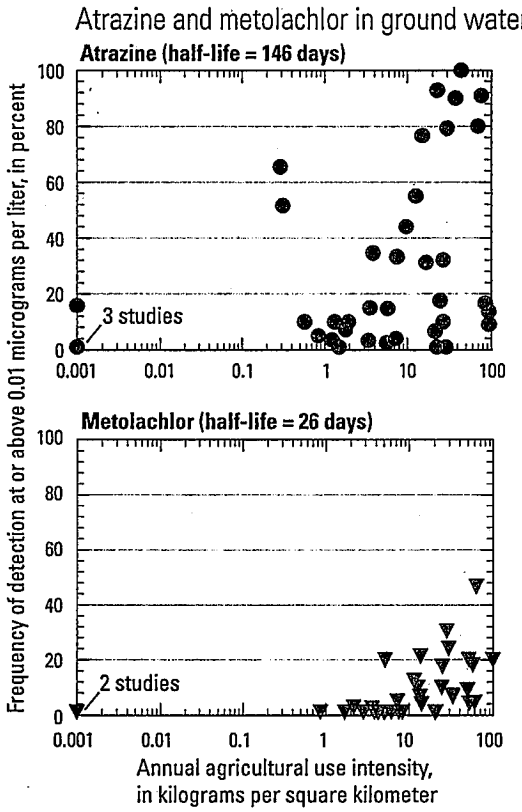

Figure 2–8. Frequencies of detection in shallow ground water beneath agricultural areas were usually greater for atrazine than for metolachlor given equivalent annual use rates, in part because of the greater persistence of atrazine in soil (Barbash and others, 1999).

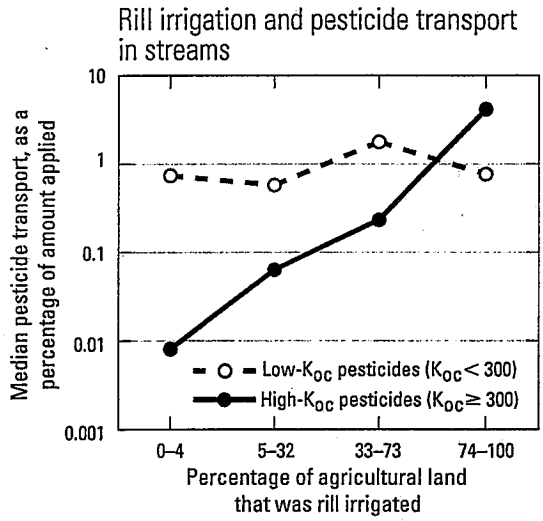

Figure 2–9. In the Yakima River Basin, transport of pesticides with high K_{oc} values (high affinity for soil particles) was greater in streams draining larger proportions of farmland that was rill irrigated, a practice that results in soil erosion. In contrast, the amount of rill irrigation had little effect on low-K_{oc} pesticides, which have lower affinities for soil particles and are not as affected by soil erosion. (modified from Fuhrer and others, 2004.)

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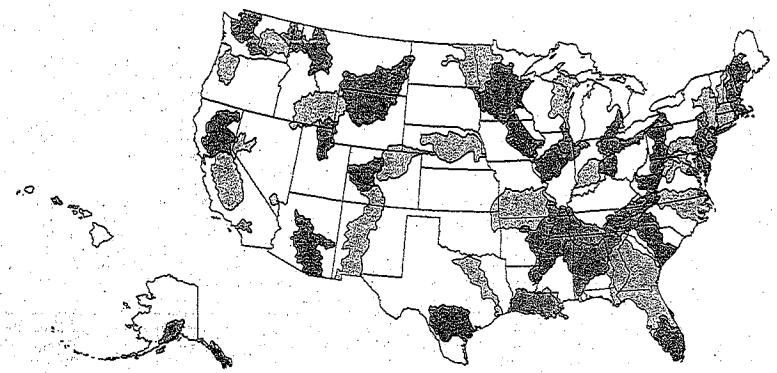
3 NAWQA's Approach to Pesticide Assessment

NAWQA's assessment of pesticides during 1992–2001 provides the most comprehensive analysis to date of pesticide occurrence in streams and ground water of the United States. The assessment followed a national study design in which the most important hydrologic systems were studied on a rotational schedule using nationally consistent sampling and analytical methods. This approach yields an understanding of water-quality conditions in a national context, while also supporting comparisons and assessments within and among individual watersheds, aquifers, and geographic regions. By systematically relating pesticide occurrence and transport to key factors that control contamination—such as pesticide use and properties, land use, hydrology, and other environmental features—NAWQA provides information needed for managing pesticides within the Nation's diverse land-use and environmental settings.



This chapter summarizes the primary features of the NAWQA study design, providing the context for understanding findings about pesticides in the Nation's streams and ground water.

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Targeted Sampling Across the Nation's Diverse Land Uses and Environmental Settings

This report is based on results from NAWQA's first decade of water-quality assessments, which were completed on a rotational schedule from 1992 to 2001 in 51 major hydrologic systems across the country—referred to as Study Units—as well as the High Plains Regional Ground Water Study, using a nationally consistent study design (see p. iv–v). Assessments were conducted in 20 Study Units during 1992–1995; in 16 during 1996–1998; and in 15 Study Units during 1998–2001. Collectively, the 51 NAWQA Study Units and the High Plains Study cover a substantial portion of the Nation's land area; account for more than 70 percent of total water use and more than 50 percent of the population served by public water supplies and domestic wells; and are representative of the Nation's diverse landscapes, hydrologic systems, ecological resources, and land uses.

The primary objectives of the NAWQA pesticide assessment were to determine: (1) the occurrence and concentrations of pesticides in streams (ranging from small streams to large rivers) and ground water; (2) where and when pesticides occur in relation to factors that govern their sources and transport in the hydrologic system; (3) whether any pesticides may be present at concentrations that could affect human health, aquatic life, or fish-eating wildlife; and (4) how concentrations are changing over time.

To address these goals, NAWQA employed a targeted assessment focusing on studies of:

- streams and shallow ground water in specific, relatively homogeneous land-use and environmental settings to relate pesticide occurrence to individual types of nonpoint sources; and
- streams and major aquifers (regionally extensive aquifers that are important ground-water resources for water supply) in areas of mixed land uses to evaluate the integrated effects of multiple sources of pesticides on their occurrence and concentrations.

Details on the sampling design and analytical methods, as well as all data used in this report are available at: *http://ca.water.wr.usgs.gov/pnsp/pubs/circ1291/.*

For the targeted assessment by land use, streams and shallow ground water were sampled in agricultural and urban areas, and in undeveloped areas dominated by forest or rangeland. As described in more detail below and in the accompanying sidebar, streams and ground water were sampled most intensively in agricultural and urban areas because of the importance of assessing pesticide occurrence in areas where the compounds are used most intensively. The agricultural areas are diverse in climate, geography, and crop types, and span coastal, desert, and temperate environmental settings. They include, for example, areas dominated by production of corn and soybeans in the Midwest; wheat and other grains in the Great Plains; mixed row crops and poultry in the East; rangeland in the Southwest; rice in Louisiana; pineapple in Hawaii; and areas of grain, fruits and nuts, vegetables, and specialty crops in California and the Pacific Northwest. The areas sampled in urban settings were primarily residential, typically with low-to-medium population densities (300 to 5,600 people per square mile). Some commercial or industrial areas also were included, but point sources and extensive industrial and downtown urban areas generally were not assessed.

Table 3–1. Each stream sampled by NAWQA was classified according to the dominant land uses in its watershed. The land-use data set used for these classifications was an enhanced version of the USGS 1992 National Land Cover Data (NLCD), which classified land use for each 30-by-30-meter area of land in the conterminous United States. The original and enhanced versions of the NLCD are described, respectively, by Vogelmann and others (2001) and Nakagaki and Wolock (2005).

Land-use classification	Watershed land-use criteria
Agricultural	> 50 percent agricultural land and ≤ 5 percent urban land
Urban	> 25 percent urban land and ≤ 25 percent agricultural land
Undeveloped	≤ 5 percent urban land and ≤ 25 percent agricultural land
Mixed	All other combinations of urban, agricultural, and undeveloped land

NAWQA Stream Assessment in a National Context

Potential land-use influences on the quality of water sampled at NAWQA stream sites were characterized by determining the proportions of each major land use within each stream's contributing watershed. Table 3–1 lists the criteria used by NAWQA to classify each stream sampling site by its predominant land-use category. Streams classified as "mixed land use" drain mixtures of

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Unique Features of the NAWQA Approach

Water-quality assessments by NAWQA, which is a single program among many local, State, and Federal programs, were not designed to address all of the Nation's water-resource information needs and issues. Listed below are several characteristics and limitations of the NAWQA approach that are important to consider when interpreting the findings on pesticides presented in this report.

- NAWQA assessments characterized the quality of the available, untreated water resources, and not the quality of drinking water (as would be done by monitoring water from water-treatment plants or from household taps). By focusing on the quality of streams and ground water in their present condition (ambient water quality), NAWQA complements many Federal, State, and local drinking-water monitoring programs.
- NAWQA assessments did not focus on specific sites with known water-quality problems or narrowly defined "issues of the day," but rather on the condition of the total resource, including streams and ground water in a wide range of hydrologic and land-use settings across the country.
- NAWQA assessments of pesticides focused primarily on non-point sources resulting from applications for pest management in agricultural, urban, and other land-use settings, although some sites—particularly those downstream from major metropolitan areas—also may be influenced by point sources, such as discharges from wastewater treatment plants.
- NAWQA assessments targeted specific land-use settings that are most extensive or important to water quality in a wide range of hydrologic and environmental settings across the Nation. This targeted approach gives priority to understanding the most critical factors influencing water quality. Extension of results to national analysis, however, requires careful definition of each type of water resource and environmental setting for which conclusions are drawn and the use of statistical models to extrapolate results to resources that have not been measured.
- USGS analytical methods were designed to measure concentrations as low as economically and technically feasible. Studies of contaminant occurrence and behavior benefit from the most information possible at all concentration levels, and such data help to identify emerging issues and to track changes in concentrations over time. By this approach, however, pesticides were commonly detected at concentrations far below Federal or State standards and guidelines for protecting water quality. Detections of pesticides do not necessarily indicate that there are appreciable risks to human health, aquatic life, or wildlife. The potential for such risks must be assessed by comparing measured concentrations with those that may cause adverse effects.
- USGS methods for analyzing pesticides in water measured concentrations in filtered water samples and, thus, may underestimate concentrations of compounds that have strong affinities for suspended particles. The potential for underestimation is greater for stream water compared with ground water because of the generally greater amounts of suspended particles present in stream water—which are removed by filtration along with any pesticides contained in or on the particles.
- Pesticide compounds analyzed in water by NAWQA included many of the most heavily used herbicides and insecticides, but they included only a fraction of all pesticides currently in use and few of their degradates. NAWQA findings provide insights about what to expect for pesticides and degradates that were not measured, but must be considered as only a partial assessment of currently used pesticides.
- Organochlorine pesticide compounds analyzed by NAWQA in bed sediment and fish tissue are predominantly related to pesticides that were no longer in use by 1990. Of the pesticide compounds measured in bed sediment and fish tissue, only dacthal, endosulfan, lindane, methoxychlor, and permethrin were used during all or part of the study period.

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two or more land-use settings and do not meet the criteria described in table 3–1 for individual agricultural, urban, or undeveloped settings. Land-use classifications were adjusted for a small number of streams that have watersheds with substantial areas that did not contribute streamflow during the study period. Most streams that were classified as agricultural, urban, or undeveloped also commonly have small amounts of other land uses in their watersheds. For example, and of particular importance to findings for pesticides, many streams classified as undeveloped have some agricultural or urban activity in their watersheds.

Consistent with the sampling design, which was targeted by land use, the NAWQA pesticide findings discussed in this report generally are presented by land-use category. Aggregation of NAWQA findings for streams across all land-use categories would not accurately represent all streams in the conterminous United States (fig. 3–1), which were characterized by classifying the watersheds of all stream segments in the USEPA river reach file (Nolan and others, 2003) using NAWQA land-use criteria (table 3–1). For example, nearly 40 percent of the streams sampled by NAWQA were agricultural streams, whereas agricultural streams represent about 15 percent of all streams in the conterminous United States. Furthermore, as shown in figure 3–1, agricultural streams represent only about 10 percent of all streams with public water-supply intakes. There are 1,679 public water-supply intakes on streams across the Nation for which land use could be characterized. The NAWQA design also over-represented urban streams and under-represented undeveloped streams compared with the national occurrence of streams in these land-use settings (fig. 3–1).

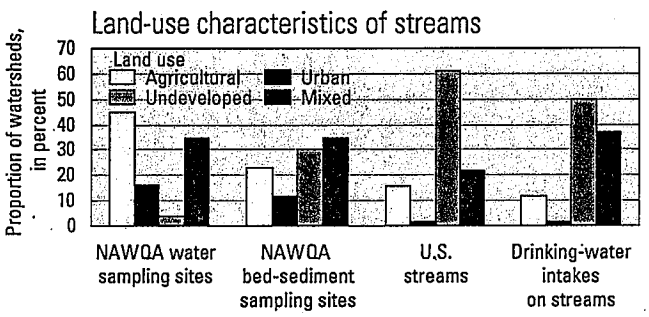

Figure 3–1. The NAWQA design for stream assessments placed greater emphasis on sampling streams that drain agricultural and urban watersheds (as defined in table 3–1), relative to those in undeveloped watersheds. Streams sampled by NAWQA included higher proportions of agricultural and urban streams—and lower proportions of undeveloped streams—compared with all streams in the conterminous United States and those with drinking-water intakes.

Even when grouped by land-use category, the watersheds of NAWQA sampling sites that were classified as agricultural and urban still tend to have higher proportions of agricultural and urban land than most streams nationwide in the same land-use groups, as well as streams with public water-supply intakes in the same land-use groups. For example, about 25 percent of agricultural streams sampled by NAWQA had watersheds with more than 90 percent agricultural land, compared with about 18 percent of all agricultural streams in the United States with more than 90 percent agricultural land. This indicates that NAWQA estimates of pesticide occurrence for agricultural and urban streams (for water and, to a lesser degree, bed sediment) are likely, as groups, to be high relative to those for other streams nationwide in these same land-use classes.

NAWQA Ground-Water Assessment in a National Context

NAWQA assessed pesticides in ground-water within specific land-use settings and in major aquifers with influences of a mixture of land uses. Land-use studies focused on shallow ground water primarily within agricultural and urban land-use settings, and to a lesser extent in undeveloped areas. Each of these studies involved the sampling of about 20 to 30 randomly located wells (using either existing or newly installed wells) within each targeted land-use area. Most of the wells selected or installed for the land-use studies sampled ground water from less than 20 feet below the water table, thus indicating as directly as possible the influence of each land use on shallow ground-water quality.

Major aquifer studies involved the sampling of about 20 to 30 domestic or public-supply wells that withdraw water from aquifers or aquifer systems that are major current or future sources of water supply. Wells that were sampled for these studies were randomly selected throughout the areas underlain by each major aquifer, without regard to land use. Thus, the ground water sampled for the major aquifer studies reflects the effects of a mixture of different land uses and ground-water ages on water quality, often including water that recharged long distances

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from the sampled wells and in a variety of different land-use settings. The nature and extent of each major aquifer sampled for these studies is described in the summary report for the NAWQA Study Unit in which it occurs (see *http://water.usgs.gov/nawqa/*).

NAWQA findings for ground water, as for streams, are grouped by land use in this report. NAWQA's targeted sampling design for ground water over-represented areas with urban and mixed land use, somewhat over-represented agricultural areas, and under-represented undeveloped areas when compared with the national distribution of these land-use settings by land area (fig. 3–2). Comparisons of land-use distributions for the NAWQA ground-water studies with those for the entire Nation were based on NAWQA land-use classifications (as defined in table 3–1) for every square kilometer in the conterminous United States. Although NAWQA agricultural and urban stream sites, as discussed above, tend to have greater proportions of agricultural and urban land in their watersheds than other streams in the same land-use groups, ground-water studies are not expected to have this tendency within these land-use groups because each well was selected by site-specific land-use criteria designed to meet the land-use objective for each study. Such site-specific control of land-use characteristics was not possible for streams because of the relatively large areas included in each watershed.

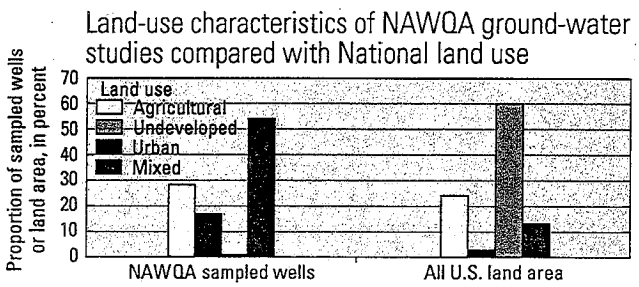
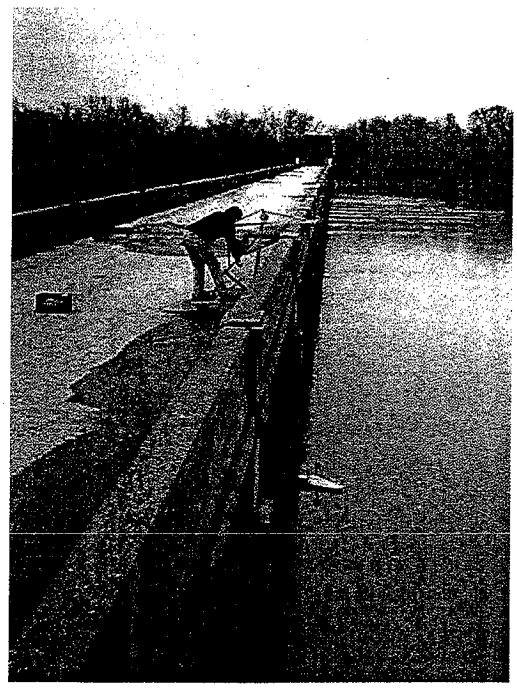


Figure 3–2. NAWQA's targeted sampling design for ground water emphasized areas with urban, mixed, and agricultural land use—and under-represented undeveloped areas—when compared with the national distribution of land uses. All wells sampled for major aquifer studies were classified as mixed land use for this graph.



Large streams and rivers required sampling from bridges, boats, or cableways.

Most wells sampled for major aquifer studies were existing water-supply wells.

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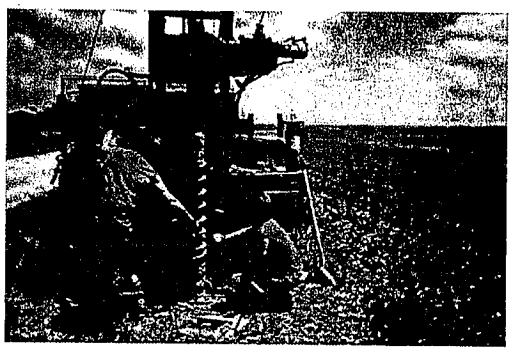
Sampling Design

The NAWQA national assessment of pesticides is based on results from the analysis of more than 10,000 samples of water, bed sediment, and fish tissue from thousands of locations within the 51 NAWQA Study Units. Water-soluble pesticides, most of which were in use during the study period, were assessed in stream water and ground water. Organochlorine pesticides, which are no longer used in the United States, but remain persistent in the environment, were assessed in bed sediment and fish tissue—environmental media in which they accumulate.



Most wells sampled for agricultural and urban land-use studies were observation wells installed by NAWQA.

Stream Water

Water samples were collected at 186 stream sites for analysis of pesticides and degradates dissolved in water (fig. 3–3). The samples were collected from streams throughout the year, including high-flow and low-flow conditions. Sampling was most intensive during the time of highest pesticide use and runoff—generally weekly or twice monthly for a 4- to 9-month period. Most analyses in this report are based on 1 year of data for each site (generally representing the single most complete year of sampling) to give equal influence to each stream. Because of the rotational assessment approach, the most complete year of sampling for each stream ranged from 1993 to 2000, depending on the particular site.

Bed Sediment and Fish

Samples of bed sediment were collected at 1,052 sites (fig. 3–3) and fish-tissue samples were collected at 607 of the bed-sediment sites (plus 93 additional sites not shown on the map) for analysis of organochlorine pesticides and selected degradates and by-products. At each site, fine-grained surficial bed sediment (sieved to < 2 millimeters [mm]) was collected from multiple depositional areas within a stream reach on a single date—usually during low-flow conditions—and combined into a single composite sample for chemical analyses. For fish, multiple individuals of the same species were collected at a site, also on a single date, and whole fish were composited for chemical analyses of tissue.

Ground Water

Water samples were collected from 5,047 wells in 187 land-use and major aquifer studies for analysis of pesticides and degradates dissolved in water (fig. 3–3). For the land-use studies, most of the wells sampled were new or existing observation wells or domestic supply wells. The major aquifer studies focused almost exclusively on existing wells used either for domestic or public supply. Repeated sampling, such as that conducted at stream sites, was not included for ground water because of the comparatively slow rate of change in most ground-water systems, relative to streams. Data analyses were based on one sample per well.

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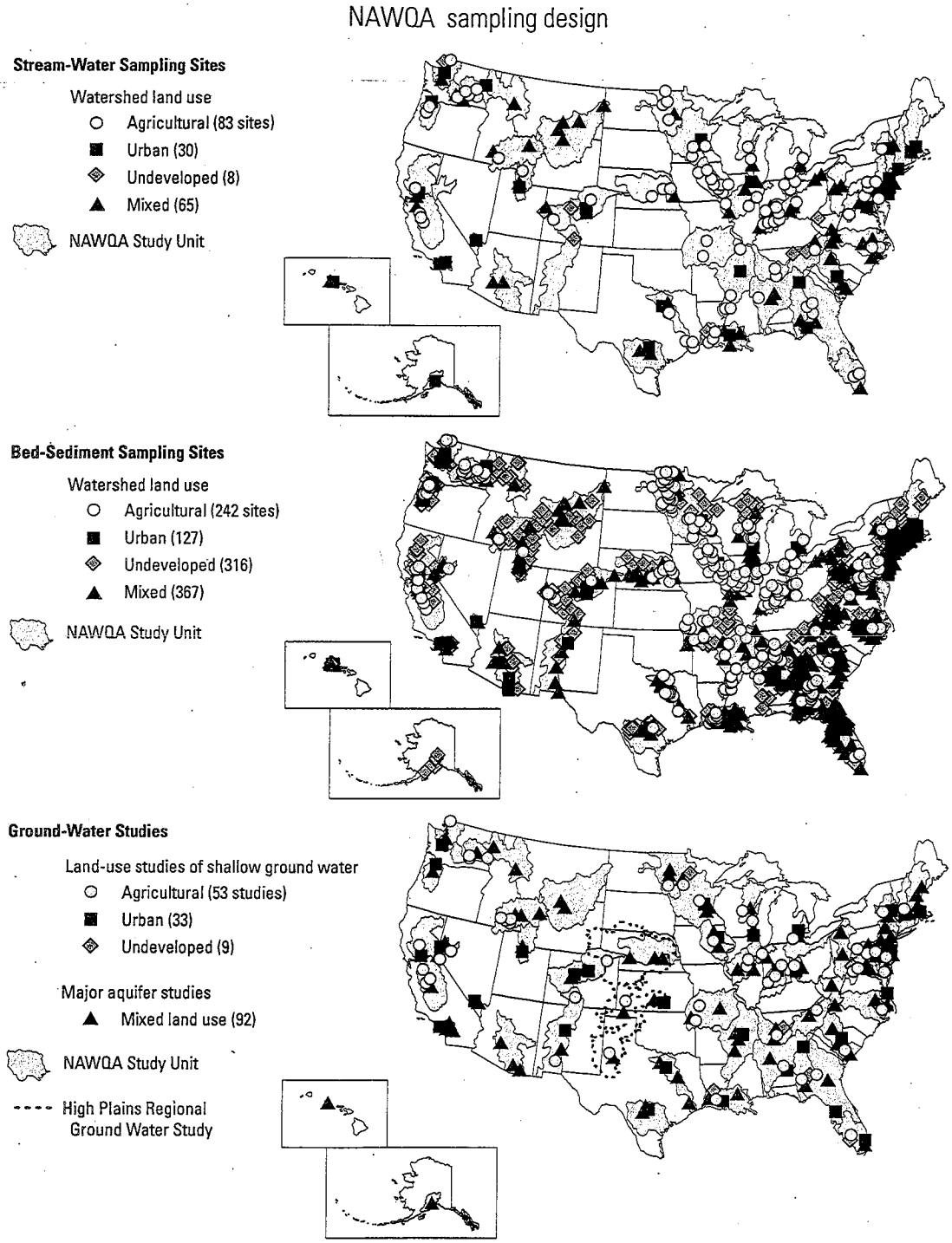

Figure 3–3. Stream sampling sites and ground-water studies in agricultural, urban, and undeveloped areas were distributed across the Nation's diverse environmental settings to evaluate the occurrence of pesticides within areas of specific land uses. Pesticides also were assessed in streams and major aquifers that represent the water-quality effects of mixed land uses and varied environmental settings.

A012035

Chemical Analyses

NAWQA chemical analyses encompassed the most complete range of pesticides ever measured in a single assessment, and included many of the Nation's most heavily used pesticides (Appendix 1). Most NAWQA water samples were analyzed for 75 pesticides and 8 pesticide degradates, which during the study period accounted for about 78 percent of the Nation's agricultural use of conventional pesticides, by weight of active ingredient (fig. 3–4). The analytical strategy resulted in relatively thorough coverage of the major herbicides and insecticides in use for agricultural purposes during the period of study, including 20 of the 25 most heavily used herbicides and 16 of the 25 most heavily used insecticides (fig. 3–5). All water samples were filtered prior to analysis. As a result, reported pesticide concentrations, particularly in stream water, may underestimate concentrations of some compounds that have

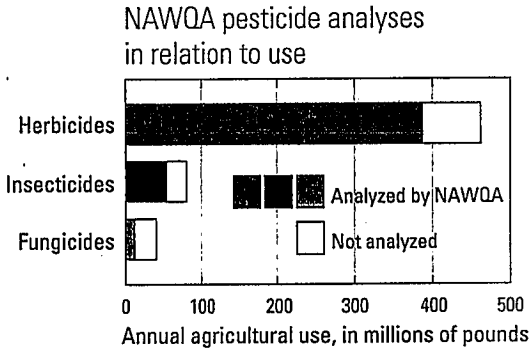

Figure 3–4. The NAWQA analytical strategy for water samples included 75 pesticides that accounted for about 78 percent of total national agricultural use during the study period, with relatively thorough coverage of the major herbicides and insecticides, but sparse coverage of fungicides, fumigants, and nematicides. (Use estimates are for 1997, as reported by Gianessi and Marcelli, 2000.)

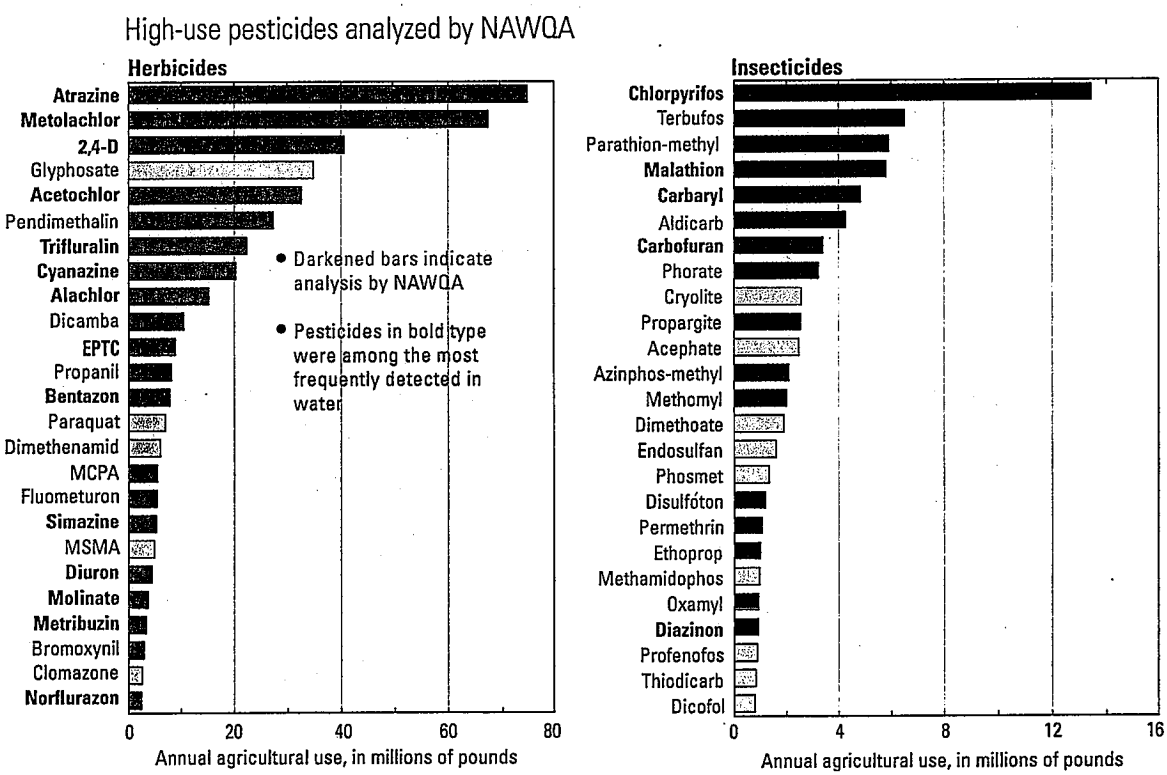

Figure 3–5. The NAWQA analytical strategy for water samples included 20 of the 25 most heavily used herbicides and 16 of the 25 most heavily used insecticides during the study period. More than half of these 36 high-use pesticides included in NAWQA analyses (dark bars) were among those most frequently detected in water (bold type), as described in Chapter 4. Some high-use pesticides, such as glyphosate, were omitted because no suitable analytical method was available, or because of budget constraints. (Use estimates are for 1997, as reported by Gianessi and Marcelli, 2000.)

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strong affinities for suspended particles because of removal by filtration.

Historically used organochlorine insecticides (such as DDT) and selected degradates and by-products were analyzed in bed sediment and fish tissue—environmental media in which they continue to persist long after the uses of the parent compounds were discontinued in the United States. Bed-sediment and fish-tissue samples were analyzed for up to 32 pesticide compounds, consisting of 19 parent pesticides and 13 degradates and by-products. Results for organochlorines are sometimes described for pesticide groups (such as "total DDT") because all compounds in the group are derived either from common parent pesticides (for example, the isomers p,p′-DDD and p,p′-DDE are degradates of p,p′-DDT), or from indistinguishable pesticide products (for example, dieldrin may originate from application of dieldrin or or as a degradate of aldrin). Pesticide groups are identified and defined in Appendix 1B. Together, the organochlorine pesticides examined by NAWQA account for more than 90 percent of the Nation's historical use (by weight) of organochlorine pesticides in agriculture.

Some pesticides and degradates were assessed only in selected study areas or for limited periods of time. For example, several degradates of alachlor and metolachlor were measured at selected sites in different parts of the Nation, including streams draining parts of the Great and Little Miami River Basins, where use of the parent pesticides was high. Some pesticides were included in newly developed analytical methods late in the study period and were examined only in selected high-use areas, as was the case for fipronil in the Acadian–Pontchartrain Drainages. These and other pesticides with limited data are described for selected case studies in this report, but are not included in the national analysis.

Pesticides Not Assessed

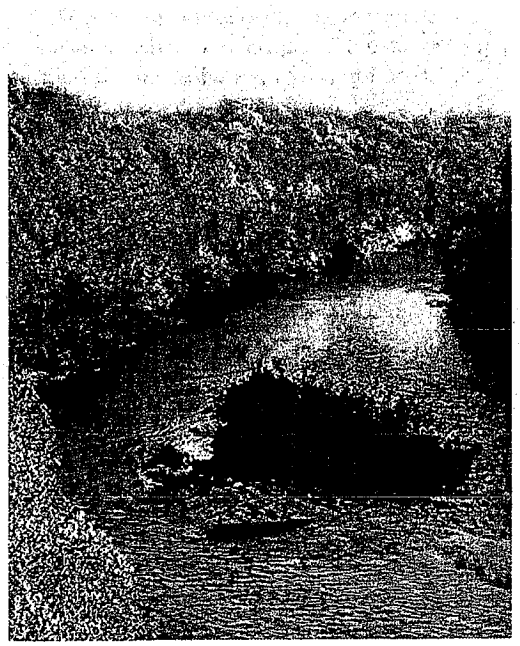
Many potentially important pesticides and degradates were not assessed because of limited analytical methods or budget constraints. For example, glyphosate, the pesticide that ranked fourth among the top 10 herbicides used in 1997, was not routinely analyzed because its chemical structure and properties require analytical methods that are different from NAWQA methods, which were designed to cost-effectively measure large suites of compounds simultaneously. As a result, a separate method was developed for glyphosate and it was added as an analyte in selected studies late in the study period. Similarly, cryolite—an inorganic insecticide used on grapes and that ranked ninth among the top 10 insecticides used in 1997—was also not routinely analyzed in NAWQA samples. Of all the fungicides used, only chlorothalonil (ranked highest in use among fungicides) was included, and there were no nationally consistent analyses of any fumigants or nematicides. Other pesticide compounds that were not assessed by NAWQA include other inorganic pesticides (such as sulfur and copper), oil, biological pesticides, and numerous pesticide degradates, manufacturing by-products, and adjuvants.

Although NAWQA included the broadest and most complete range of pesticides measured in a single national assessment, it still must be considered selective. Consequently, NAWQA results should be expected to underestimate the overall occurrence of pesticides and degradates in many of the hydrologic systems that were studied.

A012037

Occurrence and Distribution in Streams and Ground Water

Pesticides were found at detectable concentrations in streams and ground water within most areas sampled that have substantial agricultural or urban land uses. Pesticides were detected in almost every water sample from streams, but were less common in ground water. Organochlorine pesticide compounds were detectable in fish andwom most streams, despite the fact that most of the parent pesticides have not been used in the United States for years. Although more than 100 pesticide compounds were analyzed in water, fish, or sediment, less than 40 of these compounds accounted for most of the detections. The distributions of the most prevalent pesticides in streams and ground water largely follow geographic patterns in land use and associated present or past pesticide use.



Photograph by Eric Hatch Photography, Loveland, Ohio

This chapter summarizes NAWQA results from 1992 to 2001, focusing on the pesticides that were most frequently detected in streams and ground water. Pesticide detections are assessed in relation to land use, pesticide use, hydrologic settings, and the properties of the pesticides themselves. More detailed examination of seasonal patterns, pesticide mixtures, and degradates is included in Chapters 5 and 6. Screening-level assessment of the potential significance of pesticides to human health, aquatic life, and wildlife is provided in Chapter 8.

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Overview of Pesticide Occurrence

NAWQA results show that pesticides occurred at detectable concentrations in streams and ground water within most areas that have substantial agricultural or urban land uses. These findings build upon an extensive body of previous research, demonstrating that pesticides and their degradates are present in ground water (for example, Barbash and Resek, 1996; Kolpin and others, 1996), surface waters (for example, Larson and others, 1997; Battaglin and others, 2003), and stream sediments and aquatic biota (for example, Nowell and others, 1999; Seiler and others, 2003) in a wide variety of hydrologic, ecological, and land-use settings across the United States.

In streams sampled by NAWQA, at least one pesticide or degradate was detected more than 90 percent of the time in water, in more than 80 percent of fish samples, and in more than 50 percent of bed-sediment samples collected during 1992–2001 (fig. 4–1). Pesticides analyzed in water were primarily those that are currently used, whereas those analyzed in fish and sediment were predominantly pesticides (or their degradates and by-products) that are no longer used in the United States, such as DDT and other organochlorine pesticides. Detections in stream water were evaluated on a time-weighted basis and results are expressed as the percentage of time that concentrations were detectable. For both fish tissue and bed sediment, one sample was analyzed per site and detections are expressed as a percentage of samples or sites analyzed. Detectable concentrations occurred in water more than 90 percent of the time for streams draining watersheds with agricultural, urban, and mixed land use. Similarly, organochlorine pesticide compounds were detected in more than 90 percent of fish-tissue samples and in more than 50 percent of bed-sediment samples from streams in watersheds with agricultural, urban, and mixed land use. In water, fish tissue, and bed sediment, detections were the least frequent, but not absent, for streams draining undeveloped watersheds—where pesticide use is lowest.

Pesticides were detected distinctly less often in ground water than in streams (fig. 4–1). Detections in ground water are based on one sample per well. Streams are generally more vulnerable to contamination than ground water because of the direct and relatively rapid overland transport of pesticides that occurs with surface runoff (see Chapter 2). Ground water in most areas is less vulnerable because water infiltrates the land surface and moves slowly through soil and aquifer materials before reaching most wells. This extended travel time allows more opportunities for the concentrations of pesticides in water to

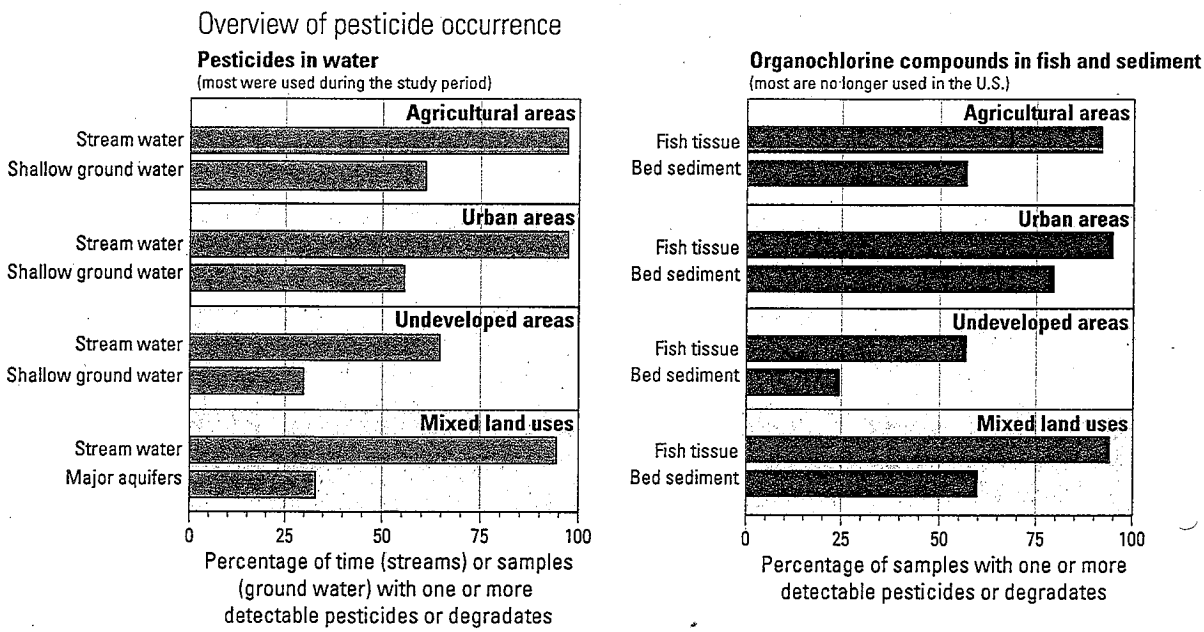

Figure 4–1. Considering all streams sampled across all land uses, one or more pesticides or their degradates were detectable more than 90 percent of the time in water, and were detected in more than 80 percent of fish samples and in more than 50 percent of bed-sediment samples. Less than half of all ground-water samples contained one or more detected pesticides or their degradates, with the most frequent detections occurring in shallow ground water beneath agricultural and urban areas.

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be reduced from the combined action of sorption, dispersion, dilution, and transformation. The slow movement of water and solutes through the subsurface, however, also makes contamination of ground water more difficult to reverse once it occurs. The highest frequencies of detection were in shallow ground water beneath agricultural and urban areas, where almost 60 percent of samples had detections of one or more pesticides or degradates. The lowest frequencies of detection were found in shallow ground water beneath undeveloped areas and in deeper ground water in major aquifers. Samples from major aquifers generally represent older ground water that originated as recharge in areas of mixed land use, sometimes before the current land uses were present.

Pesticides Detected Most Frequently

About 40 pesticide compounds, of the more than 100 examined by NAWQA, accounted for most detections in water, fish, or bed sediment. Understanding the occurrence and distribution of these most prevalent pesticides—both spatially and temporally—in relation to their use and properties, land use, and hydrologic settings is critical for evaluating the potential significance of pesticides to water quality.

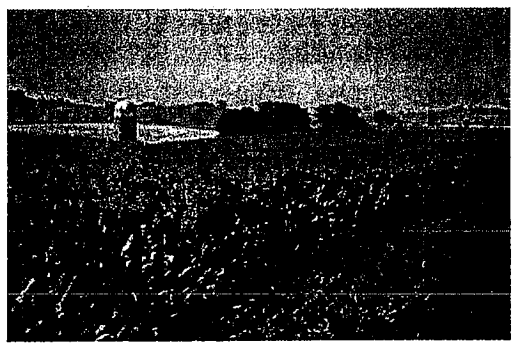
Water

Twenty-five pesticide compounds, including 24 pesticides and 1 degradate, were each detected more than 10 percent of the time in streams in agricultural, urban, or mixed-land-use settings, or in more than 2 percent of wells in agricultural or urban settings (fig. 4–2). These 25 pesticide compounds include 11 of the herbicides used most heavily in agriculture during the study period (plus the atrazine degradate, deethylatrazine)—hereinafter referred to collectively as agricultural herbicides; 7 herbicides used extensively (though not exclusively) for nonagricultural purposes—referred to as urban herbicides; and 6 insecticides used in both agricultural and urban settings, but most intensively in urban settings (fig. 4–3).

The broad patterns of pesticide occurrence in streams generally corresponded to land use and pesticide use. For example, major agricultural herbicides, such as atrazine and metolachlor, were found most often in agricultural settings, whereas herbicides frequently used in urban areas, such as simazine and prometon, were found most often in urban settings. Urban herbicides also were detected in some agricultural areas, either because of agricultural uses (such as for simazine), or their use for nonagricultural weed control (such as for prometon). Insecticides were generally found most often in urban settings where, with the exception of carbofuran, they are used more intensively than in most agricultural settings. Patterns of detection in ground water also generally corresponded with patterns of land use, although not as closely as for streams. For example, atrazine and metolachlor were among the pesticides detected most frequently in both streams and shallow ground water in agricultural areas.

Pesticides were detected least often in streams and shallow ground water in undeveloped areas. The occurrence of atrazine, deethylatrazine, and metolachlor in undeveloped streams was likely caused by one or more of several factors: (1) most undeveloped watersheds include small areas of agricultural or urban land; (2) pesticides are used in many undeveloped areas for a variety of purposes, such as pest control in forest lands or weed control along utility and roadside rights-of-way; and (3) pesticides can be transported in the atmosphere from other areas.

Not surprisingly, the pesticides that were most commonly detected in streams draining watersheds with mixed land use reflected multiple sources from agricultural and urban applications. The overall frequency of pesticide occurrence in mixed-land-use streams was similar to those observed in both agricultural and urban streams. Likewise, the pesticides detected in major aquifers indicate the influences of both agricultural and urban sources, but overall detection frequencies were lower in major aquifers than in shallow ground water in agricultural and urban areas.



The pesticide detected most frequently in streams and ground water was atrazine, an herbicide used to control weeds in corn fields.

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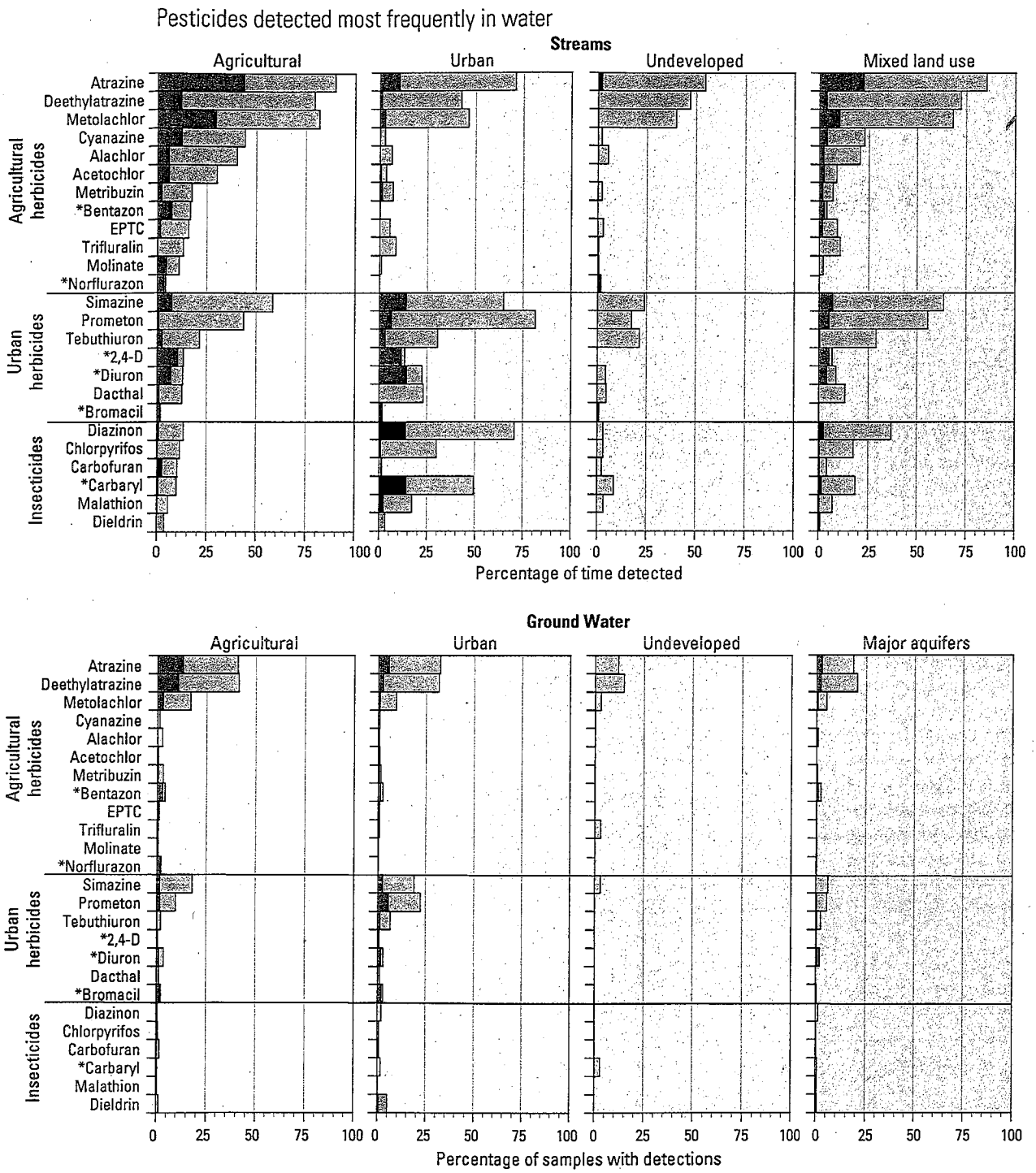

Figure 4–2. Consistent with their patterns of use during the study period, agricultural herbicides—most commonly atrazine (and its degradate deethylatrazine), metolachlor, cyanazine, alachlor, and acetochlor—were detected more frequently in agricultural areas than in urban areas; urban herbicides were found most often in urban areas; and most insecticides, such as diazinon and carbaryl, were detected more frequently in urban streams than in agricultural streams. Two different detection levels are used in this analysis. The dark portion of each bar indicates detections at concentrations greater than or equal to 0.1 µg/L , the light portion indicates detections less than 0.1µg/L*, and the end of each bar is the total for all detections.

*The pesticides 2,4-D, bentazon, bromacil, carbaryl, diuron, and norflurazon could not be detected reliably at concentrations less than 0.1 µg/L; consequently, the reported frequencies below this level for these compounds are minimum estimates.

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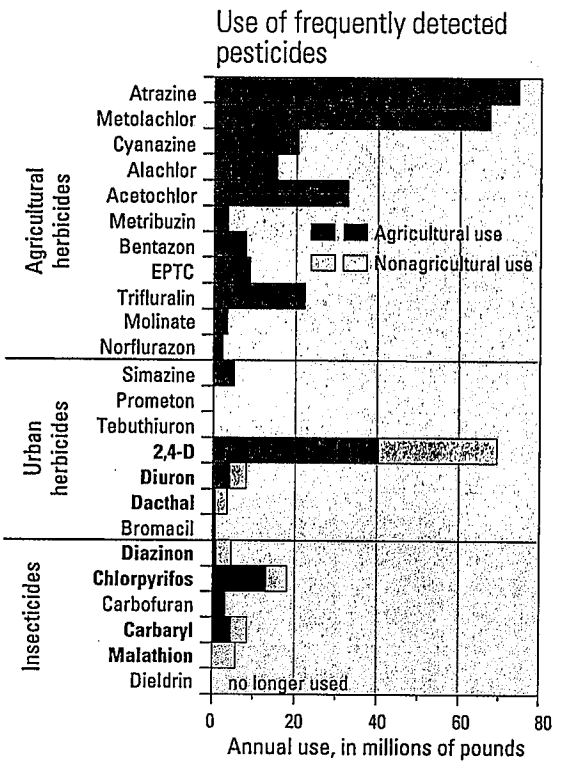

Figure 4–3. The pesticides detected most frequently in water include 11 of the herbicides used most heavily for agriculture during the study period, 7 herbicides used extensively for nonagricultural purposes (mostly in urban areas, but with some agricultural applications), and 6 insecticides. (Agricultural-use estimates are from Gianessi and Marcelli [2000] for 1997; nonagricultural-use estimates are from Kiely and others [2004] for 1999, but were available only for 2,4-D, carbaryl, chlorpyrifos, dacthal, diazinon, diuron, and malathion—indicated by bold type.)

Understanding the Occurrence Assessment

The overview described in this chapter serves as a broad first step toward understanding the distribution and importance of pesticides that were detected in streams and ground water. As explained in Chapter 3, the NAWQA assessment did not include samples from all parts of the Nation or include all pesticides currently used. To provide a national perspective, the occurrence of pesticide compounds in streams and ground water is summarized by land use, environmental medium and component of the hydrologic system sampled, and detection level—all of which have important influences on how results are interpreted.

- **Land use**—Grouping results by land use follows the NAWQA design by combining data from sites expected to have similar influences of land use on water quality (see Chapter 3). Within each general land-use setting, however, there can be substantial variability among sampling sites in specific land-use conditions and pesticide use, as well as hydrologic settings. A pesticide that is common in agricultural streams as a national group, such as a corn herbicide, may never occur in some particular agricultural streams, whereas another pesticide that is uncommon nationally, such as a rice herbicide, may be frequently detected in a few particular streams.

- **Media and hydrologic component sampled**—Grouping results by the different environmental media that were sampled from streams clearly separates organochlorine compounds—which were derived primarily from past use and which, because of their hydrophobic nature, were assessed by their occurrence in fish tissue and bed sediment—from predominantly water-soluble pesticides, most of which were in use during the study period and were measured in water. Grouping results by hydrologic component further distinguishes between streams and ground water for analysis of pesticides in water. The occurrence and concentration results for stream water, unless noted otherwise, were evaluated on a time-weighted basis for each site to eliminate biases caused by more frequent sampling during high-use seasons. Ground-water results are based on one sample per well, and bed-sediment and fish-tissue results are based on one composite sample per site.

- **Detection level**—Analyses of pesticide occurrence in this chapter are based on two different detection levels: (1) detection at any concentration—as low as 0.001 µg/L in water—referred to as total detection frequency, and (2) detections greater than or equal to a common detection level for all compounds in a particular medium—0.1 µg/L for water, 5 micrograms per kilogram (µg/kg) wet weight for fish tissue, and 2 µg/kg dry weight for bed sediment. Two detection levels are necessary for certain data analyses because variations in analytical sensitivity result in differences in minimum detectable concentrations among different compounds. Consequently, direct comparisons of detection frequencies among compounds should be based on a common detection level. For example, of the 25 pesticide compounds most frequently detected in water, 2,4-D, bentazon, bromacil, carbaryl, diuron, and norflurazon could not be reliably detected at concentrations less than about 0.1 µg/L, whereas the other 19 compounds were detectable at levels substantially less than 0.1 µg/L. The reported total detection frequencies of the 6 less-detectable pesticides are thus underestimates of occurrence compared with the total frequencies for the other 19 compounds. Variations in detection sensitivity must be carefully considered when interpreting data on occurrence—the absence of detections does not indicate with certainty that pesticides are not present.

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Fish Tissue and Bed Sediment

Thirteen organochlorine pesticide compounds, including historically used parent pesticides and their degradates and by-products, were each found in more than 10 percent of fish or bed-sediment samples from streams draining watersheds with either agricultural, urban, or mixed land use. Figure 4–4 summarizes findings for these 13 compounds, as well as for 2 additional compounds derived from DDT use—*o,p'*-DDT and its degradate, *o,p'*-DDE, which were detected less frequently than the others. The fish and bed-sediment data for organochlorine compounds provide complementary types of information for understanding the presence of these compounds in streams.

The 15 organochlorine pesticide compounds included in figure 4–4 are derived from 8 parent pesticides. The parent pesticides applied were the insecticides DDT, DDD (also known as TDE), dieldrin, aldrin, chlordane, and heptachlor—each of which had all agricultural and nonagricultural uses cancelled by 1988 or earlier, and the fungicides hexachlorobenzene and pentachlorophenol—most uses of which were discontinued by the mid 1980s or before. DDT and chlordane were applied as technical mixtures containing the parent pesticides and other compounds. For example, technical DDT was typically composed

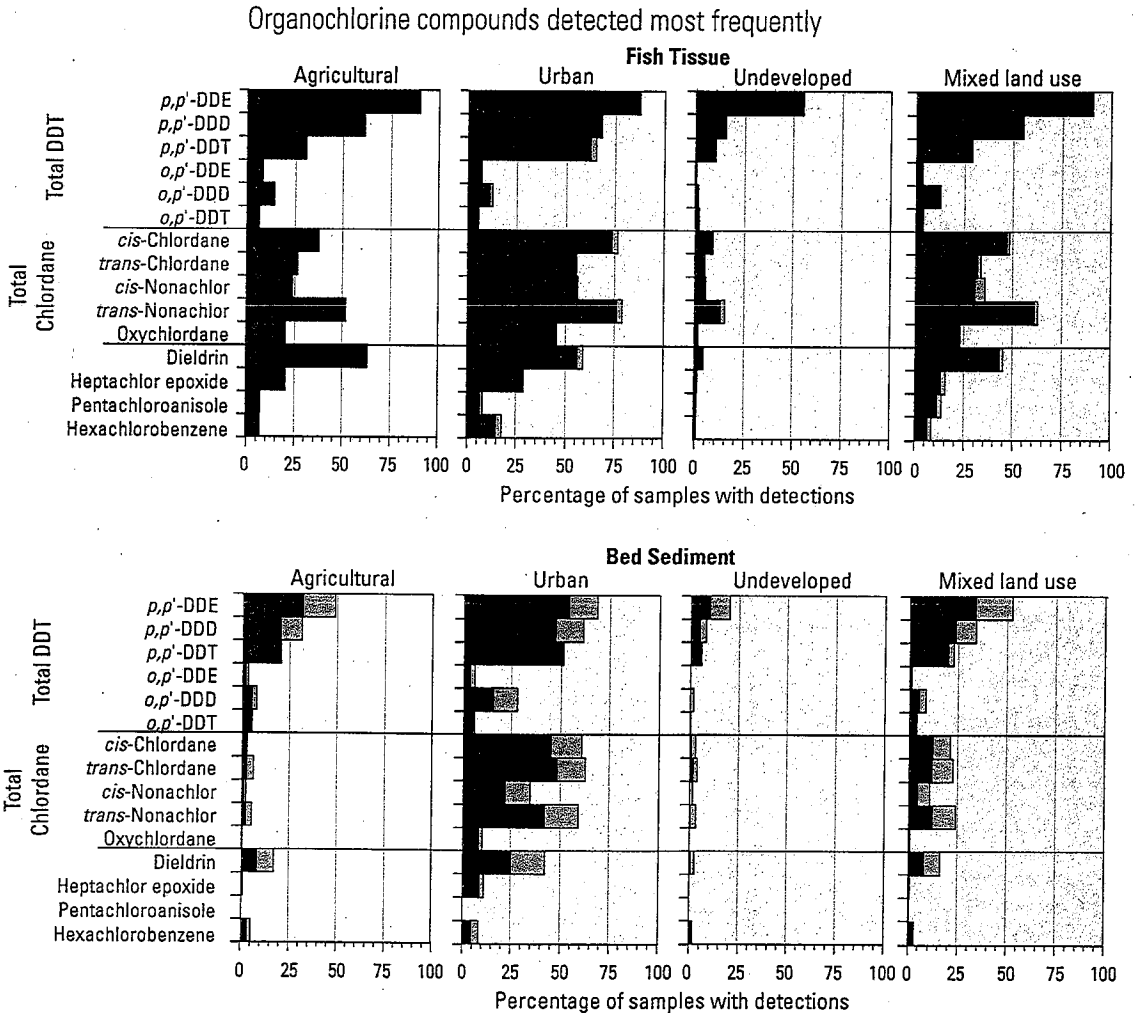

Figure 4–4. Historically used organochlorine pesticides and their degradates were generally detected more frequently in whole fish and bed sediment in urban streams than in agricultural streams, thus matching the pattern found for currently used insecticides in water. DDT and chlordane compounds, as well as dieldrin, were relatively widespread. The dark portion of each bar indicates detections at concentrations greater than or equal to 5 µg/kg (wet weight) for fish tissue and 2 µg/kg (dry weight) for bed sediment, the light portion indicates detections at concentrations less than these levels, and the end of each bar is the total for all detections.

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of about 80 percent *p,p'*-DDT (the active ingredient) and 20 percent *o,p'*-DDT (*o,p'* and *p,p'* indicate different isomers of DDT). Furthermore, in addition to being applied as pesticides, DDD and dieldrin are also formed in the environment from the transformation of DDT and aldrin, respectively. Dieldrin that originated from the application of aldrin could not be distinguished from dieldrin applied as dieldrin. Thus, for the purposes of certain data analyses, parent pesticide compounds were grouped together with their corresponding degradates and by-products, reflecting their common or indistinguishable origins.

Six compounds were analyzed in the DDT group (the *p,p'* and *o,p'* isomers of DDT, DDE, and DDD). The sum of the concentrations of these compounds is referred to as the total DDT concentration. Five compounds were analyzed in the chlordane group, with total chlordane concentration calculated as the sum of concentrations of the *cis* and *trans* isomers of chlordane and nonachlor, plus the chlordane degradate oxychlordane. Additional individual compounds frequently found in streams included dieldrin; pentachloroanisole, a degradate of pentachlorophenol; heptachlor epoxide, a degradate of heptachlor; and hexachlorobenzene. Historically, DDT, DDD, aldrin, and dieldrin were used widely in both agricultural and urban areas, whereas chlordane use for urban applications was greater than its agricultural use. As shown in figure 4–5, the agricultural uses of DDT plus DDD, and of dieldrin plus aldrin, were higher than the uses of heptachlor and chlordane. Most organochlorine insecticides had their agricultural uses discontinued in the 1970s, whereas some urban applications (including termite control) were permitted until the late 1980s.

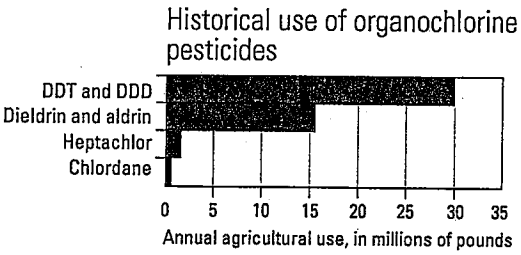

Figure 4–5. In 1966, the agricultural uses of DDT plus DDD (mostly as DDT), and of dieldrin plus aldrin (mostly as aldrin), were greater than the present-day agricultural use of any individual insecticide. Heptachlor and chlordane had much lower agricultural use. (Use estimates are from Eichers and others, 1970.)

Results for fish tissue and bed sediment show generally similar patterns of detection among the organochlorine pesticide compounds (fig. 4–4), but detections were more frequent in fish tissue because these compounds typically accumulate to higher concentrations in biological tissues (wet-weight concentrations) than in sediment (dry-weight concentrations). Patterns of occurrence of organochlorine compounds in fish and bed sediment generally match the patterns in relation to land use that are evident for currently used insecticides in water. Frequencies of detection were higher for most organochlorine pesticide compounds in urban streams than in agricultural streams. The most frequently detected compounds were those composing the DDT group, the chlordane group, and dieldrin.

Streams with undeveloped watersheds had the lowest frequencies of detection of organochlorine compounds in either fish or bed sediment, yet more than half of the fish-tissue samples from these streams had detectable levels of *p,p'*-DDE, a principal degradate of DDT. The frequent presence of *p,p'*-DDE in fish from undeveloped streams may be explained by factors similar to those believed to result in the presence of currently used pesticides in water from undeveloped streams: (1) past use in small areas of developed land within their watersheds, (2) past use for control of insects in undeveloped areas (such as for forest management), and (3) atmospheric transport from other areas.

Fish and bed sediment from streams draining watersheds with mixed land use had frequencies of detection of DDT, dieldrin, and chlordane that generally reflected a mixture of agricultural and urban influences, and were higher than in undeveloped streams (fig. 4–4).

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Influence of Land Use

The preceding overviews of detection frequencies clearly show that pesticide occurrence in streams and ground water is strongly influenced by land use and associated pesticide use. These relations are explored in more detail below, focusing on the occurrence of some of the pesticides that were detected most frequently in agricultural and urban settings.

Agricultural Areas

The pesticides detected most often in water from agricultural streams (fig. 4–2) were among the agricultural herbicides used most heavily during the study period (figs. 4–3 and 3–5). The top five, from highest to lowest frequency of detection at concentrations at or above 0.1 µg/L, were atrazine (ranked 1st in national agricultural use; deethylatrazine was also frequently detected), metolachlor (2nd in use), cyanazine (8th in use), 2,4-D (3rd in use), and simazine (18th in use). Prometon was detected frequently at low levels (rarely at concentrations greater than 0.1 µg/L) and ranked only behind atrazine, metolachlor, simazine, and cyanazine in total detection frequency. Prometon is not registered for use on crops, but is used for weed control around fences, buildings, and roads within agricultural areas.

As with streams, the pesticides most commonly found in shallow ground water within agricultural areas were atrazine (and deethylatrazine) and metolachlor, the two herbicides used most heavily for agriculture during the study period. Although atrazine and metolachlor had about the same total use, atrazine and deethylatrazine were found in ground water more than twice as often as metolachlor, probably because atrazine is considerably more persistent than metolachlor (as discussed in more detail later in this chapter). Deethylatrazine was detected in ground water about as frequently as atrazine, whereas in streams it was found less often than atrazine and usually at lower levels. The greater proportional occurrence of deethylatrazine in ground water reflects the greater opportunity for atrazine degradation over the longer periods of time that water in the subsurface spends in contact with microbes, especially in the soil zone (as discussed further in Chapter 5). Cyanazine, alachlor, and acetochlor—which are used on corn and other crops, but in less than half the amounts of atrazine and metolachlor—were seldom detected in ground water, most likely because of their lower use and relatively low persistence (Appendix 2). In contrast, simazine and prometon were among the pesticides found most often in ground water, despite even lower agricultural use than cyanazine, alachlor, or acetochlor. Simazine and prometon are more persistent in soil than these other herbicides, and thus have greater opportunities for transport to ground water.

Currently used insecticides were found less frequently than herbicides in most agricultural streams and were rarely found in ground water. This finding results from their relatively low application rates in most agricultural settings, compared with herbicides (fig. 3–5), and their generally lower mobility and persistence in the environment (Appendix 2). The insecticide used most heavily for agricultural purposes during the study period was chlorpyrifos. Yet, annual use of chlorpyrifos was only about 20 percent that of atrazine use, and chlorpyrifos is also less mobile in the hydrologic system. Although the annual agricultural use of each of the other four major insecticides examined—diazinon, carbofuran, carbaryl, and malathion—was less than half that of chlorpyrifos during the study period, the total detection frequencies of all five insecticides in agricultural streams were notably similar.

Historically used organochlorine pesticides and their degradates and by-products remained a common occurrence in fish and bed sediment in agricultural streams, although most were detected less frequently in samples from agricultural streams than from urban streams—especially in sediment (fig. 4–4). The compounds found most commonly in agricultural streams were those in the DDT group, followed by dieldrin and the chlordane group. Relative frequencies of detection corresponded to their rankings of historical use in agriculture (fig. 4–5). The frequency of occurrence of compounds in the chlordane group in agricultural streams was higher than expected from its low historical agricultural use compared with DDT plus DDD and dieldrin plus aldrin—possibly because of extensive nonagricultural applications in agricultural areas (such as termite control). In addition, chlordane was a minor component (10–20 percent) of technical-grade heptachlor, which was also used extensively both in agriculture and as a termiticide (IARC, 2001).

Although these broad patterns in pesticide occurrence across all agricultural areas that were sampled provide a useful national perspective, the aggregated results obscure many substantial differences among different agricultural settings in the types and levels of pesticides that were detected. The many diverse agricultural settings

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of the United States that were sampled—each with its own unique combination of climate, crops, and pests—have distinctive patterns in pesticide use that resulted in different patterns of pesticide occurrence. These patterns of occurrence are complex because of the wide ranges of different use practices, pesticide properties, and hydrologic processes that govern the sources, movement, and persistence of pesticides in streams and ground water.

Comparisons of patterns in pesticide occurrence among three of the Nation's major crop-group settings illustrate the variability among settings. Classification of the Nation's agricultural areas for the NAWQA water-quality studies identified 21 major crop-group settings of varying areal extent (Gilliom and Thelin, 1997). This classification is based on combinations of one to three crops that account for most of the harvested acreage in each of the Nation's counties. Three crop-group settings were selected as examples for comparison in this report: "corn and soybeans," "wheat and alfalfa," and "rice." Each crop-group setting has a different geographic distribution and extent (fig. 4–6). Other crops are also present to varying degrees in each of the three settings; thus, the estimated use of a pesticide in a particular crop setting may also include its estimated use for other crops in the same area.

Estimates of pesticide use intensity, expressed as an annual average rate of application on all cropland in each crop-group setting, show clear differences between the settings (fig. 4–7). Overall rates of use were highest in the corn-and-soybeans setting and lowest in the wheat-and-alfalfa setting. Use in each setting is dominated by the particular herbicides and insecticides needed to control the pests specific to the crops grown in that setting. For example, atrazine and metolachlor dominated herbicide use in the corn-and-soybeans setting; 2,4-D was the top herbicide used in the wheat-and-alfalfa setting

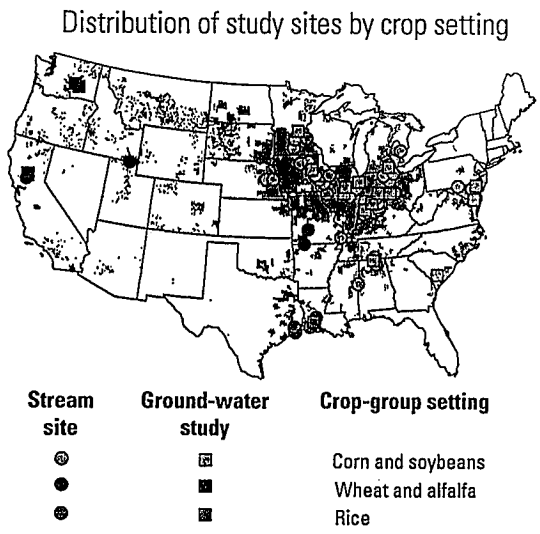

Figure 4–6. The distributions of crop-group settings and study sites for the corn-and-soybeans, wheat-and-alfalfa, and rice crop groups show distinct differences in the locations and extent of the three agricultural settings. (Crop groups are from Gilliom and Thelin, 1997.)

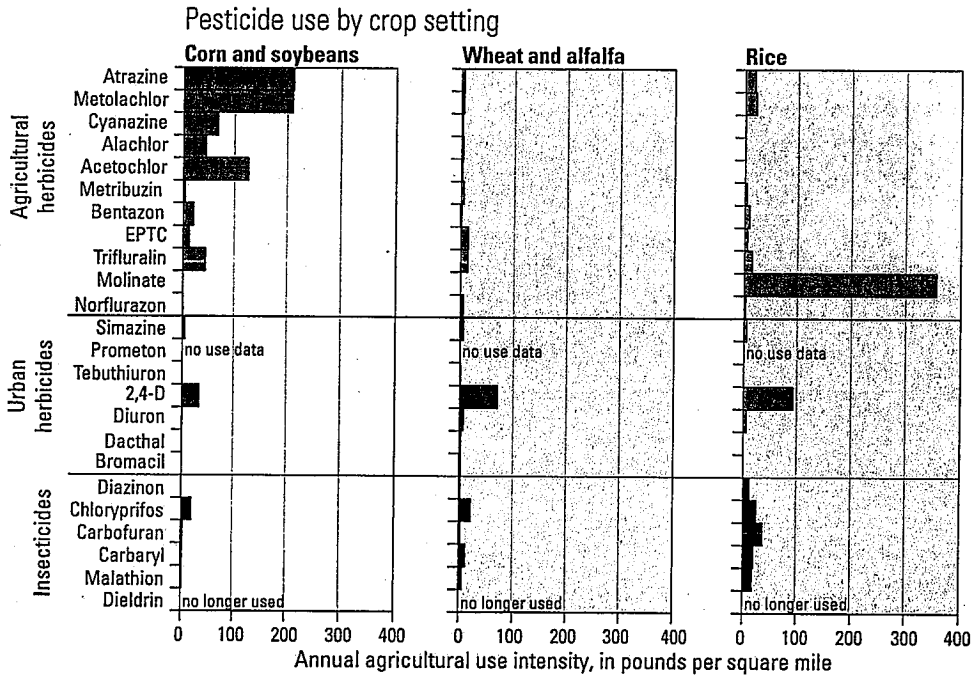

Figure 4–7. Different pesticides dominated use in each of the crop-group settings, as illustrated by the estimated 1997 agricultural use. The herbicides atrazine, metolachlor, acetochlor, and cyanazine were the most intensively used pesticides in the corn-and-soybeans setting; molinate, 2,4-D, and several insecticides were most intensively used in the rice setting; and 2,4-D and chlorpyrifos were the most intensively used pesticides in the wheat-and-alfalfa setting, where overall use was least.

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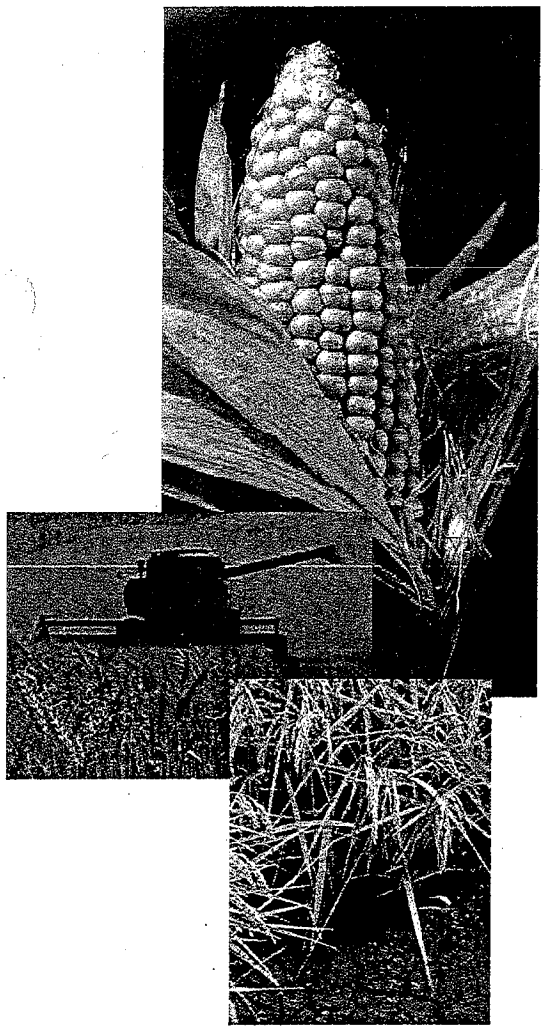
(but at less than half the intensity of atrazine and metolachlor use in the corn-and-soybeans setting); and molinate was the top herbicide used in the rice setting (with use intensity that was 70 percent greater than that of either atrazine or metolachlor in the corn-and-soybeans setting).

The occurrence of pesticides in streams and ground water within these three crop settings (fig. 4–8) corresponded to the estimated agricultural-use patterns in many respects (fig. 4–7), but also showed some unexpected results, as summarized below. These examples of results for specific crop-group settings illustrate both the degree of predictability and the complexity of pesticide occurrence and transport in the hydrologic system. Each crop setting has unique characteristics, and each specific study area within a crop setting is unique as well, resulting in variability within crop-group settings as well as among them. Nonetheless, organizing the assessment of pesticides by crop-group setting can help to link the occurrence of pesticides in streams and ground water with specific management practices and can provide the foundation for customizing pesticide management to individual settings.



Photographs by Don Brennemen, University of Minnesota Agricultural Extension Service (middle), and © 2003 Corbis (top).

Expected results:

- *Corn and soybeans*—The two herbicides used most heavily for corn and soybeans—atrazine and metolachlor—were those detected most frequently in streams and ground water. In addition, deethylatrazine was detected at about the same frequency as atrazine in both streams and ground water within this setting. Chlorpyrifos was both the most frequently detected and the most heavily used insecticide.
- *Wheat and alfalfa*—Overall detection frequencies were low in the wheat-and-alfalfa setting, consistent with relatively low pesticide use. The herbicide used most heavily in the wheat-and-alfalfa setting, 2,4-D, was one of the most frequently detected pesticides in streams at concentrations at or above 0.1 µg/L.
- *Rice*—Molinate, the herbicide used most heavily on rice, was among those detected most frequently in streams. Detections of molinate were far more frequent in the rice setting than in the other agricultural settings. The insecticide used most intensively on rice, carbofuran, was the one detected most frequently at or above 0.1 µg/L in both streams and ground water. Carbofuran and the other four insecticides used mostly in the rice setting were detected more frequently in the rice setting than in the other two crop-group settings, where their use was less intensive.

Unexpected results:

- *Corn and soybeans*—Simazine and prometon were found more frequently than was expected from their low agricultural use, indicating relatively substantial use of these herbicides for noncrop purposes within agricultural areas (although most concentrations were low).
- *Wheat and alfalfa*—Atrazine and prometon were the herbicides detected most frequently in streams and ground water, despite little (atrazine) or no (prometon) agricultural use on either wheat or alfalfa (although most concentrations were low).
- *Rice*—Low-use pesticides, including atrazine (and deethylatrazine), metolachlor, and tebuthiuron, were frequently detected, probably because of noncrop uses within this setting. Bentazon was frequently detected in streams and particularly in ground water. Bentazon was detected most frequently in the rice-growing area of California, where it was used heavily until it was banned in 1989.

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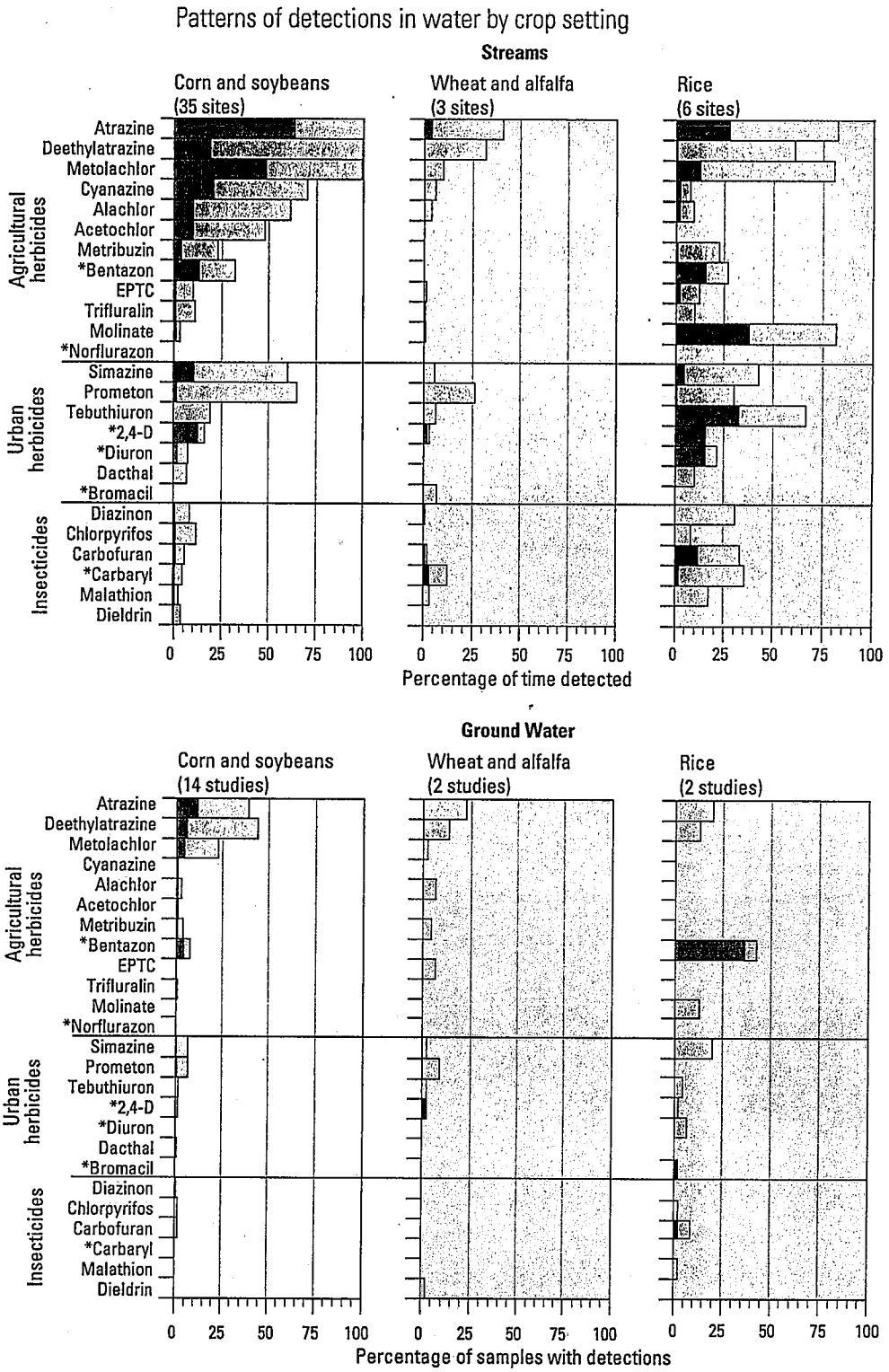

Figure 4–8. The occurrence of pesticides in streams and ground water sampled within the corn-and-soybeans, wheat-and-alfalfa, and rice crop-group settings corresponded to the patterns of estimated agricultural use in many respects (see fig. 4–7), but nonagricultural uses also influence occurrence. The dark portion of each bar indicates detections at concentrations greater than or equal to 0.1 µg/L , the light portion indicates detections less than 0.1µg/L*, and the end of each bar is the total for all detections (see sidebar on p. 45.)

*The pesticides 2,4-D, bentazon, bromacil, carbaryl, diuron, and norflurazon could not be detected reliably at concentrations less than 0.1 µg/L, and the reported frequencies below this level for these compounds are minimum estimates.

A012048

Urban Areas

The most distinct differences between pesticides found in urban and agricultural areas were the more frequent detections and higher concentrations of insecticides in urban streams, and the frequent detections of urban herbicides in streams and shallow ground water sampled in urban areas.

Diazinon, chlorpyrifos, carbaryl, and malathion, which nationally ranked 2nd, 4th, 8th, and 15th among pesticides in frequencies of outdoor applications for home-and-garden use at the beginning of the study period (Whitmore and others, 1992), accounted for most detections of insecticides in urban streams (fig. 4–2). Diazinon and carbaryl were by far the most frequently detected and were found at frequencies and levels comparable to those for the common herbicides. The use of diazinon and chlorpyrifos has been substantially curtailed since the end of the study period, and analysis of recent data for diazinon (Chapter 8) shows that concentrations in some streams have now declined as well. Historically used insecticides also were found most frequently in fish and bed sediment from urban streams, which had among the highest detection frequencies for chlordane compounds, DDT compounds, and dieldrin (fig. 4–4). Urban streams also had the highest concentrations of total chlordane and dieldrin in both sediment and fish tissue. Chlordane and aldrin were widely used for termite control until the mid-to-late 1980s, although their agricultural uses were restricted during the 1970s.

Insecticides were seldom detected in ground water beneath urban areas (fig. 4–2). The most commonly detected insecticide in shallow ground water in urban areas, however, was dieldrin, which was found in about 5 percent of the wells sampled. Although dieldrin is not very mobile in water, its environmental persistence and the extensive historical use of dieldrin and aldrin have apparently combined to yield detectable concentrations in some wells 5 to 15 years after all uses of dieldrin and aldrin were discontinued.

The most frequently detected herbicides in streams and shallow ground water in urban areas were atrazine (and deethylatrazine), simazine, prometon, and metolachlor, although metolachlor was seldom detected in ground water—probably because of its lower urban use and lower persistence compared with the other herbicides. Considering only detections at or above 0.1 µg/L, however, the herbicides detected most frequently in urban streams were diuron (14 percent of the time), simazine (14 percent), 2,4-D (11 percent), and atrazine (10 percent).

The herbicides found more often in urban areas than in most agricultural areas—considering detections at all concentrations—were simazine, prometon, diuron, 2,4-D, tebuthiuron, and dacthal. The use of 2,4-D and prometon ranked 1st and 14th among herbicides in frequency of outdoor home-and-garden applications at the beginning of the study period (Whitmore and others, 1992). Although 2,4-D, simazine, and diuron also ranked 3rd, 18th, and 23rd among herbicides in national use for agriculture, no agricultural use was reported for prometon or tebuthiuron.

Pesticides are used extensively in residential areas and associated recreational and commercial areas, including golf courses.

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Geographic Distribution

The geographic distribution of each pesticide in streams and ground water is governed by the intensity and distribution of its use, its chemical and physical properties, and the characteristics of the hydrologic system. The interactions among these factors are illustrated by comparing the findings for several different pesticides in relation to their uses and properties. Results for five pairs of the most frequently detected pesticides are presented—atrazine and metolachlor; simazine and prometon; acetochlor and 2,4-D; diazinon and chlorpyrifos; and total DDT and dieldrin—representing a wide range of use patterns and properties (figs. 4–9 to 4–16). These comparative stories provide insights about some of the most important pesticides, while also illustrating the types and magnitudes of influences that affect all pesticides.

Methods and Statistics for Assessing Geographic Distributions of Pesticides

Consistent measures and scales are used to represent concentration levels appropriate to each medium in the comparisons of geographic distributions among pesticides (figs. 4–9 to 4–16):

- For pesticides in stream water, maps in this chapter are based on the time-weighted 95th-percentile concentration at each site for the selected year of data, which is the concentration exceeded about 5 percent of the time, or about 18 days per year (generally not consecutive). Use of the 95th percentile for comparisons reduces the influence of different detection levels among compounds because it is usually higher than the lowest detectable concentration.
- For pesticides in ground water, maps in this chapter are based on the frequency of detections at or above 0.01 µg/L within each study area. Evaluation of each of the pesticides using only detections at or above the detection level of 0.01 µg/L yields results that are directly comparable among all pesticides mapped for ground water. Symbols representing ground-water studies are shown at the centroid of each study area.
- For total DDT and dieldrin in streams, data for bed sediment are used because fish were not collected in all parts of the country. One composite bed-sediment sample was collected at each site—maps are based on the concentration in each individual sample.
- For all maps, the distribution of agricultural use for each pesticide is shown by a consistent set of categories of 1997 use intensity—or historical use intensity for total DDT and dieldrin—so that maps can be directly compared among the 10 pesticides. Use was estimated for 1997 by combining the 1997 state-level use data reported by Gianessi and Marcelli (2000) with county crop acreages from the 1997 Census of Agriculture (U.S. Department of Agriculture, 1999), using methods described by Thelin and Gianessi (2000). Use intensity was mapped for agricultural land using land-cover data from the early 1990s (Vogelmann and others, 2001) as described by Nakagaki and Wolock (2005). Historical use of DDT (including DDD) and dieldrin (including aldrin) was estimated by a similar approach, but using regional use estimates for 1966 (Eichers and others, 1970) and 1971 (Andrilenas, 1974), and the 1964 and 1969 Censuses of Agriculture for crop distributions (Nowell and others, 2006). Use intensity was mapped for agricultural land using land-cover data from the mid-1970s (Fegeas and others, 1983).
- Chemical and physical properties that help explain observed patterns were introduced in Chapter 2 and are tabulated in Appendix 2. The properties emphasized are environmental persistence (soil half-life) and mobility in water (represented by the soil organic carbon-water partition coefficient, or K_{oc}). The higher the K_{oc} value, the greater the affinity of the compound for soil organic matter, suspended particles, and bed sediment—and, thus, a lower tendency to be transported in water.

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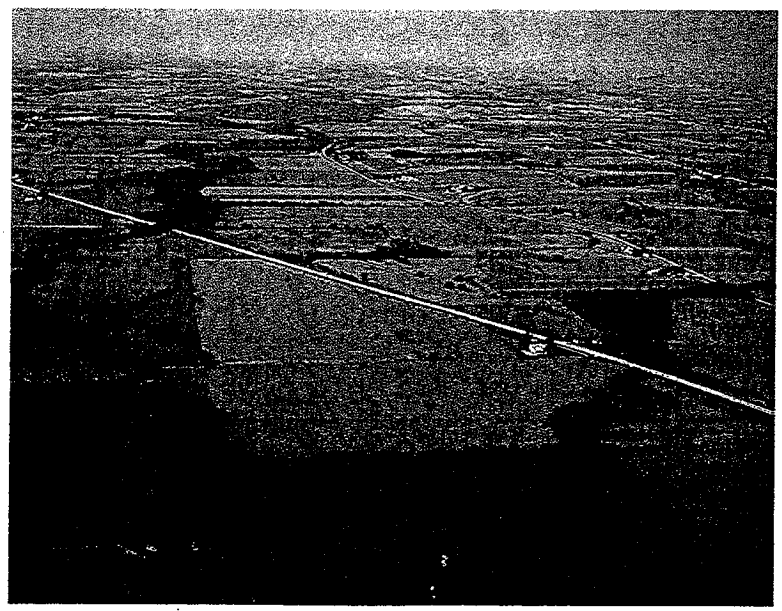
Atrazine and Metolachlor—

The two most heavily used herbicides occurred at similar levels in streams, but atrazine was more prevalent than metolachlor in ground water, probably because of its greater persistence.

Atrazine and metolachlor were the two most heavily used herbicides in the United States during the 1990s. Most of their agricultural use was associated with corn production—about 85 percent of 75 million lb/yr for atrazine and 75 percent of 67 million lb/yr for metolachlor (fig. 4–3). Both herbicides also have relatively low and poorly quantified nonagricultural use—atrazine is estimated at less than 1 million lb/yr (USEPA, 2003a). Uses of metolachlor include turf, nurseries, fence rows, and landscaping, and uses of atrazine include conifer forestry, Christmas tree farms, sod, golf courses, and residential lawns (particularly in the South). Both atrazine and metolachlor are highly soluble and mobile in water, but atrazine is more persistent than metolachlor, with a soil half-life of 146 days, compared with 26 days for metolachlor (Appendix 2).

Concentrations of both atrazine and metolachlor in agricultural streams closely matched the geographic distribution of corn cultivation, where applications are greatest (fig. 4–9). Both atrazine and metolachlor were also frequently detected in urban streams, but at substantially lower concentrations compared with agricultural streams in high-use areas, except in parts of the South where atrazine is used on turf grasses. Concentrations in streams draining watersheds with mixed land use most closely resembled those in agricultural streams, in large part because many of these streams have watersheds with relatively high proportions of agricultural land.

In contrast to their similarity in streams, patterns of atrazine and metolachlor were different from each other in ground water (fig. 4–10). Metolachlor was detected less frequently than atrazine, regardless of land use or depth of ground water. This difference probably occurs because metolachlor transforms more quickly in soil than does atrazine. Metolachlor, therefore, is less likely to be transported to ground water, although the opposite may be true for some of its degradates that appear to be more persistent than the parent compound (Kalkhoff and others, 1998). Neither metolachlor nor atrazine was detected at the highest frequencies (> 25 percent) in ground water underlying large areas of Illinois, Indiana, and Ohio, despite their high use in this region. This distinct regional pattern, which has been noted by several previous studies (Hallberg, 1989; Burkart and Kolpin, 1993; Baker and others, 1994), is most likely a consequence of the widespread use of subsurface drainage systems in this area (which move shallow ground water rapidly to streams and reduce transport to deeper ground water), as well as the presence of low-permeability glacial till.



Atrazine and metolachlor were heavily used on cropland throughout the Corn Belt during the study period.

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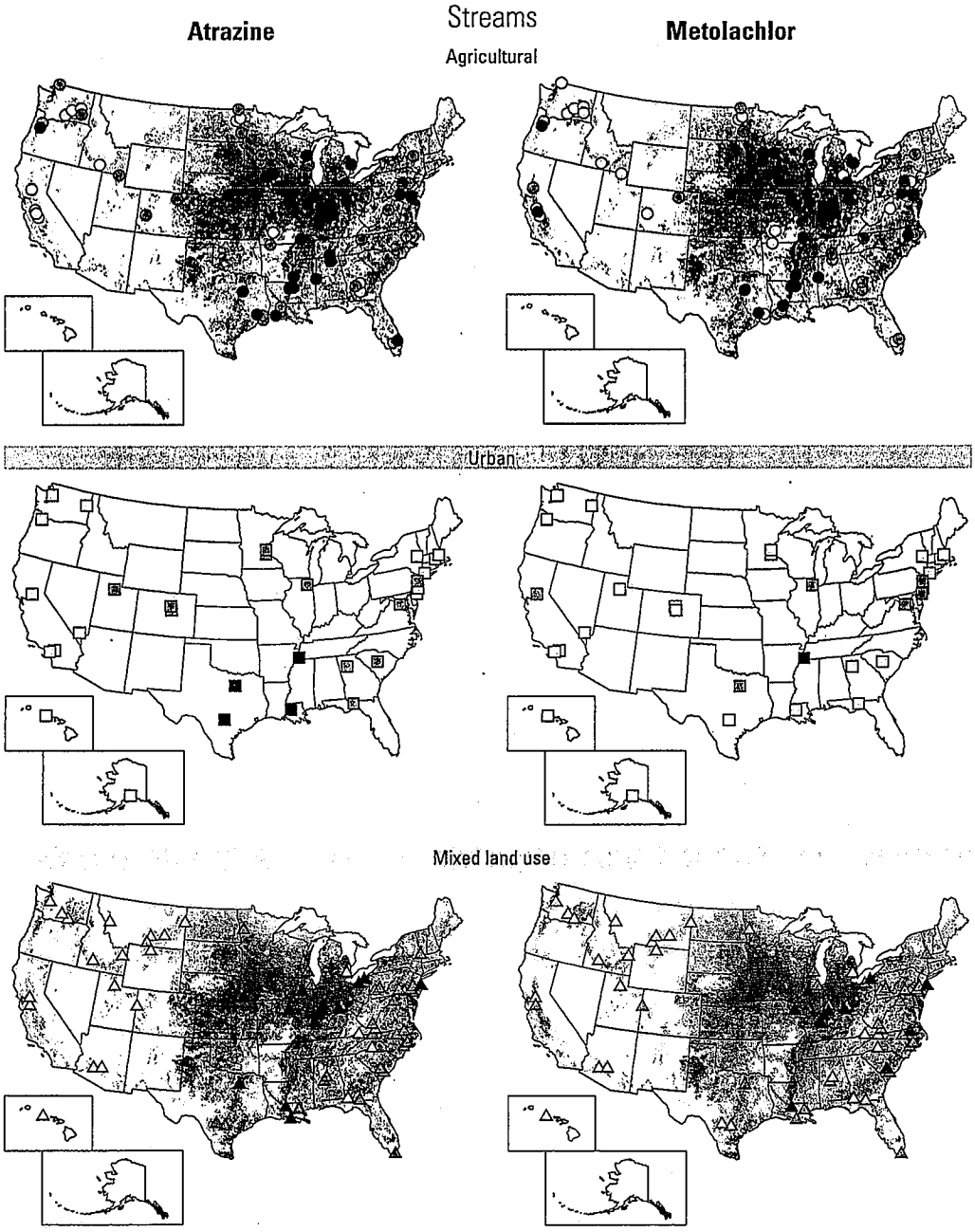

Figure 4–9. Concentrations of both atrazine and metolachlor in agricultural streams closely matched the geographic distribution of their use on crops. Both atrazine and metolachlor were also often found in urban streams, but at substantially lower concentrations compared with most agricultural streams. An exception is atrazine in some urban streams in parts of the South where atrazine was used on turf grasses. Agricultural use for 1997 was estimated as described in the "Methods" sidebar on p. 53.

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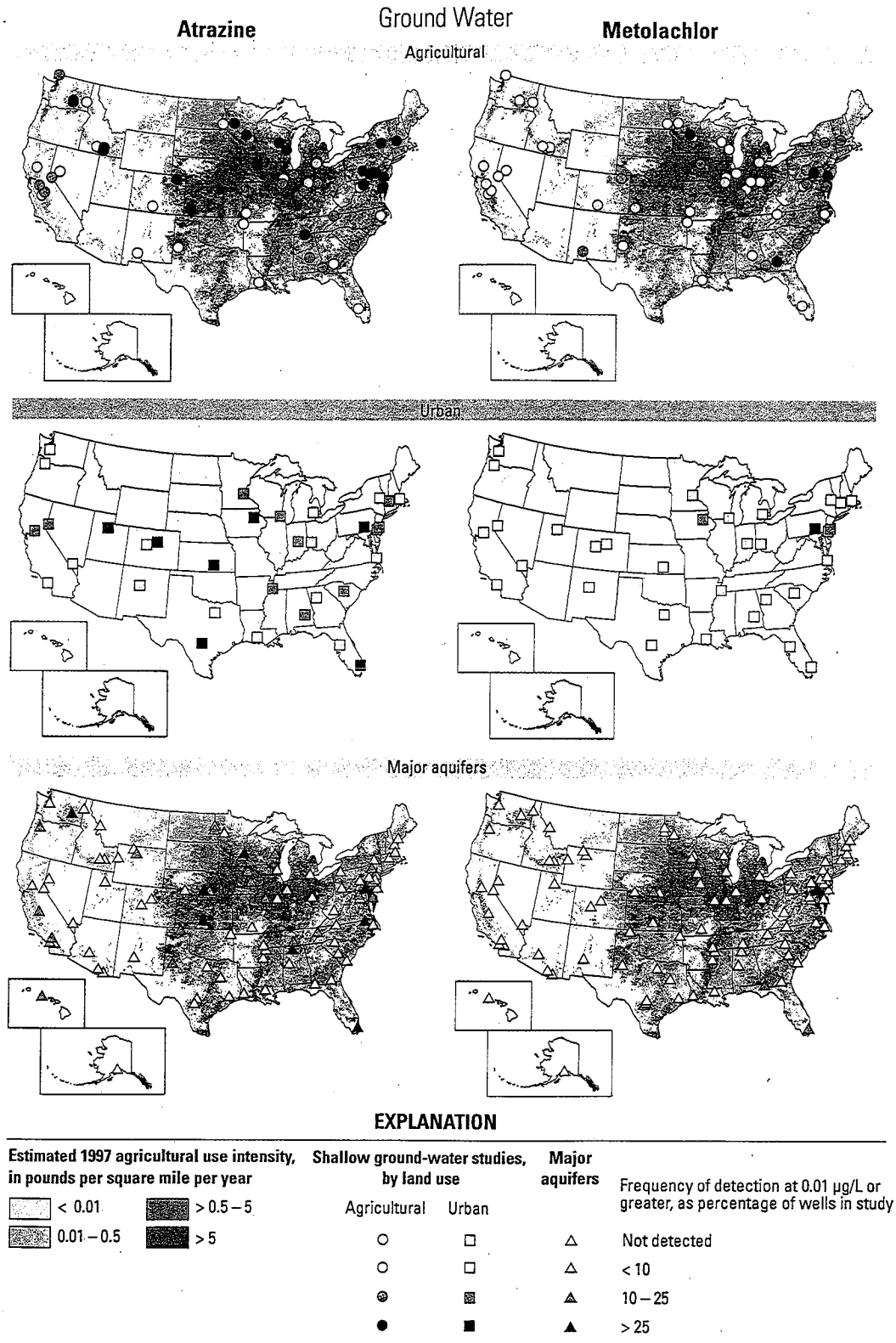

Figure 4–10. Patterns of atrazine and metolachlor detections were different from each other in ground water, although both were detected less frequently than expected in the central Corn Belt where the intensity of use was greatest. Metolachlor was detected less frequently than atrazine, regardless of land use or depth of ground water, probably because metolachlor is less persistent in soil than atrazine. Agricultural use for 1997 was estimated as described in the "Methods" sidebar on p. 53.

A012053

Simazine and Prometon—

Although prometon is not registered for agricultural use, it frequently occurred in agricultural streams and ground water, probably because of use for nonagricultural purposes in those areas and its high persistence.

Simazine and prometon are commonly used herbicides that, compared with atrazine and metolachlor, had lower total use and higher proportions of nonagricultural use during the study period. About 5 million lb/yr of simazine were applied for agricultural purposes nationwide (fig. 4–3), compared with about 75 and 67 million lb/yr of atrazine and metolachlor, respectively. Relative to atrazine and metolachlor, simazine is used on a wider variety of crops—including corn (about 40 percent of total use), citrus orchards (about 35 percent), and other orchards and vineyards (about 20 percent). Nonagricultural uses of simazine include applications to turf grasses and lawns, roadsides and other rights-of-way, and nurseries. Prometon is not registered for agricultural use, but is applied for nonagricultural purposes—albeit in small amounts—for bare-ground weed control around buildings, storage areas and fences, as well as along roadways, railroads, and other rights-of-way. Both simazine and prometon are highly soluble and mobile in water, but prometon is more persistent than simazine, with a soil half-life of 932 days, compared with 91 days for simazine (Appendix 2).

The occurrence of simazine in agricultural and urban streams was consistent with its geographic patterns of use (fig. 4–11), particularly in comparison to the more heavily used atrazine (fig. 4–9). For example, concentrations of simazine in agricultural streams in the Corn Belt were notably lower than concentrations of atrazine, reflecting the lower use of simazine on corn. On the other hand, detection frequencies and concentrations of simazine in urban streams were nearly identical to those of atrazine, reflecting generally similar nonagricultural use. Prometon was detected less frequently than simazine in agricultural streams, at lower concentrations, and without the geographic patterns that follow use on crops. The prometon detections in agricultural areas probably result from nonagricultural applications in these areas. In urban streams, prometon was detected at frequencies similar to those observed for simazine, atrazine, and diazinon—although at somewhat lower concentrations (see figs. 4–11, 4–9, and 4–14, respectively). The most likely explanation for the frequent occurrence of prometon is that its high persistence (10 times that of simazine and more than 5 times that of atrazine) results in its prolonged presence in watersheds.

The occurrence and concentrations of simazine in ground water (fig. 4–12) were consistent with patterns observed for atrazine and metolachlor (fig. 4–10). Like atrazine and metolachlor, detection frequencies were relatively low in shallow ground water beneath agricultural areas in Illinois, Indiana, and Ohio relative to other high use areas—probably because of the common use of subsurface drainage systems and widespread presence of glacial till in this region (noted earlier). Simazine was generally detected more frequently than atrazine and metolachlor in Florida and California, which is consistent with its higher use in orchards and vineyards in those areas. Prometon, consistent with its lack of registered agricultural uses, was detected less frequently than simazine in shallow ground water in agricultural areas. In most urban study areas, prometon was detected at similar or greater frequencies than simazine in shallow ground water.

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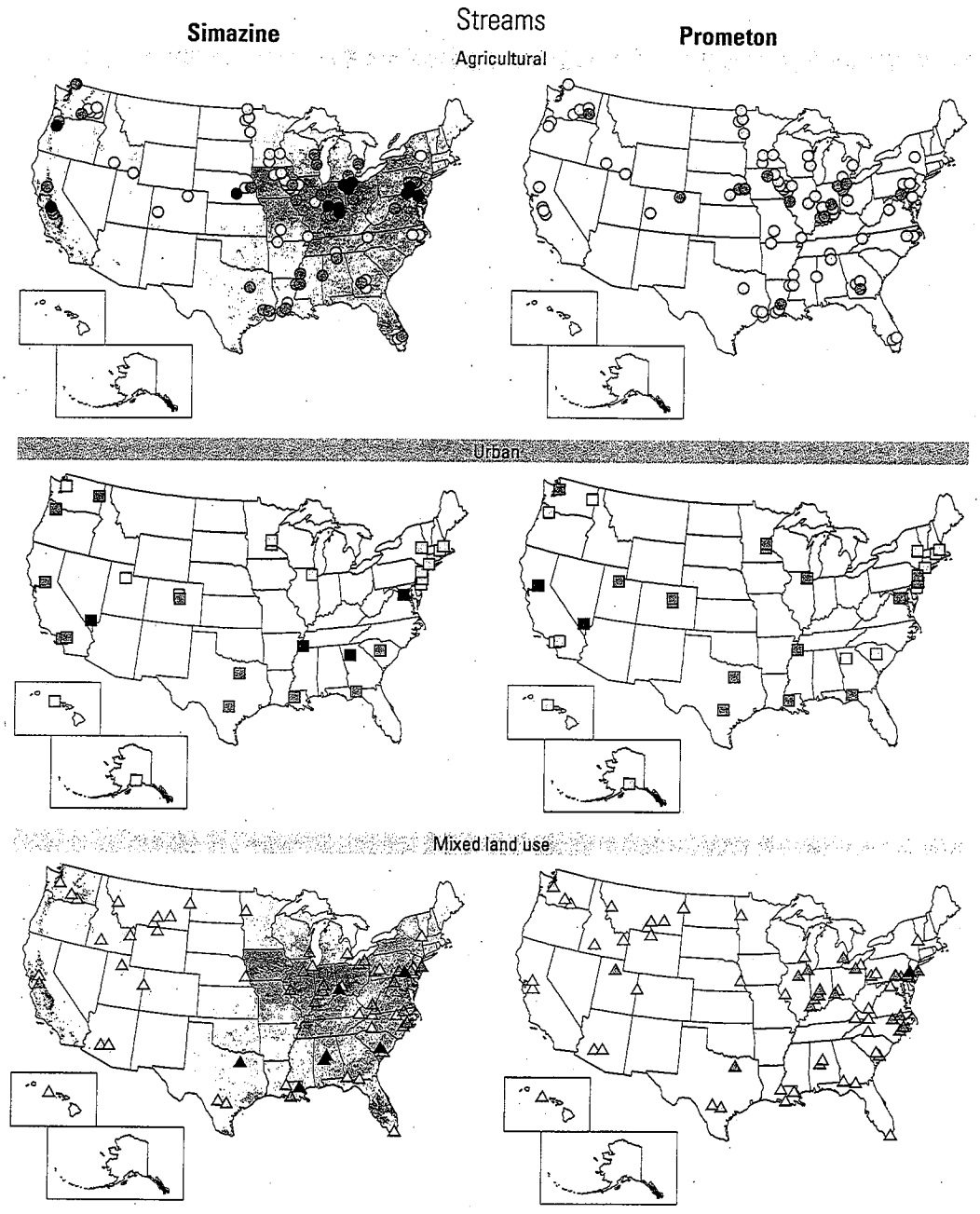


Figure 4–11. The occurrence and concentrations of simazine in agricultural and urban streams were consistent with its use, particularly in comparison with the more heavily used atrazine (fig. 4–9.) Prometon was detected less frequently than simazine in agricultural streams, at lower concentrations, and without the geographic patterns that follow use on specific crops. Prometon is not registered for agricultural use and no estimates of agricultural use are shown. Agricultural use of simazine for 1997 was estimated as described in the "Methods" sidebar on p. 53.

A012055

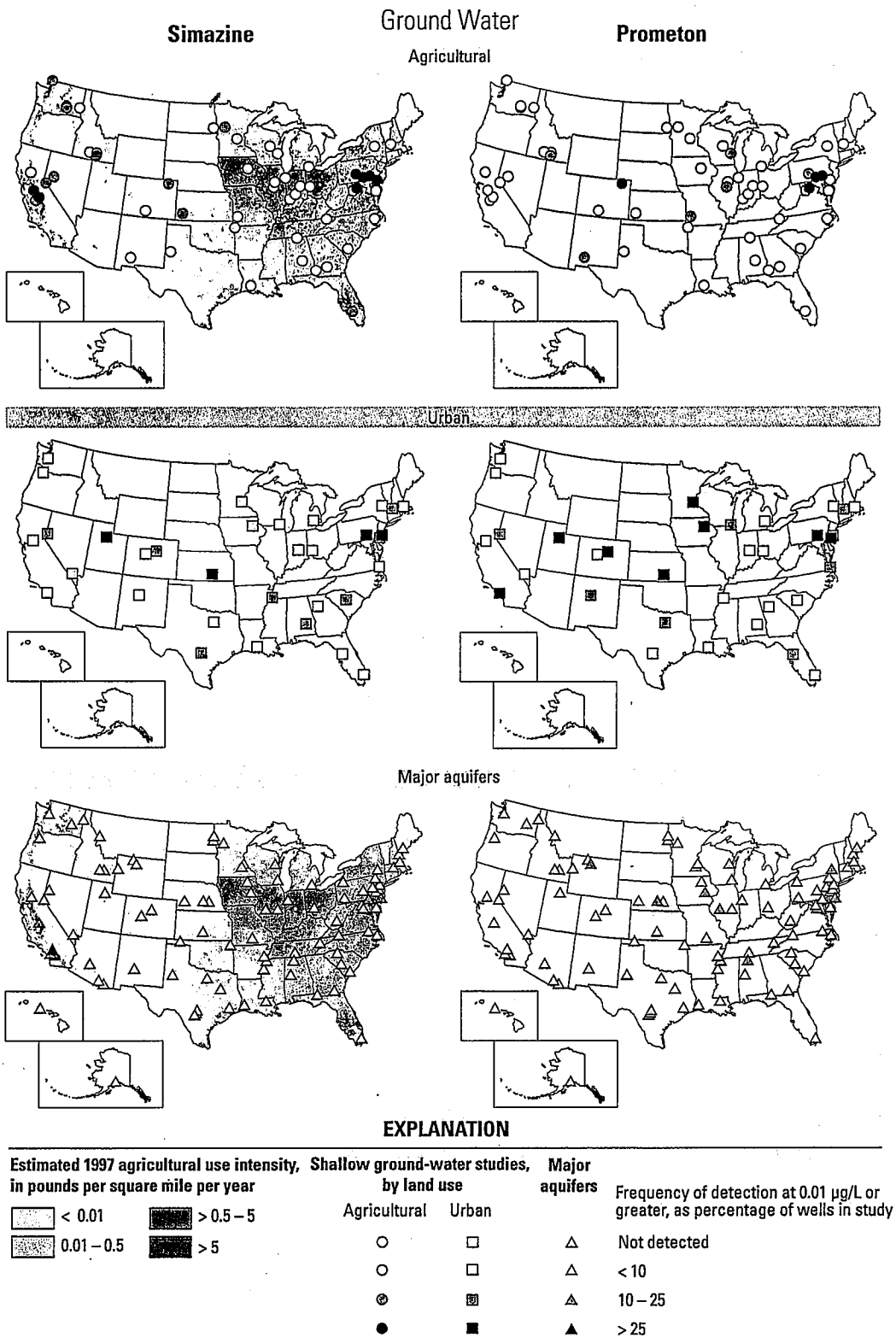


Figure 4–12. The occurrence of simazine in ground water was less frequent than atrazine and metolachlor (fig. 4–10), but the relative patterns were similar, including relatively low detection frequencies in shallow ground water beneath agricultural areas in Illinois, Indiana, and Ohio, compared with other high-use areas around the Nation. Prometon was detected less frequently than simazine in shallow ground water within agricultural areas. Prometon is not registered for agricultural use and no estimates of agricultural use are shown. Agricultural use of simazine for 1997 was estimated as described in the "Methods" sidebar on p. 53.

A01.2056

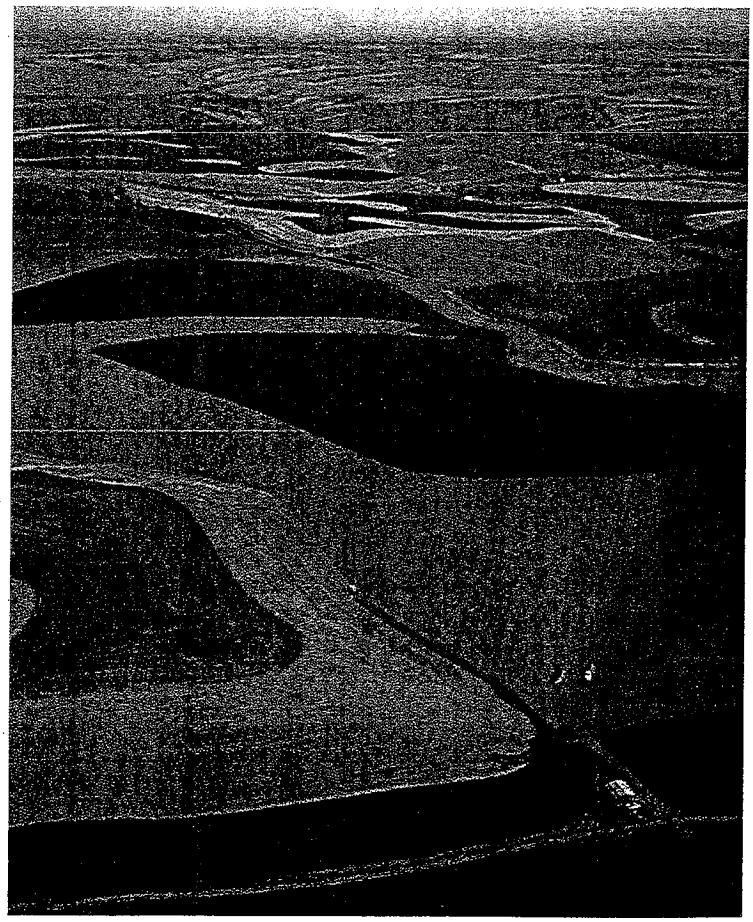
2,4-D and Acetochlor—

These two herbicides, which have relatively similar chemical and physical properties, have different geographic patterns of occurrence in streams because of their different use patterns.

The herbicides 2,4-D and acetochlor ranked 3rd and 5th in national agricultural use during the study period (about 41 and 33 million lb/yr, respectively, in 1997; fig. 4–3), but their use is distributed differently. Acetochlor, which is a relatively new pesticide introduced in 1994, is used only on corn, whereas 2,4-D is widely applied for multiple agricultural purposes, including weed control for pasture (accounting for about 40 percent of use), wheat (20 percent), corn and soybeans (17 percent), as well as other crops and fallow land. In addition, 2,4-D has the highest documented nonagricultural use of any pesticide (nearly 30 million lb/yr; fig. 4–3). Both 2,4-D and acetochlor are relatively soluble and mobile in water and neither is particularly persistent, with soil half-lives of 7 and 14 days, respectively.

The occurrence and concentrations of these two compounds in agricultural and urban streams were generally consistent with their patterns of use (fig. 4–13). Specifically, relatively high concentrations of 2,4-D occurred in agricultural streams across the Nation in various high-use areas, whereas the highest concentrations of acetochlor were generally in the heart of the Corn Belt and in other corn-growing areas. Also consistent with their use patterns, 2,4-D concentrations were higher in urban streams than concentrations of acetochlor. Infrequent low-level detections of acetochlor in some urban streams may result from relatively minor agricultural use within the predominantly urban watersheds or atmospheric transport from nearby agricultural areas.

Geographic results for 2,4-D and acetochlor are not presented for ground water because both pesticides were detected in less than 1 percent of the wells sampled (fig. 4–2). Their infrequent occurrence in ground water is probably a result of their low persistence. For acetochlor, this hypothesis is supported by the more frequent detection of at least two of its degradates in ground water—relative to acetochlor itself—in some studies (for example, Kalkhoff and others, 1998; Groschen and others, 2004).



2,4-D was a commonly used herbicide during the study period on croplands where wheat is grown (Photograph copyright by Phil Schofield).

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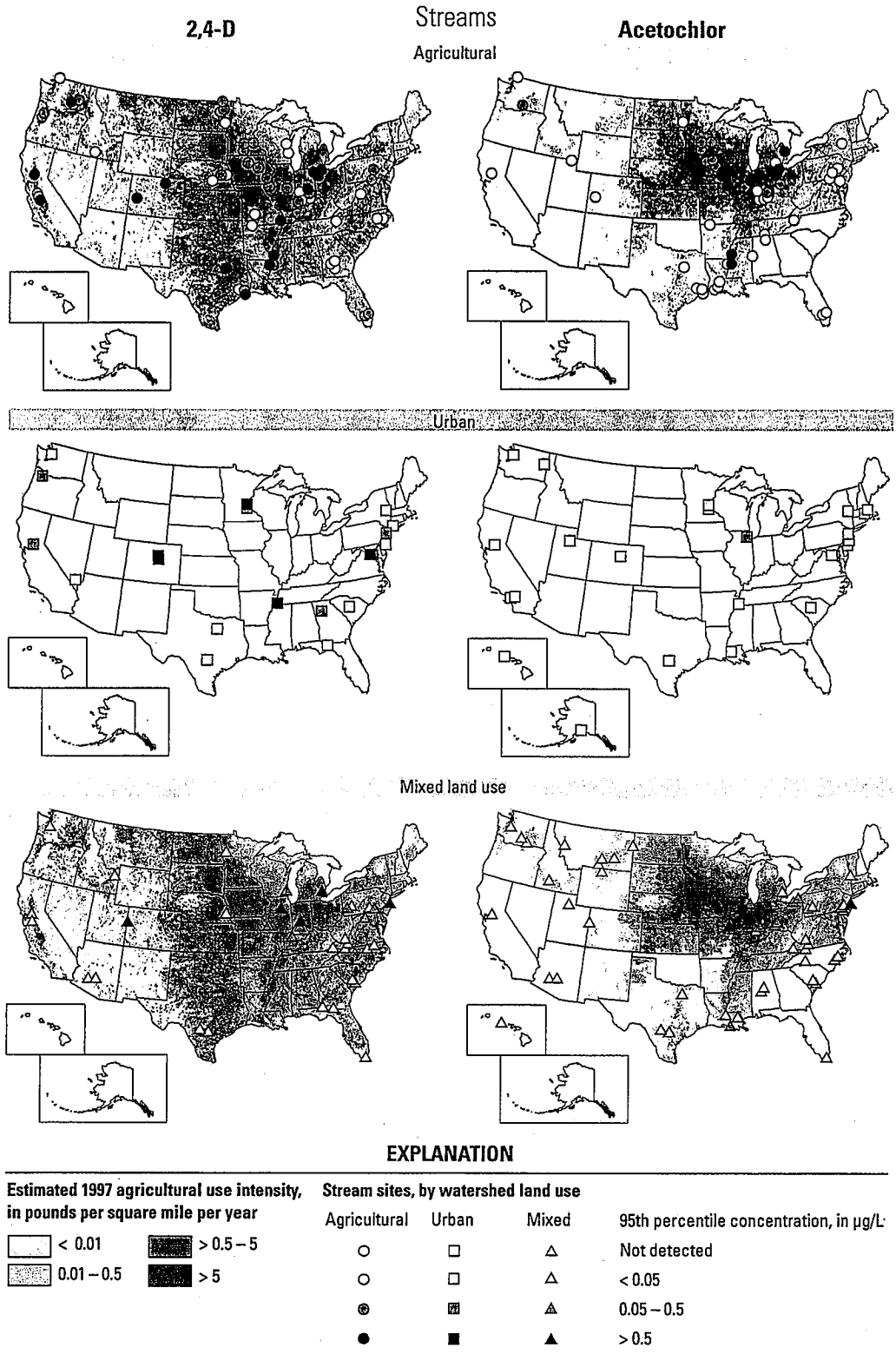


Figure 4–13. The occurrence and concentrations of 2,4-D and acetochlor in agricultural streams were generally consistent with their patterns of use. Relatively high concentrations of 2,4-D were observed in agricultural streams across the Nation, whereas elevated concentrations of acetochlor were generally observed in the heart of the Corn Belt and in other corn-growing areas. In urban streams, 2,4-D concentrations were generally higher than those of acetochlor. Agricultural use for 1997 was estimated as described in the "Methods" sidebar on p. 53.

A012058

Chlorpyrifos and Diazinon—

Despite greater use, chlorpyrifos was found less frequently than diazinon in water, probably because of its greater affinity for particles and resulting lower mobility in water.

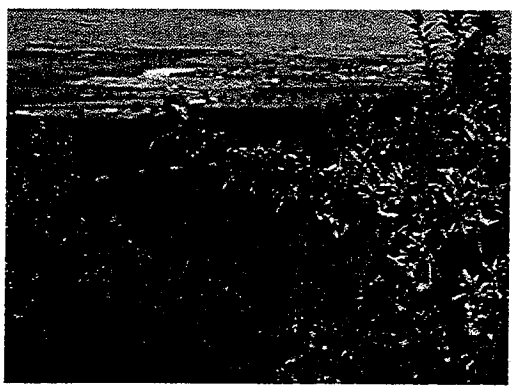
Chlorpyrifos and diazinon are insecticides that were commonly used in both agricultural and urban areas during the study period. About 13 million lb of chlorpyrifos were applied to crops in 1997, mostly on corn and cotton (accounting for more than 50 percent of national use), with the remainder on alfalfa, peanuts, wheat, tobacco, and orchards. Less diazinon was used for agriculture (about 1 million lb in 1997), mostly for a wide variety of fruits, nuts, and vegetables (fig. 4–3). Nonagricultural uses of chlorpyrifos and diazinon totaled about 5 million and 4 million lb/yr in 2001, respectively (fig. 4–3). Both diazinon and chlorpyrifos are substantially less mobile in water than the six herbicides just discussed, but chlorpyrifos has a greater affinity for soil organic matter and particles (higher K_{oc}) than diazinon and, thus, a lower solubility and mobility in water. Both pesticides have similar half-lives in soil—39 days for diazinon and 31 days for chlorpyrifos (Appendix 2).

The geographic distributions of these insecticides in agricultural and urban streams were consistent with their patterns of use (fig. 4–14). Of agricultural streams, the highest concentrations of chlorpyrifos were in streams draining the corn-growing areas of the central United States and the lower Mississippi River Basin, where both corn and cotton are grown, and in streams draining orchard areas in the West. Concentrations of diazinon in agricultural streams were highest in parts of the West where it is intensively used on fruits, nuts, and vegetables. For both insecticides, concentrations in most urban streams were higher than in most agricultural streams, and were similar to those found in agricultural areas with the greatest intensities of use.

In urban streams, diazinon was detected about 75 percent of the time, compared with about 30 percent for chlorpyrifos (fig. 4–2), even though their nonagricultural use was similar. In addition, 95th-percentile concentrations equaled or exceeded 0.05 µg/L in 23 of 30 urban streams for diazinon, compared with only 3 streams for chlorpyrifos. In agricultural streams, both chlorpyrifos and diazinon were found at relatively similar frequencies and concentrations, despite the 10-fold higher use of chlorpyrifos. The markedly greater occurrence of diazinon in proportion to use, compared with chlorpyrifos, may be explained by the greater solubility and mobility of diazinon in water. Because chlorpyrifos has a greater affinity for organic matter than diazinon, however, there may have been substantial occurrence and transport of chlorpyrifos in suspended sediment in streams that was not observed. As discussed in Chapter 3, all NAWQA stream-water samples were filtered prior to analysis.

Chlorpyrifos and diazinon were rarely detected in ground water (less than 1 percent of samples; fig. 4–2), so their geographic distributions are not shown. This infrequent occurrence is explained by their relatively low persistence and low water solubility, as well as their low use compared with the major herbicides.

Chlorpyrifos was commonly used on cotton during the study period.



Both chlorpyrifos and diazinon were used on apples and other orchard crops during the study period.

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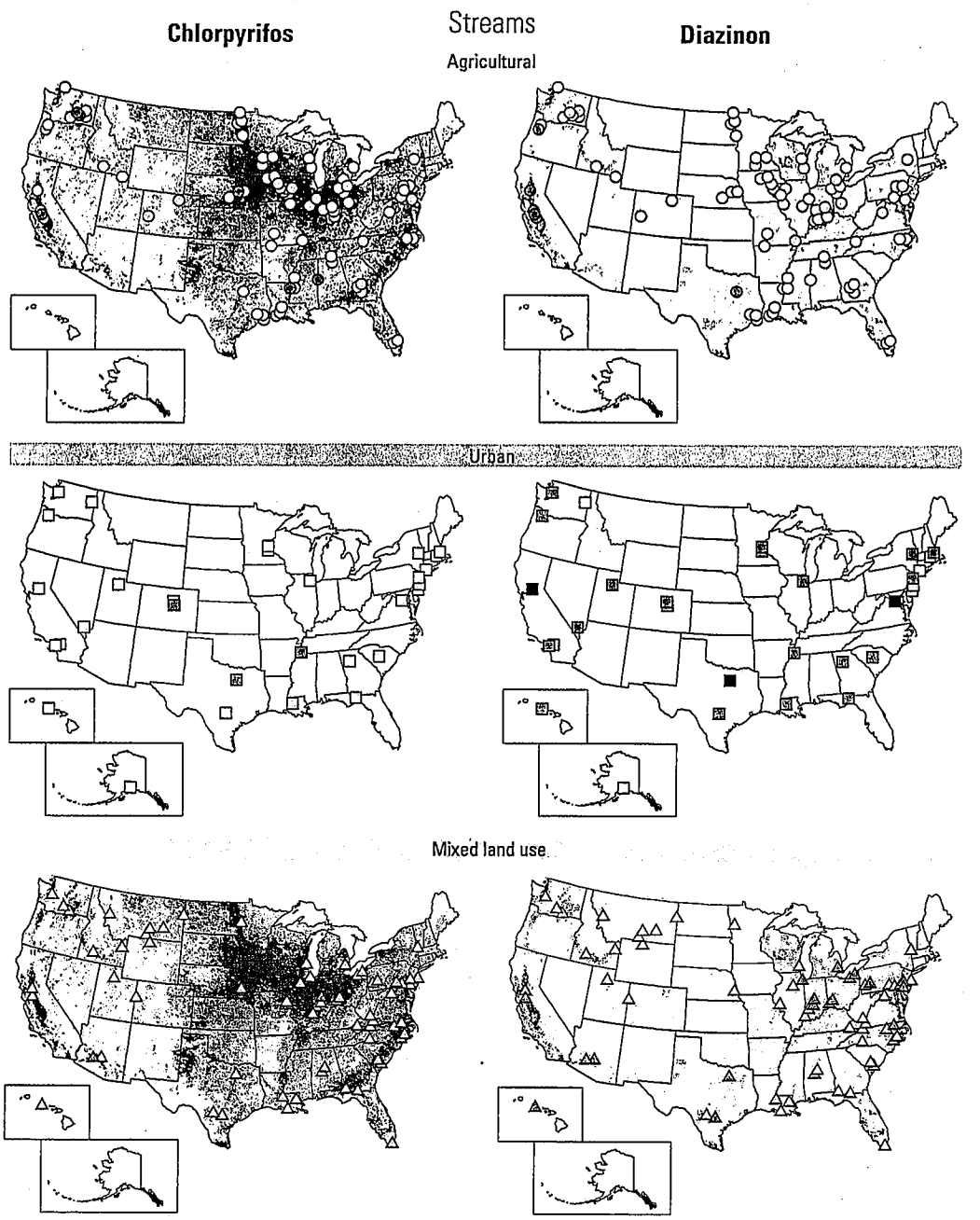

Figure 4–14. Concentrations of diazinon, and to a lesser degree chlorpyrifos, in most urban streams were greater than concentrations in most agricultural streams. Concentrations of diazinon in urban streams were generally similar to those found in agricultural areas with the greatest intensities of agricultural use. The highest concentrations of diazinon in agricultural streams were found in the West where it was used on fruits, nuts, and vegetables. The highest concentrations of chlorpyrifos in agricultural streams were detected in corn-growing areas of the central United States; the lower Mississippi River Basin, where both corn and cotton are grown; and in streams draining orchard areas in the West. Agricultural use for 1997 was estimated as described in the "Methods" sidebar on p. 53.

A012060

DDT and Dieldrin in Bed Sediment—

The geographic distributions of these historically used insecticides follow their past agricultural use and indicate that use in urban areas probably was substantial.

Although the parent pesticides were not used in the United States for about 5–20 years prior to the beginning of the study period, compounds in the DDT group and dieldrin were frequently detected in bed sediment. In 1966, the combined agricultural use of DDT and DDD was about 30 million lb (fig. 4–5), with 66 percent used on cotton, 9 percent on tobacco, 8 percent on peanuts, and 17 percent on orchards, soybeans, vegetables, potatoes, and other crops. The combined agricultural use of dieldrin and aldrin (aldrin rapidly transforms to dieldrin in the environment) was about 15 million lb in 1966, with 92 percent used on corn and 6 percent on orchards, vegetables, tobacco, and cotton. Agricultural uses of these insecticides decreased after the mid-1960s, and were discontinued by the mid-1970s. In addition to their agricultural use, aldrin and dieldrin were also widely used for termite control, most intensively in urban areas. Use of these compounds as termiticides continued until the late 1980s. Although quantitative data are not available, DDT also was used extensively in nonagricultural applications to control insects deemed to be a risk to public health (such as mosquitoes), as well as in forestry (U.S. Department of Health and Human Services, 2005; Larson and others, 1997). Compounds in the DDT group and dieldrin are all highly persistent—most with field-dissipation half-lives greater than 1,000 days (Nowell and others, 1999)—and all have a high affinity for soil organic matter (Appendix 2).

Concentrations of total DDT and dieldrin in bed-sediment samples from agricultural streams correspond reasonably well to both the total amounts and the distributions of their historical agricultural use (figs. 4–15 and 4–16). Reflecting the higher use of their parent pesticides, compounds in the DDT group were detected in bed sediment at 49 percent of agricultural stream sites, compared with 17 percent for dieldrin. The highest total DDT concentrations occurred in high-use areas of the Southeast—where cotton, tobacco, and peanuts were grown—and in a number of other high-use areas where orchard crops, potatoes, vegetables, or specialty crops were grown. Dieldrin was found at the highest overall concentrations in the Corn Belt, where use of aldrin on corn was most intensive.

Although there are few historical data on the urban use of organochlorine insecticides, the NAWQA bed-sediment results indicate that it probably was substantial. Compounds in the DDT group and dieldrin were found at higher frequencies and generally higher concentrations in urban streams than in agricultural streams, with the exception of DDT in some streams draining agricultural watersheds that had high DDT use in the past. Compounds in the DDT group were detected in 72 percent of samples from urban streams, compared with 42 percent for dieldrin.

For most streams with mixed land use in their watersheds, the concentrations of total DDT and dieldrin were generally similar to those in agricultural streams, but lower than those in urban streams. Streams in undeveloped watersheds had the lowest concentrations of these compounds.

In addition to agricultural uses, DDT also was applied to wetlands and marshes to control mosquitoes (photograph courtesy of the Tennessee Valley Authority Historic Collection, 1938).

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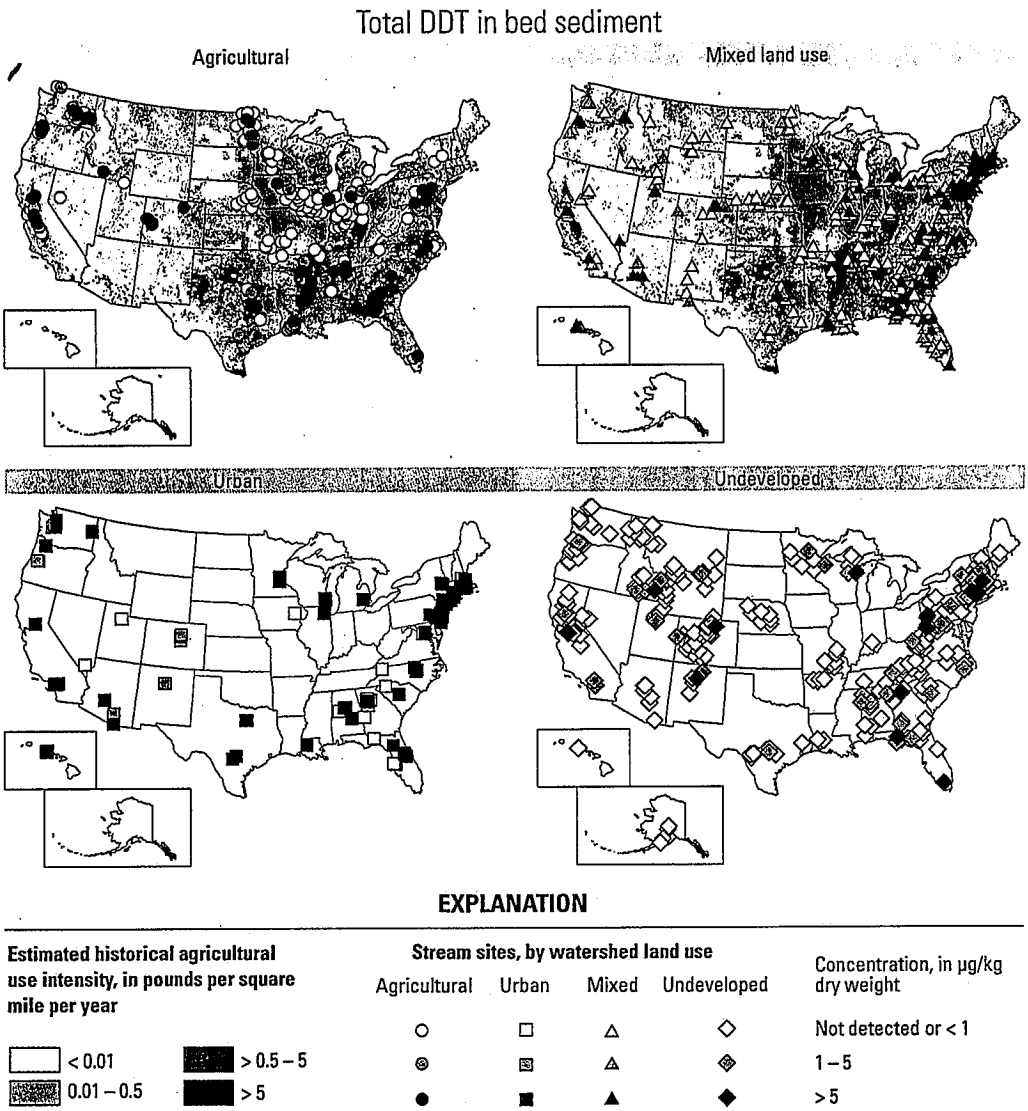

Figure 4–15. Total DDT concentrations in bed sediment were generally higher in urban streams than in agricultural and mixed-land-use streams, with the exception of a few streams draining watersheds in areas that had high agricultural use of DDT plus DDD in the past. The distribution of concentrations of total DDT found in bed sediment of agricultural streams corresponded reasonably well to both the total amount and the distribution of historical agricultural use of DDT plus DDD. Total DDT concentrations were highest in high-use areas of the Southeast where cotton, tobacco, and peanuts were grown, and in a number of other high-use areas where orchard crops, potatoes, vegetables, or specialty crops were grown. Historical use for the late 1960s was estimated as described in the "Methods" sidebar on p. 53.

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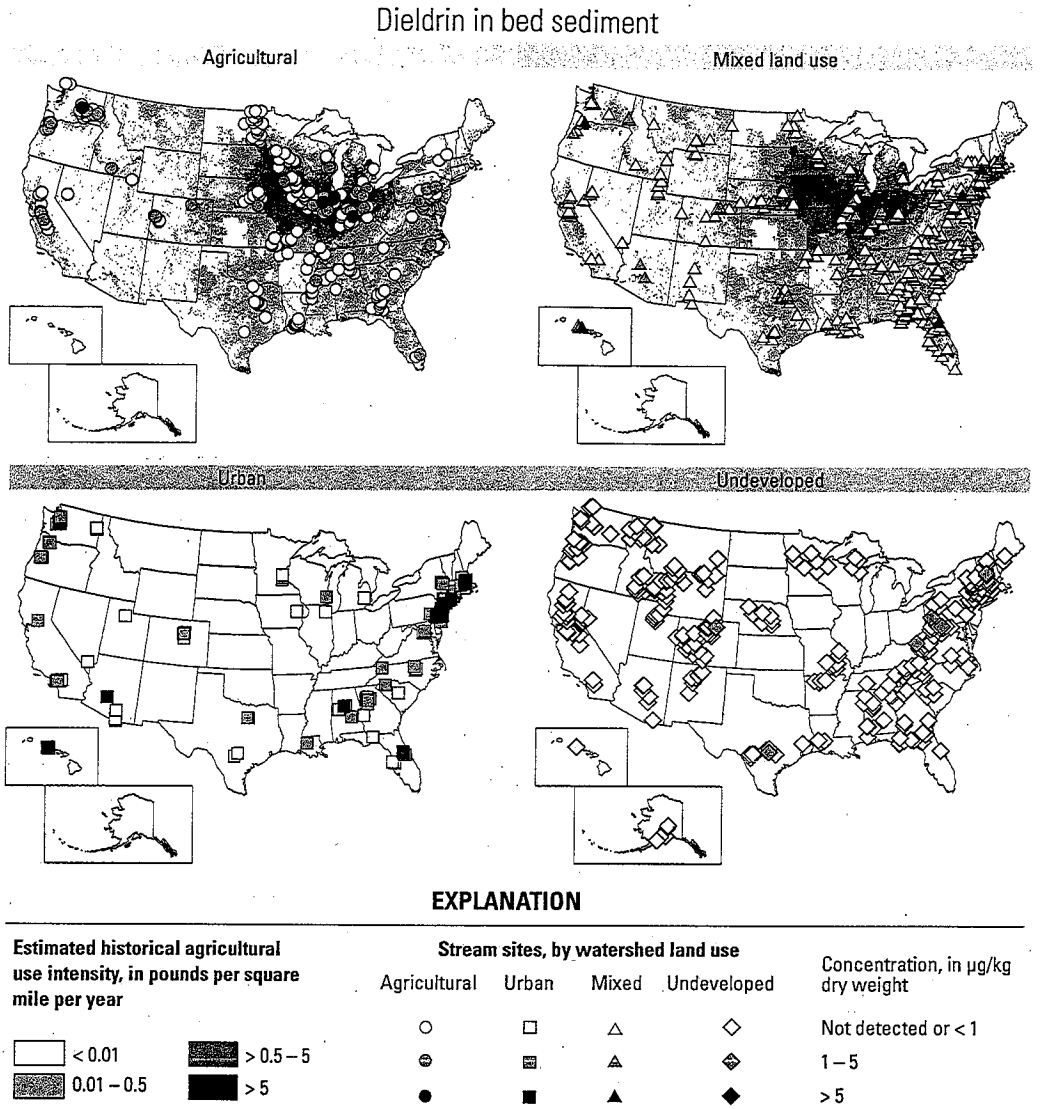
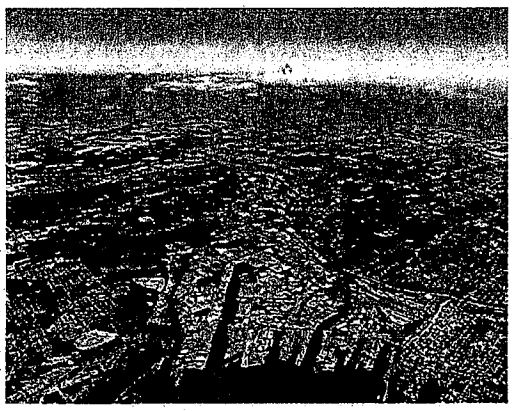


Figure 4–16. Dieldrin in bed sediment generally occurred at higher frequencies and higher concentrations in urban streams than in most agricultural streams. Concentrations of dieldrin found in bed sediment of agricultural streams corresponded reasonably well to the distribution of historical agricultural use of aldrin plus dieldrin. In agricultural streams, dieldrin was detected most frequently and at the highest overall concentrations in the Corn Belt, where past use of aldrin on corn was most intensive. Historical use for the late 1960s was estimated as described in the "Methods" sidebar on p. 53.

A012063

Complexities: Seasonality, Mixtures, and Degradates

The occurrence of pesticides in streams and ground water, which was characterized in relation to land use and the geographic patterns in pesticide use in Chapter 4, is further complicated by three additional factors: strong seasonal patterns, the prevalence of mixtures of pesticides, and the frequent occurrence of degradates. Seasonal patterns occur year after year in most streams and dictate the timing of the highest pesticide concentrations; mixtures of multiple pesticide compounds are found more often than individual pesticides; and pesticide degradates may occur more frequently and at higher concentrations than their parent compounds, particularly in ground water. These complexities need to be understood and considered when assessing the potential effects of pesticides on water quality.



Photograph © Kemar Nelson, Aqualis Aerial Photography, Tacoma, Washington.

A012064

Seasonal Patterns in Streams

Concentrations of pesticides in streams typically follow marked seasonal patterns year after year. These patterns generally are characterized by long periods of low or undetectable concentrations, punctuated by a few weeks or months of higher concentrations—a seasonal pulse. Such patterns are governed primarily by the timing and intensity of pesticide use in relation to hydrologic factors that affect the transport of pesticides to streams. Key hydrologic factors include the timing and amount of runoff from rainfall and irrigation, the presence or absence of surface or subsurface drainage systems, and the degree of interaction between streams and ground water. Seasonal patterns are important to characterize because they dictate the timing and duration of the highest concentrations of pesticides that may affect the suitability of water for humans, aquatic life, and wildlife.

NAWQA findings show that concentrations of pesticides in agricultural and urban streams across the Nation usually were highest during the growing season and lowest during the winter (fig. 5–1). The highest concentrations of herbicides—generally higher in agricultural streams than in urban streams—usually occurred during

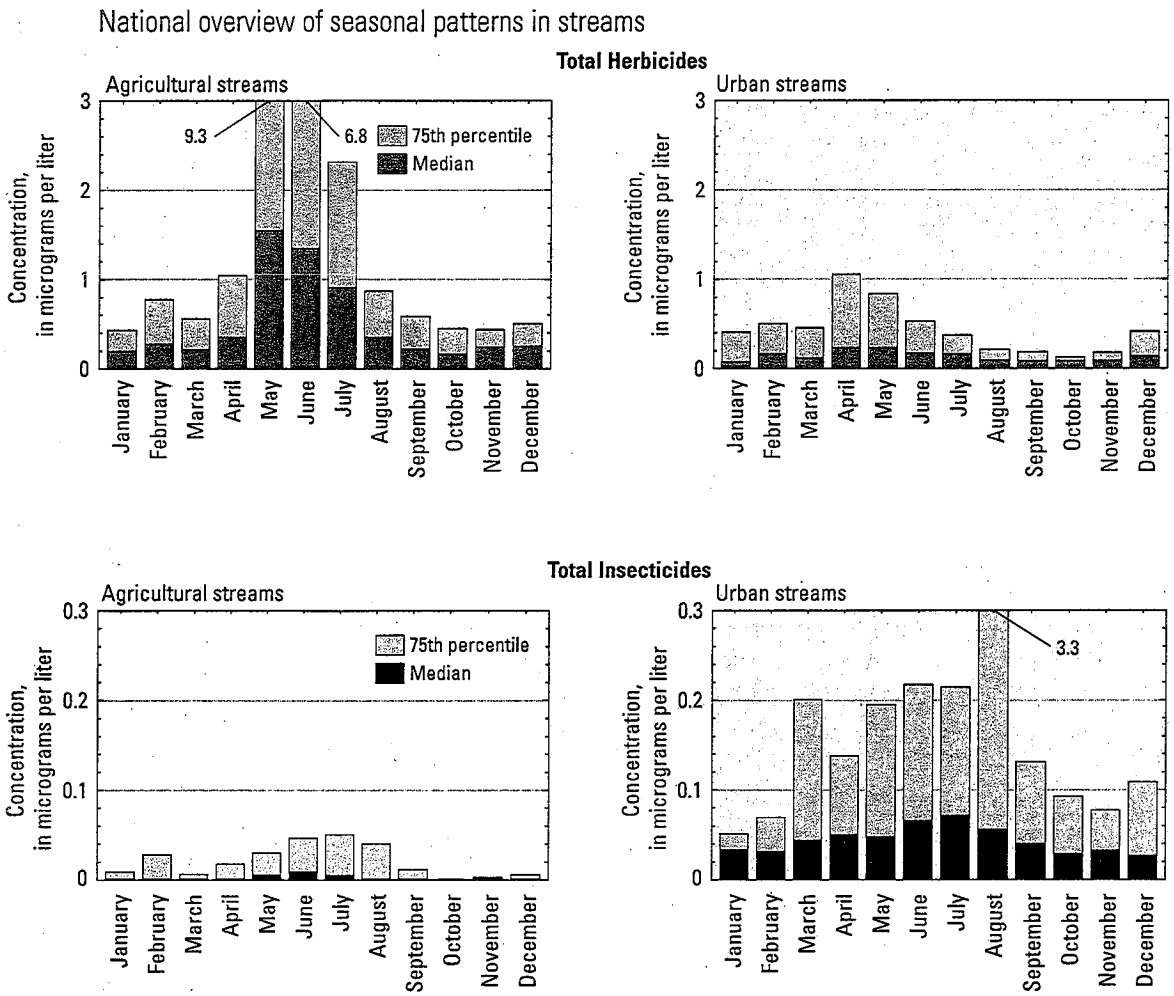
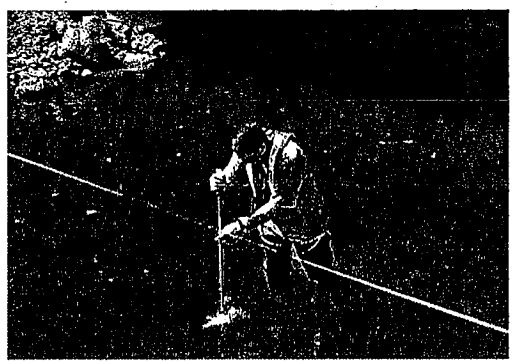


Figure 5–1. The timing and magnitude of seasonal pulses in the concentrations of herbicides and insecticides differed between agricultural and urban streams. Herbicide concentrations tended to be higher and seasonal patterns more pronounced in agricultural streams, but insecticide concentrations generally were higher in urban streams. Median and 75th percentile concentrations were determined after aggregating the total concentrations of herbicides and insecticides for all samples from agricultural streams and for all samples from urban streams.

A012065

April–July. In contrast, the highest concentrations of insecticides—generally higher in urban streams than in most agricultural streams—usually occurred at various times over a longer period, from March through September. Differences that may occur in seasonal patterns between agricultural and urban streams, even within the same geographic area, are illustrated by findings from the Mobile River Basin (fig. 5–2). Numerous additional examples of seasonal patterns have been characterized for streams in different parts of the country in individual NAWQA studies (see reports for the 51 NAWQA Study Units: *http://water.usgs.gov/nawqa/nawqasum/*).



Collecting a water sample from Cahaba Valley Creek.

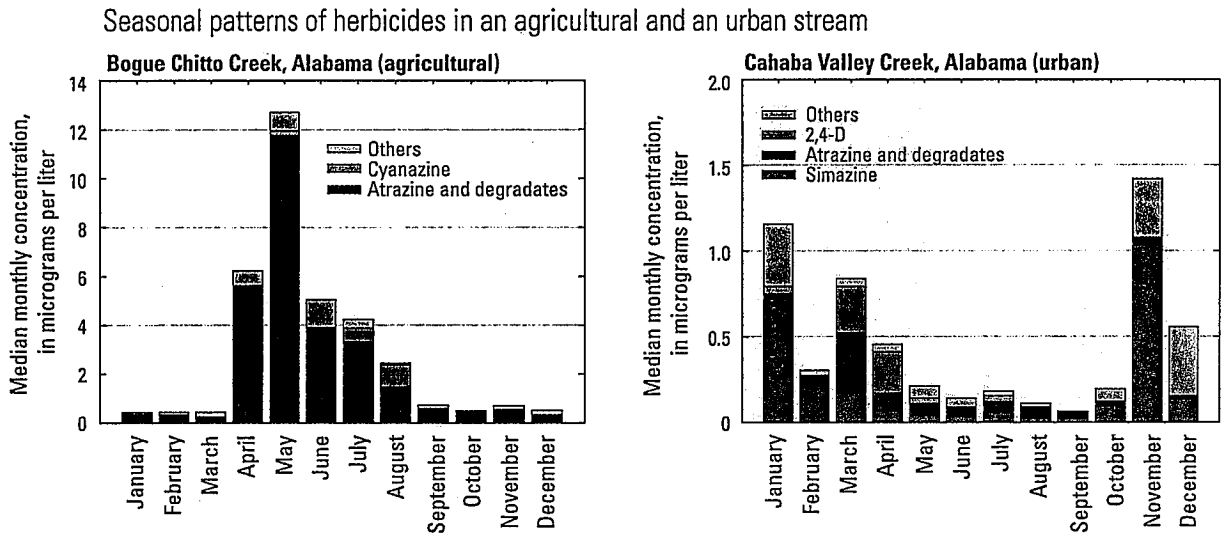


Figure 5–2. Atrazine and its degradates dominated herbicide concentrations in Bogue Chitto Creek, an agricultural stream (Mobile River Basin), with concentrations peaking in the spring following applications on corn fields and gradually declining throughout the summer and winter. In nearby Cahaba Valley Creek, an urban stream, herbicide concentrations were highest during November–April, and the dominant herbicide was simazine (Atkins and others, 2004).

A012066

Geographic Variability of Seasonal Patterns

Although the occurrence and concentrations of pesticides followed distinct seasonal patterns in most of the agricultural and urban streams sampled, the specific timing and magnitude of the observed patterns varied regionally and locally. This variability results from differences in such factors as the timing and amounts of pesticide use, climate, and the frequency and magnitude of runoff from rainstorms or irrigation. Seasonal patterns were particularly consistent within regions in which climate, land use, and crop types are relatively uniform, such as in the Corn Belt. The accompanying map and graphs (fig. 5–3) show examples that illustrate regional consistency, variability among streams, and land-use influences on seasonality using findings for atrazine, prometon, and diazinon in selected streams.

- Corn Belt Streams—Concentrations of atrazine, the dominant herbicide used in the Corn Belt during the study period, typically peaked after applications in the spring, as shown in four streams draining parts of Iowa, Indiana, Ohio, and Mississippi. Atrazine use generally is consistent from year to year, closely following annual patterns of weather and weed growth. Concentrations of prometon in these streams had weaker seasonal patterns and were lower than concentrations of atrazine, because prometon is used in smaller quantities and for a variety of nonagricultural purposes. Concentrations of diazinon were low or undetectable during most or all of the year in all Corn Belt streams except the Maumee River. The Maumee River has more urban land in its watershed compared with the other Corn Belt streams shown and was probably influenced more by nonagricultural diazinon use than the other streams.
- Urban Streams—Seasonal concentration patterns in three streams draining urban areas in Virginia, Georgia, and Nevada were more erratic than those observed in most agricultural areas. This was typical of the urban streams sampled nationwide, probably because pesticides are applied more sporadically in residential and commercial settings to control outbreaks of insects and weeds as they occur. Prometon and diazinon were generally detected at higher concentrations than atrazine in Las Vegas Wash and Accotink Creek, with the highest concentrations occurring during spring or summer. Sope Creek had higher concentrations of atrazine and lower concentrations of prometon than the other urban streams. The higher atrazine concentrations in Sope Creek may have resulted from the use of atrazine for treating turf grass in Georgia.
- Palouse River—Concentrations of prometon and atrazine were highest during winter and spring in the Palouse River in Washington, but were low overall compared with agricultural streams draining the Corn Belt. The Palouse River drains mostly nonirrigated cropland where wheat and other grains are the primary crops and pesticide use is relatively low.
- Orestimba Creek—Diazinon concentrations peaked during early winter and midsummer in Orestimba Creek, California, which drains irrigated farmlands dominated by orchards, vegetables, and alfalfa. Diazinon was used extensively in this watershed on almond orchards in January and February and on vegetable crops during the summer.

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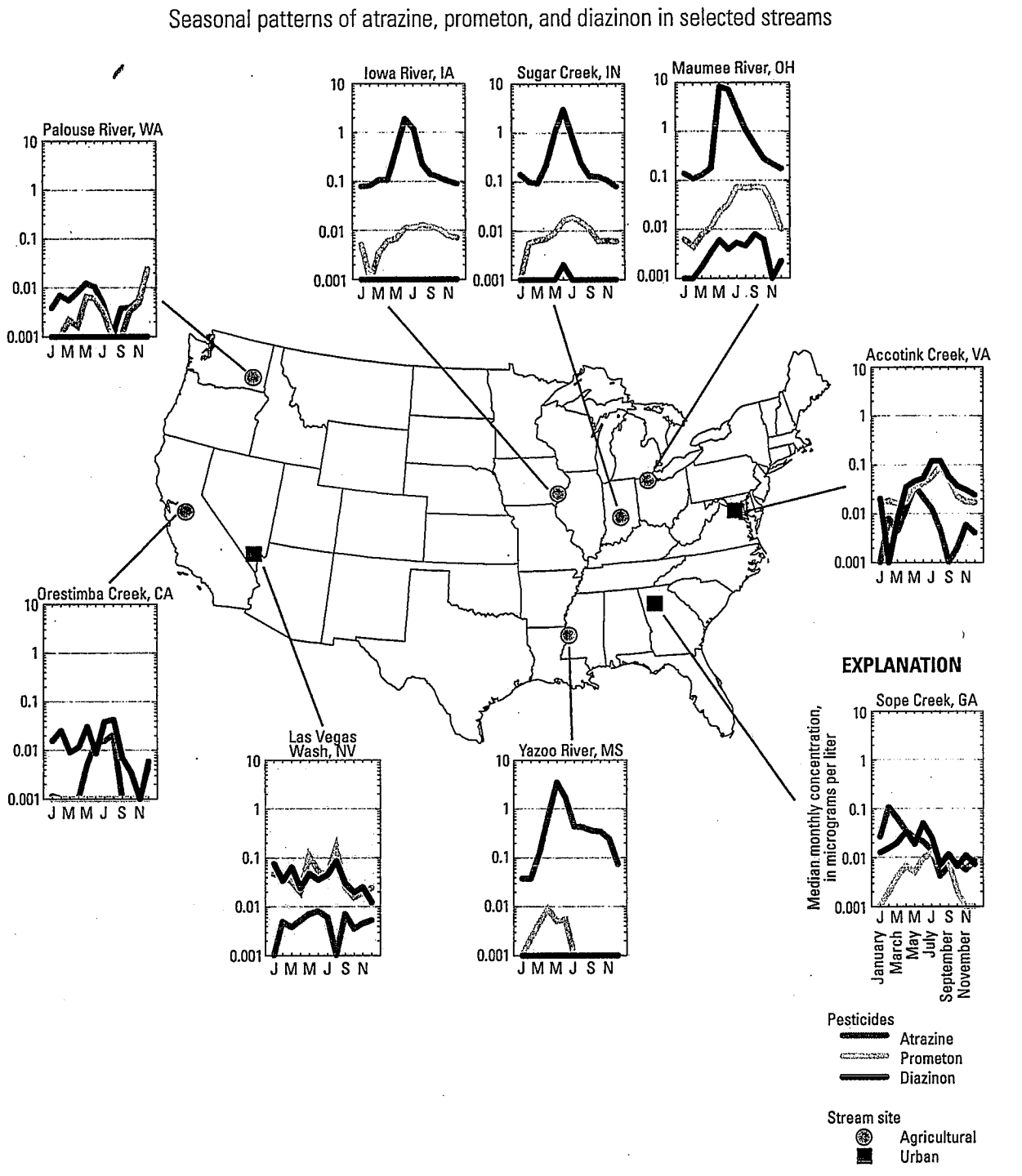

Figure 5–3. Examples of seasonal patterns in concentrations of atrazine, prometon, and diazinon in selected agricultural and urban streams illustrate (1) the regional consistency of patterns for atrazine within the Corn Belt, an area that has relatively uniform agricultural practices; (2) the variability among streams in different regions of the country; and (3) the differing influences of land use on seasonality. Median concentrations for each month were computed from at least 6 years of data for each site and nondetections are plotted at 0.001 µg/L.

A012068

Repetition of Seasonal Patterns

Seasonal patterns of pesticide concentrations in each particular stream generally repeat with varying degrees of consistency each year, as long as the pesticides are still in use. For example, atrazine concentrations in the White River followed the same pattern each year from 1992 to 2001 (fig. 5–4). Corn is planted in the region between mid-April and the end of May, and atrazine is applied each year to nearly all of the corn acreage during this time period. Runoff resulting from rainfall in May and June transports atrazine to streams, giving rise to the highest concentrations of the year during and after application. In contrast, patterns in chlorpyrifos concentrations in the White River were less regular (fig. 5–4) because the insecticide is generally applied only if and when it is needed to control outbreaks of corn root worm.

Importance of Seasonal Patterns

Seasonal patterns in pesticide concentrations are important to understand because they may affect the management of water quality for some drinking-water supplies and often define critical conditions of pesticide exposure for aquatic life in a stream. Although NAWQA did not measure pesticide concentrations at drinking-water intakes, NAWQA results for the wide range of streams sampled indicate that seasonal pulses of pesticide concentrations probably occur in some streams that are used as sources of drinking water—primarily those with substantial agricultural or urban land use in their watersheds. For drinking-water sources where seasonal patterns are evident, seasonal monitoring is important to support water-quality management decisions. For example, some drinking-water utilities that withdraw water from streams in agricultural areas employ specific management strategies to avoid use of stream water, or to increase treatment of the water, during known seasonal periods of high concentrations in source waters.

The seasonal timing of elevated pesticide concentrations in relation to the timing of changes in populations and life stages of aquatic organisms may largely determine whether pesticides have a substantial effect on aquatic life in a stream. USEPA's Office of Pesticide Programs, for example, evaluates potential acute effects of exposure on the basis of peak concentration, and potential chronic effects on the basis of the peak 21-day average for invertebrates and the peak 60-day average for fish (see Chapter 6). As indicated by figures 5–1 through 5–4, in most streams, these daily and multiday average concentrations are most likely to be approached or exceeded during relatively distinct seasonal periods for each pesticide. Knowledge of the seasonal timing of the highest concentrations for each pesticide—together with an understanding of the life stages of aquatic organisms present in each season—can be used to target and refine assessments of potential effects, and to design efficient pesticide monitoring strategies that will yield reliable estimates of the concentration statistics required for site-specific risk assessments.

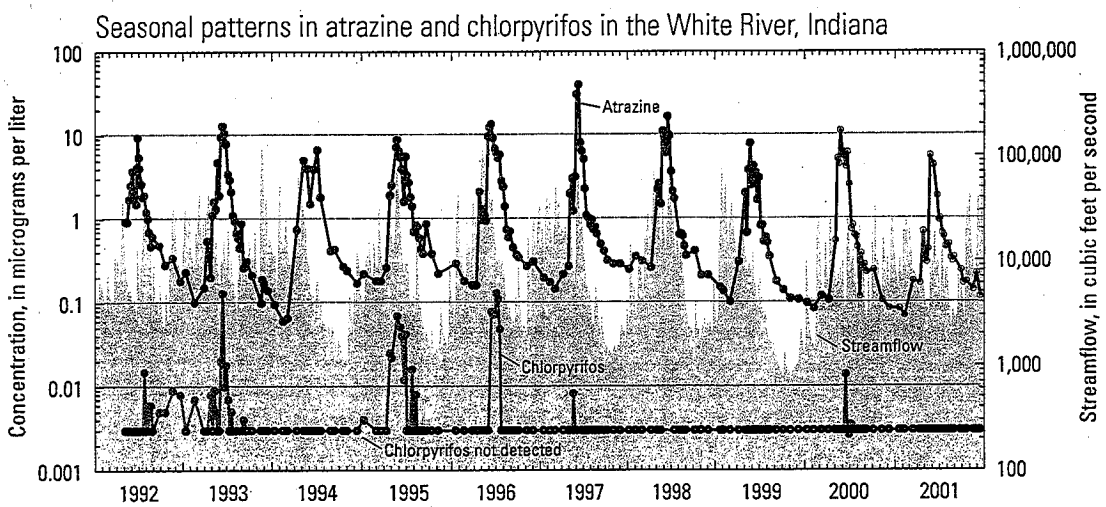

Figure 5–4. Atrazine concentrations in the White River (White River Basin) followed the same pattern each year during 1992–2001, corresponding to its use for weed control on nearly all of the corn acreage in the watershed each spring. In contrast, seasonal patterns in concentrations of chlorpyrifos and other insecticides tend to be more variable because insecticides are typically applied more sporadically than herbicides.

A012069

Mixtures of Pesticides

Assessment of the effects of pesticides on water quality is further complicated by the simultaneous occurrence of multiple pesticides and degradates as mixtures. The mixtures result from the use of different pesticides for multiple purposes within a watershed or ground-water recharge area. Pesticides generally occur more often as mixtures than as individual compounds. As a result, evaluation of the potential effects of mixtures of pesticides and other contaminants is an increasingly important component of the risk assessment methods used by USEPA, the Agency for Toxic Substances and Disease Registry (ATSDR), and other agencies (see Chapter 6).

Consistent with the results for individual compounds discussed in Chapter 4, mixtures of pesticides were detected more often in streams than in ground water (fig. 5–5) and at relatively similar frequencies in streams draining areas of agricultural, urban, and mixed land use. More than 90 percent of the time, water from streams in these developed land-use settings had detections of 2 or more pesticides or degradates; about 70 percent of the time, streams had 5 or more, and about 20 percent of the time, streams had detections of 10 or more pesticides or degradates. Mixtures also were found in streams draining undeveloped watersheds, but with far fewer compounds—about 25 percent of the time, undeveloped streams had detections of 5 or more pesticides or degradates, and no samples had more than 10.

In ground water, pesticide mixtures were detected most frequently in shallow wells in agricultural and urban areas—47 percent of wells sampled in agricultural areas and 37 percent of wells in urban areas had detections of 2 or more pesticides or degradates. Only about 9 percent of the wells sampled in these areas contained 5 or more pesticides or degradates, and less than 1 percent contained more than 10. Consistent with the slow rate of ground-water movement and the resulting greater opportunities for sorption and transformation with increasing residence time, co-occurrences of multiple pesticides and degradates were less frequent in wells that tap major aquifers—only about 20 percent of such wells had detections of 2 or more pesticides or degradates. Mixtures were least prevalent in wells sampled in undeveloped areas.

Mixtures of organochlorine pesticide compounds also were common in fish-tissue samples from most streams (fig. 5–6). About 90 percent of fish samples collected from urban streams contained 2 or more pesticide compounds and 33 percent contained 10 or more. Similarly, 75 percent of fish samples from streams draining watersheds with agricultural and mixed land use contained 2 or more pesticide compounds and 10 percent had 10 or more. As with water samples, mixtures were detected least often in fish from undeveloped streams, in which 2 or more compounds were detected in about 25 percent of the fish-tissue samples.

The potential for effects of mixtures on humans, aquatic life, and fish-eating wildlife is ultimately determined by the specific combinations of compounds that occur together, their concentrations, and when and where they occur. A unique mixture is defined in this report as a combination of 2 or more particular compounds detected in a given sample, regardless of whether other compounds were also detected in the same sample (Squillace and others, 2002). For example, a sample containing compounds A, B, and

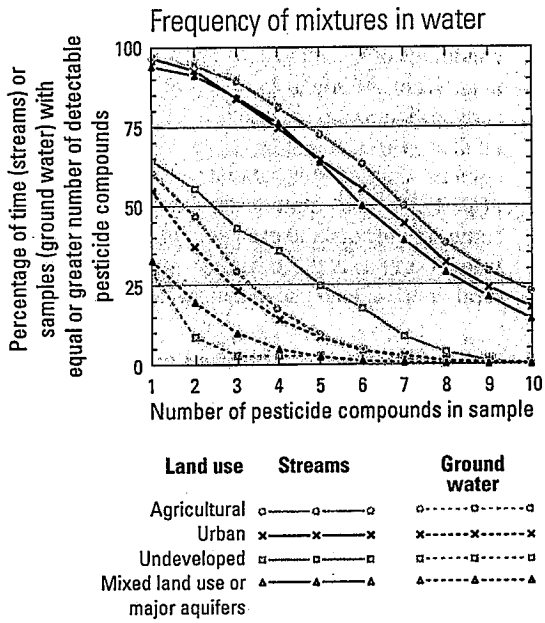

Figure 5–5. Mixtures of pesticide compounds analyzed in water were common in streams draining watersheds with agricultural, urban, and mixed land use. More than 90 percent of the time, water from streams in these land-use settings had detections of 2 or more pesticides or degradates, and almost 20 percent of the time, streams had detections of 10 or more. Mixtures were less common in ground water, but shallow wells in agricultural and urban areas had the most frequent occurrences of mixtures among all ground-water samples.

A012070

C contains four unique mixtures—AB, AC, BC, and ABC. The number of unique mixtures in one sample can be very large if many compounds are detected. A sample with 2 compounds has only one mixture, but a sample with five compounds contains 26 unique mixtures. Unique mixtures examined in this report were limited to those composed of the most commonly detected pesticide compounds—specifically, 25 compounds in water and 15 in fish tissue (figs. 4–2 and 4–4)—and were further limited to unique mixtures that occurred at least 2 percent of the time in streams or in at least 2 percent of samples for ground water and fish tissue.

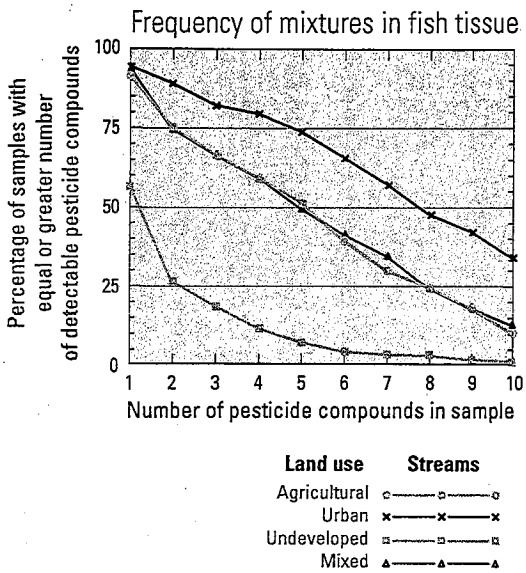

Figure 5–6. Mixtures of organochlorine pesticide compounds were detected in samples of whole fish from most streams. Fish in urban streams had the greatest numbers of organochlorine compounds detected, with about 90 percent of fish samples containing 2 or more compounds and 33 percent containing 10 or more. Streams in areas of agricultural and mixed land use had about 75 percent of fish-tissue samples with 2 or more compounds and 10 percent with 10 or more.

Unique Mixtures in Water

Streams have more unique mixtures than ground water (fig. 5–7), which is consistent with the more frequent detection of pesticides and their degradates in stream water compared with ground water. Analysis of all detections indicates that more than 6,000 unique mixtures of five pesticides were detected in agricultural streams, compared with only one unique mixture of five pesticides detected in shallow ground water within agricultural areas.

The number of unique mixtures varied with land use. For example, the greatest number of unique mixtures occurred in agricultural streams, probably because of the wide variety of agricultural settings represented, each involving the use of different combinations of pesticides (note the logarithmic scale in fig. 5–7). In ground water, however, the greatest number of unique mixtures occurred in shallow wells within urban areas, resulting primarily from the detection of urban herbicides that were not used or detected as frequently in agricultural settings. Major aquifers had the fewest mixtures, consistent with the lower frequencies of detection for individual compounds in these deeper ground waters.

The number of unique mixtures that can be detected is strongly influenced by the detection level for individual pesticides. In ground water, where pesticide concentrations usually are low, only 1 unique mixture of 2 compounds (atrazine and deethylatrazine in agricultural areas) was identified when the analysis was restricted to detected concentrations greater than 0.1 µg/L. In streams, however, many unique mixtures were detected—even when evaluating only detections greater than 0.1 µg/L (fig. 5–7). At the 0.1 µg/L detection level, greater distinctions were evident between land-use settings. For example, about 50 unique 5-compound mixtures were detected in agricultural streams when only individual pesticides at concentrations greater than 0.1 µg/L are considered (compared with more than 6,000 when including all detections at any concentration). In urban streams, only 6 unique 5-compound mixtures were detected above the 0.1 µg/L level.

The most frequent contributors to mixtures, not surprisingly, are the individual pesticides that were detected most often (fig. 5–8). These include the herbicides atrazine (and its degradate deethylatrazine), metolachlor, simazine, and prometon, each of which was present in more than 30 percent of all mixtures found in agricultural and urban areas, and in both streams and ground water. Also present in more than 30 percent of the mixtures were cyanazine, alachlor, metribuzin, and trifluralin in agricultural streams, and dacthal and the insecticides diazinon, chlorpyrifos, carbaryl, and malathion in urban streams. The most notable difference between urban and agricultural streams was the more common occurrence of insecticides in mixtures found in urban streams—consistent with the generally more frequent occurrence of insecticides in urban

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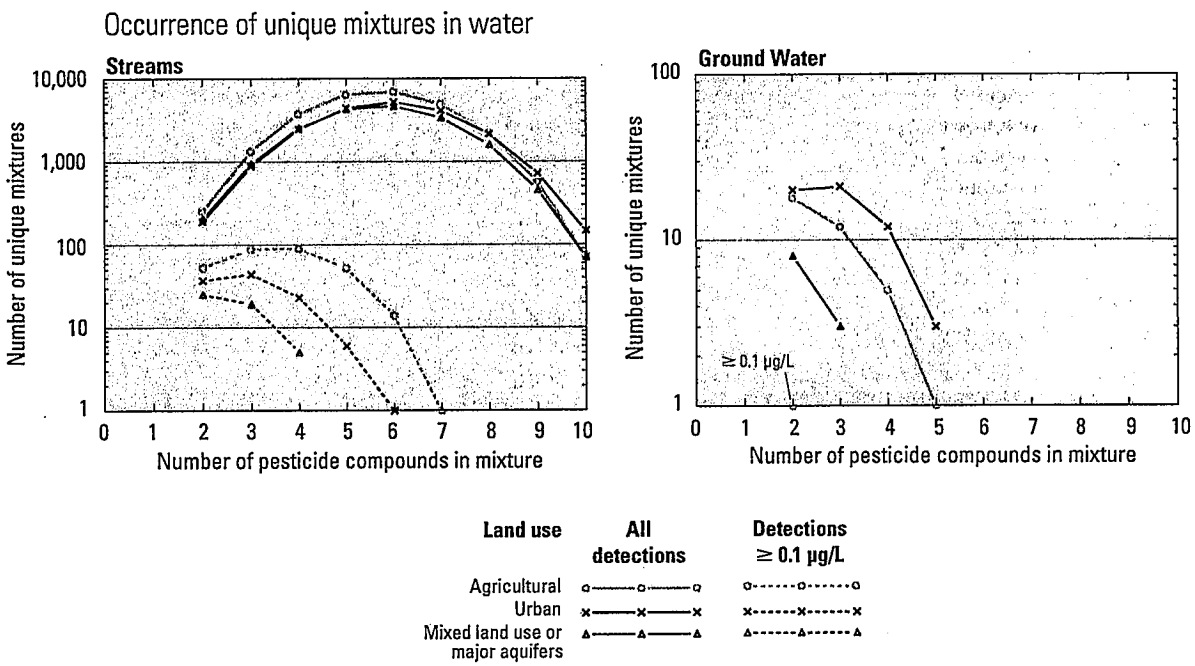
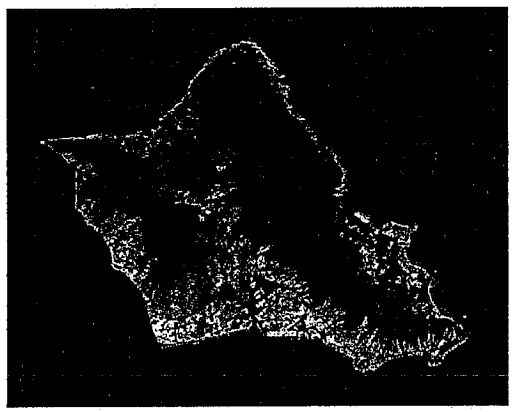


Figure 5–7. The number of unique mixtures detected in water was much greater in streams than in ground water. Considering all detections, more than 6,000 unique 5-compound mixtures were found in samples from agricultural streams, whereas only 1 unique 5-compound mixture was detected in shallow ground water beneath agricultural areas. Considering only pesticides detected at concentrations greater than or equal to 0.1 µg/L, the number of unique mixtures was far less. These graphs include only those unique mixtures that were composed of the 25 most prevalent pesticides and were detected in at least 2 percent of the samples.

streams. A notable difference in ground water between urban and agricultural areas was the occurrence of tebuthiuron, which was present in about 35 percent of the mixtures detected in wells in urban areas, but in less than 2 percent of the mixtures in wells in agricultural areas.

The unique mixtures detected most frequently in streams and ground water are summarized in table 5–1. This assessment is limited to the pesticides measured by NAWQA and by the sensitivity of the analytical method for each pesticide. For example, the analysis under-represents the contributions of 2,4-D, bentazon, bromacil, carbaryl, diuron, and norflurazon to mixtures, relative to the other pesticides, because these compounds were only detectable at higher concentrations. Most notably, 2,4-D was one of the most prevalent components of mixtures in both agricultural and urban streams at concentrations of 0.1 µg/L or greater. This implies that 2,4-D is also likely to be one of the most important contributors to mixtures at lower concentrations as well, but the low concentrations could not be measured.



Combinations of agricultural and urban land uses, such as those on Oahu, Hawaii, result in use of many different pesticides, leading to complex mixtures of pesticide compounds in streams and ground water (Landsat satellite image from the Pacific Disaster Center).

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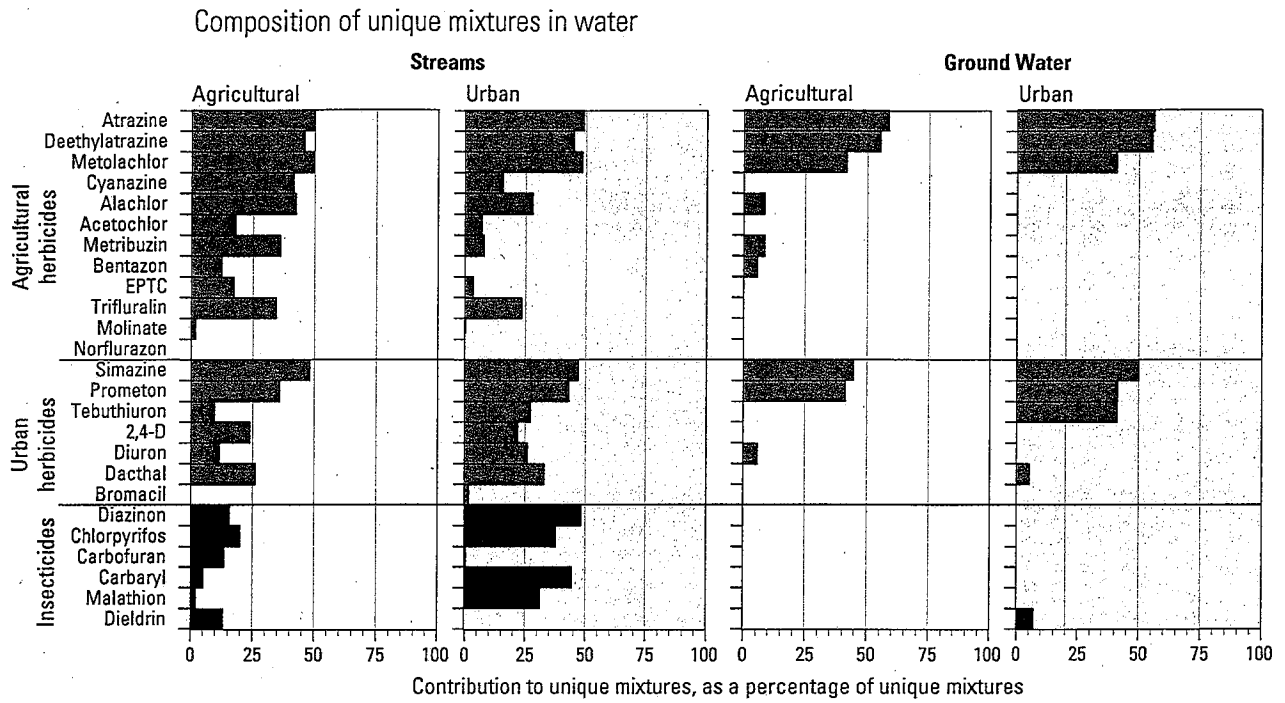

Figure 5–8. The most common components of mixtures, not surprisingly, were the pesticides and degradates that were detected most often. The most frequent contributors to unique mixtures were the herbicides atrazine (and deethylatrazine), metolachlor, simazine, and prometon—all of which were detected in more than 30 percent of all unique mixtures found in agricultural and urban areas and in streams and ground water. The most notable differences between agricultural and urban areas were (1) the greater contribution of insecticides to the mixtures detected in urban streams, and (2) the greater contribution of tebuthiuron to the mixtures found in shallow ground water in urban areas. This analysis is based on detections at any concentration, but includes only those unique mixtures that were composed of the 25 most-prevalent pesticides and were detected in at least 2 percent of samples.

A012073

Table 5–1. The most common unique mixtures of pesticides and degradates found in stream water and ground water illustrate the diversity and complexity of mixtures that occur in agricultural and urban areas. The mixtures detected most frequently for each number of compounds are shown for each land use, with all detections included, regardless of concentration. These most common unique mixtures serve as examples, rather than as a comprehensive compilation of all the most important mixtures, because other mixtures occurred almost as frequently.

Mixture	Frequency of detection (percentage of time for streams, or samples for ground water)			
	Streams		Ground water	
	Urban	Agricultural	Urban	Agricultural
2-compound mixtures				
Atrazine Prometon	79	50	15	10
Prometon Simazine	75	41	10	7
Atrazine Simazine	74	64	17	18
Atrazine Metolachlor	55	77	8	15
Atrazine Deethylatrazine	53	77	26	39
Deethylatrazine Simazine	49	57	15	17
Deethylatrazine Metolachlor	42	69	7	14
3-compound mixtures				
Atrazine Prometon Simazine	68	41	9	7
Atrazine Diazinon Prometon	60	10	1	0
Atrazine Diazinon Simazine	59	16	1	0
Diazinon Prometon Simazine	59	9	1	0
Atrazine Deethylatrazine Prometon	50	48	12	9
Atrazine Deethylatrazine Simazine	48	57	15	16
Atrazine Metolachlor Simazine	48	57	6	7
Atrazine Deethylatrazine Metolachlor	41	69	7	14
4-compound mixtures				
Atrazine Diazinon Prometon Simazine	53	9	1	0
Atrazine Deethylatrazine Prometon Simazine	46	39	8	7
Atrazine Metolachlor Prometon Simazine	43	38	4	4
Atrazine Deethylatrazine Metolachlor Prometon	39	45	5	6
Atrazine Deethylatrazine Metolachlor Simazine	37	52	5	7
Alachlor Atrazine Deethylatrazine Metolachlor	14	42	0	2
5-compound mixtures				
Atrazine Carbaryl Diazinon Prometon Simazine	36	2	0	0
Atrazine Deethylatrazine Diazinon Prometon Simazine	35	8	1	0
Atrazine Deethylatrazine Metolachlor Prometon Simazine	35	37	4	4
Atrazine Diazinon Metolachlor Prometon Simazine	35	8	0	0
Atrazine Deethylatrazine Prometon Simazine Tebuthiuron	28	16	2	1
Atrazine Deethylatrazine Metolachlor Simazine Tebuthiuron	22	19	2	1
Alachlor Atrazine Deethylatrazine Metolachlor Prometon	13	33	0	1
Alachlor Atrazine Deethylatrazine Metolachlor Simazine	13	33	0	1
Alachlor Atrazine Deethylatrazine Prometon Simazine	12	26	0	1
Atrazine Cyanazine Deethylatrazine Metolachlor Simazine	5	33	1	1

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Unique Mixtures in Fish Tissue

The numbers of unique mixtures of organochlorine pesticide compounds found in fish tissue are summarized in figure 5–9. Each individual parent compound, degradate, and by-product included in figure 4–4 was counted separately. Urban streams had more unique mixtures of these compounds in fish than streams draining areas with agricultural or mixed land use. For example, about 1,400 unique 5-compound mixtures were found in fish from urban streams, whereas streams in areas with agricultural or mixed land use had fewer than 800 unique 5-compound mixtures.

The relative contributions of most organochlorine compounds to mixtures in fish were about the same for urban and agricultural streams (fig. 5–10). This reflects the fact that most of these compounds originated with a small number of pesticide products that were applied many years ago in both land-use settings. The most frequent contributors were compounds derived from formulations of DDT and DDD (especially the *p,p'* isomers), dieldrin (resulting from use of either aldrin or dieldrin), chlordane, and heptachlor epoxide (resulting from use of heptachlor)(table 5–2). The most notable difference between agricultural and urban streams was the greater importance in urban streams of hexachlorobenzene (an industrial compound, as well as a fungicide) and both *o,p'*- and *p,p'*-DDT. The greater prevalence of DDT isomers in mixtures in urban streams, relative to agricultural streams, is consistent with the finding that the parent compounds (*o,p'*- and *p,p'*-DDT) made up a higher proportion of total DDT residues in fish from urban streams (16 percent) than in fish from streams with agricultural, undeveloped, or mixed-land-use watersheds (2–3 percent). These results indicate either that DDT was applied more recently in urban watersheds, or that there has been more recent transport of DDT-contaminated soils to the streams in urban areas than to streams in most agricultural watersheds. (DDT breaks down more rapidly in the absence of dissolved oxygen and is, in general, less persistent in aquatic sediment than in soil.)

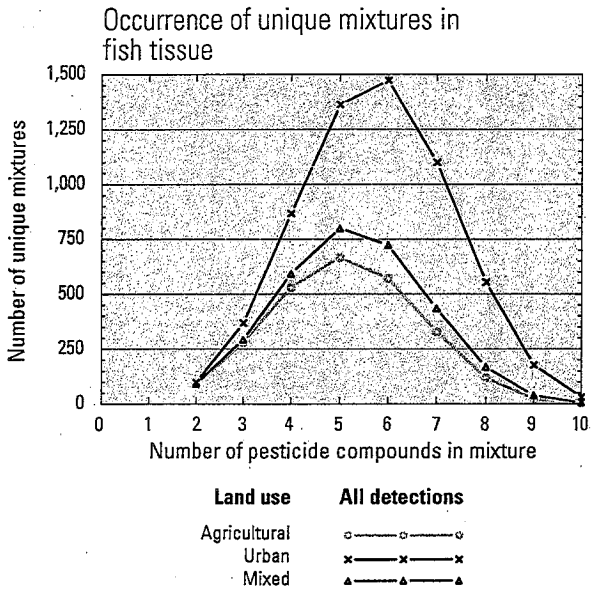

Figure 5–9. The numbers of unique mixtures of organochlorine pesticide compounds found in whole-fish tissue samples were greater in urban streams than in streams with agricultural or mixed-land-use watersheds. For example, about 1,400 unique 5-compound mixtures were found in fish from urban streams, whereas fewer than 800 unique 5-compound mixtures were detected in fish from agricultural and mixed-land-use streams. This analysis includes all detections, but only those unique mixtures that were composed of the 15 organochlorine pesticide compounds included in figure 4–4 and that were detected in at least 2 percent of samples.

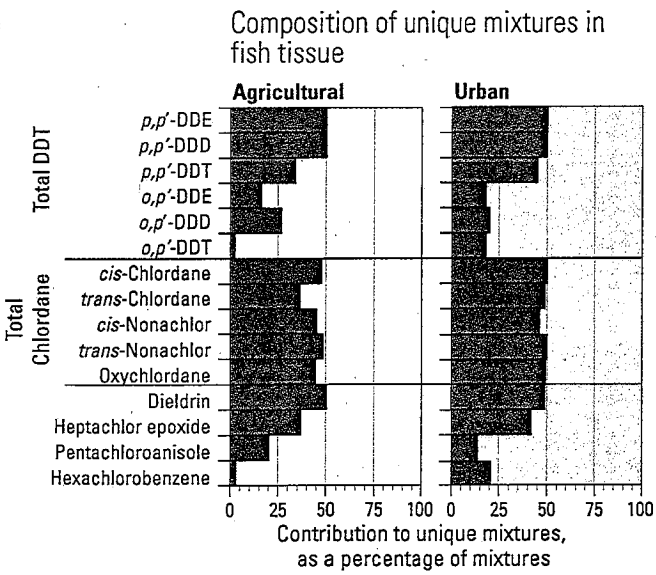

Figure 5–10. For the most part, compounds that contributed to unique mixtures found in fish tissue were similar for agricultural and urban streams, and 10 of the 15 compounds included in the analysis contributed to more than 30 percent of the mixtures in both land-use settings.

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Table 5–2. The most common unique mixtures of organochlorine pesticide compounds found in fish tissue were dominated by compounds derived from commercial formulations of DDT, DDD, and chlordane, as well as dieldrin. The mixtures detected most frequently for each number of compounds are shown for each land use. These most common mixtures serve as examples, rather than having unique importance, because many other mixtures occur almost as frequently.

Mixture	Frequency of detection (percentage of samples) Fish tissue	
	Urban streams	Agricultural streams
2-compound mixtures		
p,p'-DDE *trans*-Nonachlor	72	49
cis-Chlordane *p,p'*-DDE	72	37
cis-Chlordane *trans*-Nonachlor	72	35
p,p'-DDD *p,p'*-DDE	64	59
Dieldrin *p,p'*-DDE	53	59
3-compound mixtures		
cis-Chlordane *p,p'*-DDE *trans*-Nonachlor	68	35
cis-Chlordane *p,p'*-DDD *p,p'*-DDE	60	28
cis-Chlordane *p,p'*-DDD *trans*-Nonachlor	57	27
p,p'-DDD *p,p'*-DDE *trans*-Nonachlor	57	37
Dieldrin *p,p'*-DDE *trans*-Nonachlor	53	42
Dieldrin *p,p'*-DDD *p,p'*-DDE	40	47
4-compound mixtures		
cis-Chlordane *p,p'*-DDD *p,p'*-DDE *trans*-Nonachlor	56	27
cis-Chlordane *p,p'*-DDE *trans*-Chlordane *trans*-Nonachlor	51	25
cis-Chlordane *p,p'*-DDE *p,p'*-DDT *trans*-Nonachlor	51	9
cis-Chlordane Dieldrin *p,p'*-DDE *trans*-Nonachlor	50	33
cis-Chlordane Dieldrin *p,p'*-DDD *p,p'*-DDE	40	27
Dieldrin *p,p'*-DDD *p,p'*-DDE *trans*-Nonachlor	40	34
5-compound mixtures		
cis-Chlordane *p,p'*-DDD *p,p'*-DDE *trans*-Chlordane *trans*-Nonachlor	46	19
cis-Chlordane *p,p'*-DDD *p,p'*-DDE *p,p'*-DDT *trans*-Nonachlor	44	9
cis-Chlordane Dieldrin *p,p'*-DDE *trans*-Chlordane *trans*-Nonachlor	43	24
cis-Chlordane Dieldrin *p,p'*-DDD *p,p'*-DDE *trans*-Nonachlor	40	26
cis-Chlordane *cis*-Nonachlor Dieldrin *p,p'*-DDE *trans*-Nonachlor	39	23

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Importance of Mixtures

The frequent detection of pesticide mixtures in NAWQA samples from streams and ground water indicates that aquatic life, fish-eating wildlife, and potentially humans, are exposed primarily to mixtures of pesticides, rather than to individual compounds. As examined in Chapter 6, determining the potential effects of mixtures is an increasingly important aspect of risk-assessment procedures for pesticides. These procedures generally rely on indirect estimates of mixture toxicity—made from the toxicities of individual pesticides that occur—primarily because toxicity data are seldom available for specific unique mixtures that occur in the environment. The large number of unique mixtures present in streams, and to a lesser extent in ground water, make it impractical to assess the potential effects of all that are encountered (Lydy and others, 2004). NAWQA results provide an assessment of the unique mixtures that were detected most frequently—such as those summarized in tables 5–1 and 5–2—and make it possible to prioritize specific mixtures for further investigation. In developing a strategy for investigation, however, it must be kept in mind that findings about mixtures, like those regarding individual pesticides, are limited to the pesticides measured, and are influenced by the analytical methods used in this study. Thus, NAWQA data yield a minimum assessment of the occurrence of mixtures because of the limited number of pesticides and degradates that were analyzed.

NAWQA data on mixtures are beginning to be used to prioritize toxicological investigations. For example, the ATSDR is in the process of evaluating the toxicity of the mixture of atrazine, deethylatrazine, diazinon, nitrate, and simazine (ATSDR, 2004a) because of the frequency of its occurrence in public-supply and domestic wells that were sampled by NAWQA (Squillace and others, 2002). The importance to aquatic life, wildlife, and humans of mixtures that occur in streams and ground water is difficult to determine, and will require multiple approaches over an extended period of time.

Pesticide Degradates

Once released into the environment, pesticides are transformed over time by a variety of chemical, photochemical, and biologically mediated reactions into other compounds, which are referred to in this report as degradates. With time, degradates may become as prevalent as parent pesticides—or more so—depending on their rate of formation and their relative persistence. For example, deethylatrazine, which is a degradate of atrazine and other triazine herbicides, was one of the few degradates included in routine NAWQA analyses, one of the most frequently detected pesticide compounds in water (fig. 4–2), and one of the most frequent contributors to pesticide mixtures (fig. 5–8). In addition, degradates and by-products of organochlorine pesticides were among the most commonly detected pesticide compounds in fish (fig. 4–4). This and other evidence from many studies in a wide range of settings indicate that a diverse range of pesticide compounds routinely occur along with mixtures of parent pesticides (Boxall and others, 2004).

Degradates, like their parent compounds, have the potential to adversely affect water quality, depending on their toxicity. Degradates may be either more or less toxic than their parent pesticides, although most have toxicities to aquatic life that are similar to, or lower than, those of their parent compounds (Sinclair and Boxall, 2003; see accompanying sidebar, p. 81). For some pesticides that have not been registered or reregistered by USEPA during the last several years, the toxicities of degradates have not been evaluated, but current registration requirements include assessment of the toxicities of major degradates, as described in the accompanying sidebar on USEPA risk assessments (p. 86).

The rates of pesticide transformation and degradate formation vary widely among pesticides and under different environmental conditions, as discussed in Chapter 2. Each transformation reaction requires specific physical, chemical, and biological conditions. For example, most oxidation reactions require the presence of dissolved oxygen, whereas reduction reactions require its absence. Photochemical reactions require the presence of sunlight that has sufficient energy to break specific chemical bonds. Many transformations—such as the conversion of atrazine to deethylatrazine, or the formation of alachlor ethanesulfonic acid (ESA) from alachlor in soil—will not occur without the assistance of microbes or other organisms (Barbash, 2004). Selected transformations of atrazine are dis-

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Potential Risks of Pesticide Degradates to Aquatic Life

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Recent advances in analytical methodology and greater access to analytical standards have led to the detection of degradates from a wide variety of pesticides and other compounds in surface water, ground water, precipitation, air, and sediment (Boxall and others, 2004). Many of these degradates are more persistent in the environment than their parent compounds, and many are more mobile, as well.

In most cases, degradates have similar or lower toxicity to aquatic life than their parents, but some are more toxic. In a recent review of available ecotoxicity data for degradates of pesticides and other compounds, Sinclair and Boxall (2003) reported that 41 percent of degradates were less toxic than their parent compounds and 39 percent had a toxicity similar to their parents; however, 20 percent were more than 3 times more toxic than their parent compound and 9 percent were more than 10 times more toxic. In general, the greatest increases in toxicity from parent to degradate were observed for parent compounds that had a low toxicity. Similar patterns are apparent for degradates of 8 pesticides frequently detected by NAWQA (fig. 5–11), with 28 percent of the degradates being more toxic to fish than their parent compounds and 21 percent being more toxic to daphnids.

Because pesticides and their degradates are more commonly detected in environmental media as mixtures than as isolated compounds, assessments of their potential biological effects should account for the combined effects of multiple substances. As discussed in further detail in Chapter 6 of this report, the influence of a given compound A on the toxicity of a second compound B may be antagonistic (overall toxicity less than that of A and B combined), additive (overall toxicity is roughly equal to that of A and B combined) or synergistic (overall toxicity exceeds the added effects of the two compounds). The "mixture risk quotient" can be used to assess the combined risk of multiple compounds (parent compounds and/or degradates) simultaneously, based on the assumption that the toxic effects of different compounds are additive. This approach was recently applied by Fenner and others (2002) to assess the potential toxicities of predicted concentrations of nonylphenol ethoxylate (NPEO, a widely used nonionic surfactant) and its degradates to aquatic biota in Switzerland.

Although a variety of methods have been used to estimate mixture risk quotients, Fenner and others (2002) computed this parameter by summing the ratios of the concentrations predicted in Swiss rivers to the no-effect levels (for acute health effects in aquatic organisms) predicted for individual compounds in hypothetical mixtures of NPEO and its degradates. Risk quotients for NPEO alone and for each of the individual NPEO degradates were all below 1 for water and sediment, indicating relatively low risk to aquatic ecosystems with respect to acute (but not necessarily chronic) effects. The risk quotient calculated for the mixture of NPEO plus all of its transformation products, however, was 2.2, indicating a high risk of acute health effects for aquatic organisms if the toxicities are additive. This and other studies indicate that, in some instances, degradates from pesticides and other anthropogenic compounds may be of concern in the environment. An improved understanding is therefore needed of the environmental distributions, patterns of co-occurrence, and toxicities of these compounds in the hydrologic system—both in isolation and in mixtures.

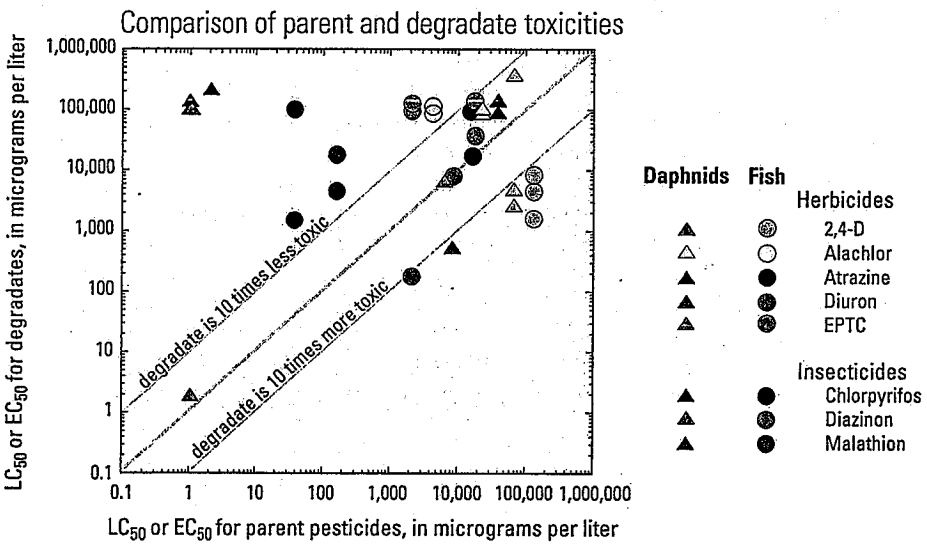

Figure 5–11. Comparison of acute toxicity values (LC_{50} or EC_{50}; see glossary) for parent compounds and degradates for 8 pesticides frequently detected by NAWQA in water samples from streams shows that 28 percent were more toxic to fish and 21 percent of the degradates were more toxic to daphnids than the parent pesticides. Multiples of the same symbol are different degradates of the same parent pesticide.

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played in figure 5–12, to show three of the multiple pathways that these reactions may involve, and to provide a sense of the complexity involved with tracking the formation, transport and fate of degradates for all of the pesticides in use. This example also illustrates the varying effects of different reactions on toxicity, discussed earlier. The first two reactions produce degradates with mammalian toxicities similar to that of the parent compound (atrazine). By contrast, the third reaction generates a compound (hydroxyatrazine) with substantially lower mammalian toxicity, owing to the removal of chlorine (Jordan and others, 1970; Rodriguez and Harkin, 1997).

As noted earlier, degradates are often more prevalent than their parent pesticides in streams and ground water, particularly when conditions favor transformation to degradates that are chemically persistent. In parts of some hydrologic systems, the concentrations of degradates may exceed those of the parent pesticides throughout much of the year. In surface waters, degradates often predominate when much of the streamflow is either from ground water, or from surface runoff occurring long enough after pesticide applications for the parent pesticide to have substantially transformed. For example, the summed concentrations of atrazine, cyanazine, acetochlor, alachlor, and metolachlor in the Iowa River in the Eastern Iowa Basins changed rapidly in response to the timing of their applications, but the summed concentrations of their degradates were higher and relatively constant throughout most of the year (fig. 5–13). Similarly, in the Mermentau River in the Acadian–Pontchartrain Drainages, the concentration of the insecticide fipronil reached its maximum value immediately following the spring application season, and then declined, to be exceeded by concentrations of fipronil degradates from June to February. This cycle repeated itself with the springtime applications the following year (fig. 5–14). Information on the concentrations and fluxes of degradates—especially in relation to those of their parent

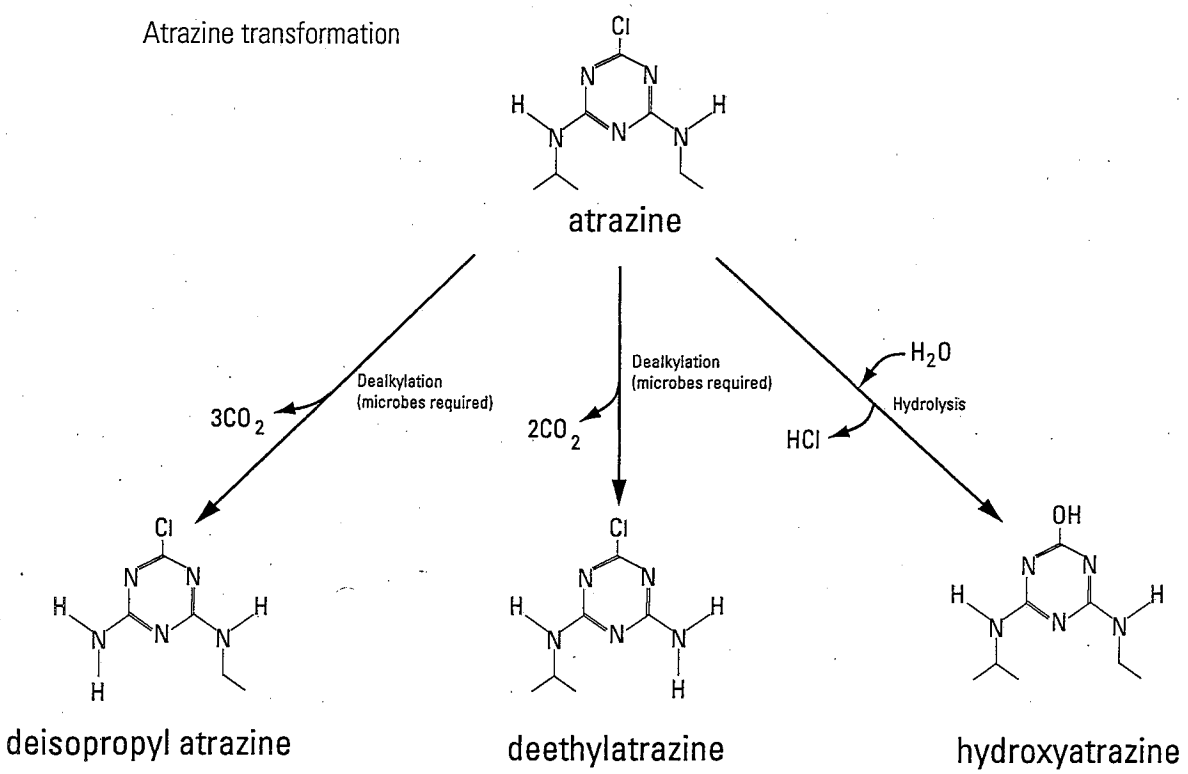

Figure 5–12. Atrazine transforms to three primary degradates (although there are others as well), one of which—deethylatrazine—was routinely measured by NAWQA. Two of these transformation reactions require microbes, resulting in the formation of deethylatrazine and deisopropyl atrazine. The third is hydrolysis, an abiotic reaction with water that produces the degradate hydroxyatrazine.

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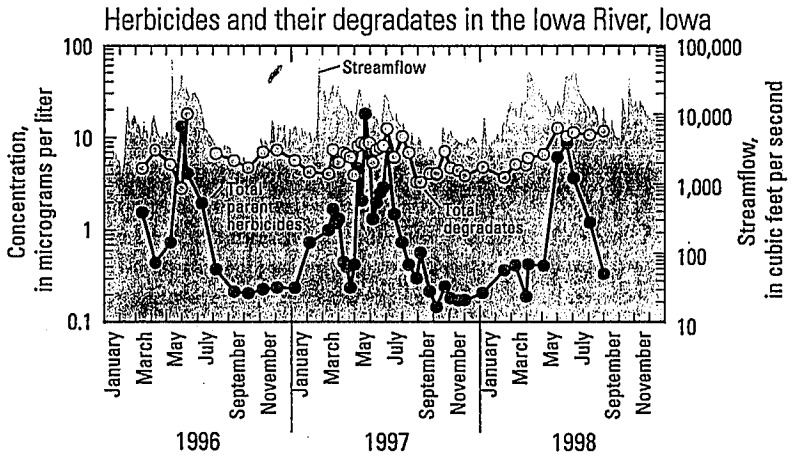

Figure 5–13. The summed concentrations of the parent herbicides atrazine, cyanazine, acetochlor, alachlor, and metolachlor in the Iowa River (Eastern Iowa Basins) rose and fell in response to spring applications, whereas the summed concentrations of their degradates remained relatively steady and at higher levels throughout most of the year (Schnoebelen and others, 2003).

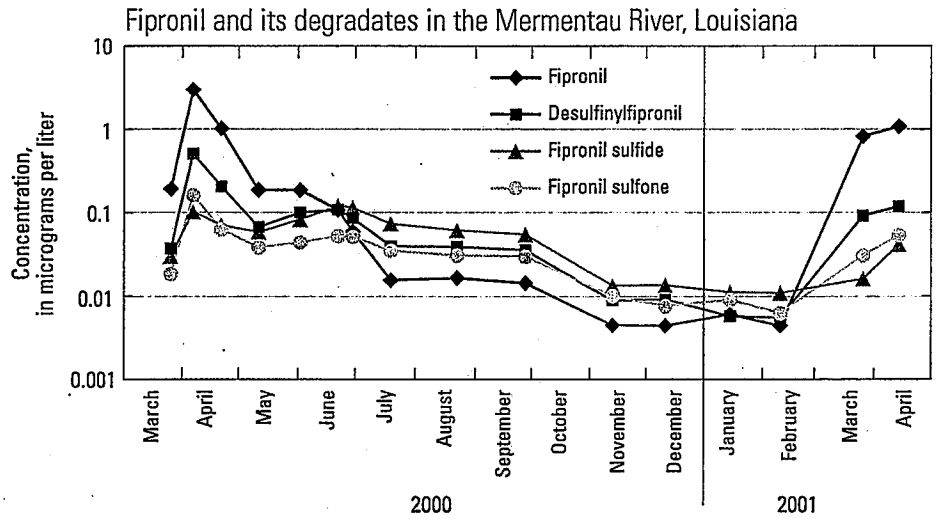

Figure 5–14. Concentrations of the insecticide fipronil and its degradates in the Mermentau River (Acadian–Pontchartrain Drainages) peaked in March or April, following applications. Although fipronil dominated the total concentration of fipronil compounds during the high-use period, concentrations of its degradates were greater during the rest of the year (Demcheck and others, 2004).

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pesticides—contributes to our understanding of the environmental fate of pesticides as they move and transform within the hydrologic system.

In ground water, degradates were often detected more frequently, or at higher concentrations, than their parent pesticides. For example, in ground water of the Upper Illinois River Basin, degradates of acetochlor, alachlor, metolachlor, and atrazine accounted for substantially more detections than the parent compounds (fig. 5–15). Two of the principal factors likely to be responsible for this general observation are that (1) ground water recharges through soil where microbial populations—and thus transformation rates—are relatively high, and (2) residence times in ground water are usually long prior to sample collection, allowing more time for transformations to occur than is usually the case for surface waters.

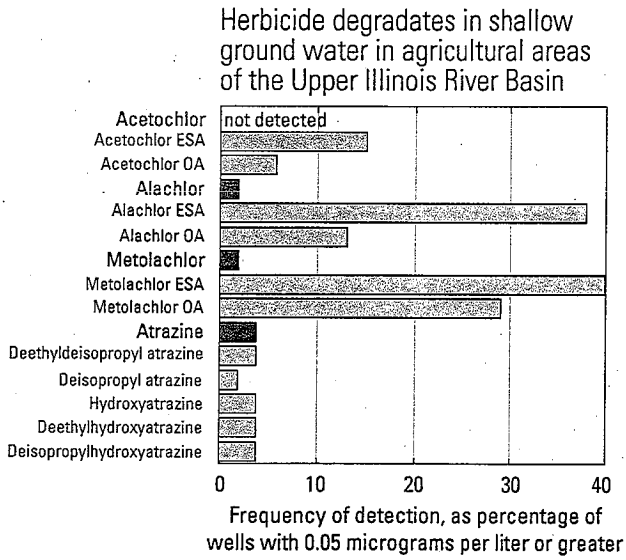


Figure 5–15. In ground water of the Upper Illinois River Basin, degradates (light bars) were generally detected more frequently than parent compounds (dark bars) for the acetanilide herbicides (acetochlor, alachlor, and metolachlor), but at comparable frequencies for atrazine (Groschen and others, 2004).

Deethylatrazine-to-Atrazine Ratios

As pesticides are transported through the hydrologic system, transformations occur continuously and at various rates, resulting in changes in the proportional relations between parent pesticides and their degradates with time and space. In general, the extent of transformation increases with increasing residence time in the hydrologic system. As a result, degradate-to-parent compound concentration ratios—such as the deethylatrazine-to-atrazine ratio (Adams and Thurman, 1991)—have been used as indicators of residence time in the environment. Because the transformation of atrazine to deethylatrazine requires microbial assistance (fig. 5–12)—and microbial populations are generally much higher in the soil than at greater depths beneath the land surface or in surface waters—the deethylatrazine-to-atrazine ratio provides an indication of the amount of time that atrazine has been in contact with soil. In streams, the deethylatrazine-to-atrazine ratio increased with the time elapsed between atrazine applications and sampling—from the lowest values during atrazine applications in the spring, to higher values in autumn, and to the highest values in winter, just before applications (fig. 5–16). Figure 5–17 shows how the ratio changed over time during the year in the White River. Because the analytical recovery (the proportion of the actual total concentration that could be measured) for deethylatrazine was lower than for atrazine, the ratios reported here underestimate the true value, but the focus of this analysis is on the relative magnitudes of the ratios among different media, settings, and times of year, rather than their absolute values.

Deethylatrazine-to-atrazine ratios were generally higher in ground water than in streams throughout the year, reflecting the longer periods of time spent in contact with soil for the atrazine detected in the ground-water system, relative to streams (fig. 5–16). The proportions of deethylatrazine in water collected from major aquifers—which generally represents ground water that is deeper and older than water collected from shallow wells—were typically higher than those measured in the shallow ground water sampled within agricultural areas.

A012081

Importance of Pesticide Degradates

NAWQA results are consistent with findings from other studies that found that pesticide degradates occur frequently in streams and ground water (Battaglin and others, 2001; Scribner and others, 2003; Kolpin and others, 1998; Kolpin and others, 2004). Assessment of the occurrence, distribution, and toxicities of pesticide degradates in the hydrologic system is important because of the potential effects of these compounds on human health and the environment (Sinclair and Boxall, 2003), as well as their value for understanding the ultimate fate of pesticides in the hydrologic system (Barbash, 2004). Pesticide degradates should continue to be considered and accounted for in assessments of pesticide exposure and in evaluating the potential effects of pesticides. Improved assessment of pesticide degradates will require expanded coverage of degradates in water-quality monitoring, continued research on pesticide transformations and transport, and continued attention to these compounds in toxicity studies, including as components of pesticide mixtures (see Chapter 6).

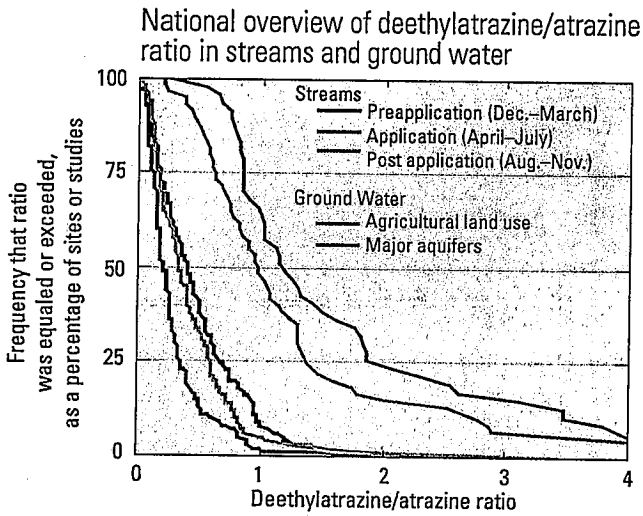


Figure 5–16. The ratios of deethylatrazine to atrazine concentrations—which increase with the transformation of atrazine to deethylatrazine—increased with increasing residence time in the hydrologic system. (Ratios were computed from µg/L concentrations for all NAWQA stream and ground-water samples in which both compounds were detected.)

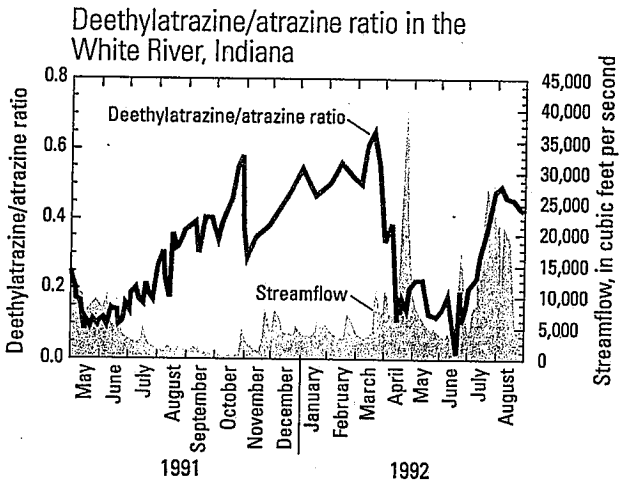


Figure 5–17. The ratios of deethylatrazine to atrazine concentrations in the White River (White River Basin) were lowest in the spring, following widespread atrazine applications. The ratio generally increased through the summer and winter as atrazine transformed to deethylatrazine and ground water made up an increasing proportion of streamflow. (Ratios were computed from µg/L concentrations; modified from Carter and others, 1995.)

White River, Indiana.

A012082

Pesticide Degradates in USEPA Risk Assessments and Regulations

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

When USEPA characterizes the risks of a pesticide to humans and the environment to meet the requirements of FIFRA, the agency evaluates both the parent pesticide and its degradates. Before a pesticide is registered, USEPA reviews and evaluates available studies on the pesticide's properties and effects, including its degradates (USEPA, 2005a). The types of data needed vary depending on how and where the pesticide is used (USEPA, 2004a).

Available studies may provide information on the degradation rates, mobility parameters, and toxicity for potentially important degradates. If adequate data are not available for specific degradates, USEPA's risk assessments for drinking-water exposure under FIFRA assume that degradates are highly persistent and mobile. If different toxicities are expected between degradates and the parent pesticide, concentrations are estimated separately. If the same toxicity is expected, concentrations of the parent and degradates are added together. These risk estimates are often conservative (protective) because it is frequently assumed that the degradate and parent have equal toxicities and that they are mobile and persistent. If data are available for a specific degradate, however, then those data are used. In some cases, degradates are known to be more toxic than the parent compound. In situations where degradates occur in substantial amounts or are of toxicological concern, risk assessments include a quantitative or qualitative analysis of the potential implications of an organism's exposure to these degradates, in addition to the parent pesticide.

USEPA environmental fate scientists work with human health and ecotoxicology scientists to identify the degradates of toxicological concern. The formation of degradates is monitored as part of fate studies required for pesticide registration. Methods are used that have detection limits sufficiently low to allow for detailed tracking of the production of degradates. Degradates formed at greater than 10 percent of radioactively labeled parent pesticide are considered major degradates and must be identified (USEPA, 1982). The 10-percent criterion is a general guideline, such that degradates approaching concentrations of 10 percent of the parent are usually identified as well. In addition, degradates of known toxicological or ecotoxicological concern must be quantified and identified even when present at lower levels.

When environmental monitoring data are available for pesticide degradates, the data are characterized and summarized in USEPA's assessments for FIFRA. In evaluating monitoring data, scientists evaluate the analytical methods used, pesticide-use information, and the design of the monitoring studies. Monitoring data on the occurrence of degradates are included in the FIFRA risk assessment, but the assessment of risk also depends on a variety of additional factors, including the mode of toxicity of the degradate—information that is needed to determine if concentrations of the parent pesticide and degradates can reasonably be aggregated to assess risk.

Clean Water Act (CWA)

Ambient water-quality criteria, developed by USEPA under section 304(a) of the CWA, focus on individual chemicals. If a degradate is toxicologically important, a separate criterion may be developed for the degradate. Human health ambient water-quality criteria exist for DDT, DDE, and DDD; endrin and endrin aldehyde; heptachlor and heptachlor epoxide; and endosulfan and endosulfan sulfate. Whole-effluent toxicity tests, described in Chapter 6 in relation to assessing potential effects of pesticide mixtures on aquatic life, also provide an approach for assessing degradate toxicity.

Safe Drinking Water Act (SDWA)

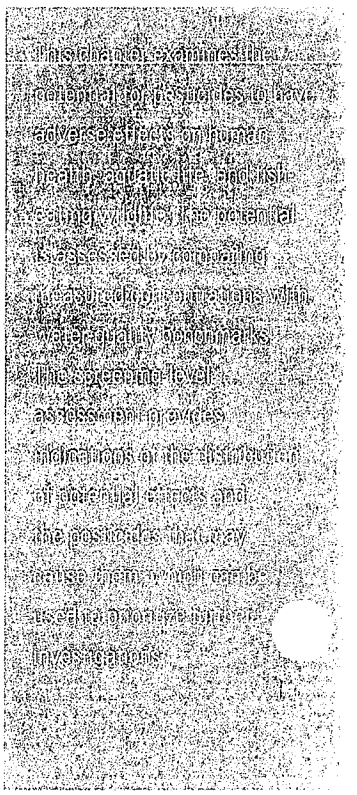
Maximum Contaminant Levels (MCLs) are legally enforceable drinking-water standards developed by USEPA under the SDWA. Although drinking-water standards have typically been developed only for the pesticide parent, the SDWA does not preclude USEPA from developing standards for pesticide degradates. Several unregulated pesticide degradates are listed on USEPA's drinking-water Contaminant Candidate List (CCL) and its Unregulated Contaminant Monitoring Regulation (UCMR) (USEPA, 2005b,c). Once sufficient information and data are available on health risks, occurrence, analytical methods, and treatment technologies, USEPA will determine whether any of the listed pesticide degradates are candidates for future drinking-water standards.

USEPA also develops drinking-water Health Advisories for chemical substances, including some pesticides and pesticide degradates. Health Advisories, which are not legally enforceable, provide technical guidance for Federal, State, Tribal and local officials in the event of an emergency spill or contamination situation. USEPA periodically updates Health Advisories when new information becomes available (USEPA, 2005d).

A012083

Potential for Effects on Human Health, Aquatic Life, and Wildlife

The occurrence of pesticides in streams and ground water raises the question—Do pesticides occur at concentrations that may affect human health or stream ecosystems? Comparisons of concentrations measured by NAWQA to water-quality benchmarks provide a screening-level assessment of the potential for adverse effects. Concentrations of pesticides detected in streams and wells were usually lower than human-health benchmarks, indicating that the potential for effects on drinking-water sources probably is limited to a small proportion of source waters. More than half of the wells sampled, but none of the stream sites that were sampled, are current sources of drinking water. Concentrations in streams more frequently exceeded benchmarks for aquatic life and fish-eating wildlife. More than half of all agricultural streams sampled and more than three-quarters of all urban streams had concentrations of pesticides in water that exceeded one or more benchmarks for aquatic life. In addition, organochlorine pesticides—most uses of which were discontinued 15–30 years ago—still exceeded benchmarks for aquatic life and fish-eating wildlife in bed-sediment or fish-tissue samples from many streams.



A012084

Screening-Level Assessment of Potential Effects

The potential for pesticide concentrations measured by NAWQA to adversely affect human health, aquatic life, or fish-eating wildlife was evaluated by screening-level assessments similar in concept to USEPA screening-level assessments (USEPA, 2004d). The NAWQA screening-level assessments compare site-specific estimates of pesticide exposure (concentration statistics or concentrations determined from measurements of pesticides in various media at NAWQA sampling sites) with water-quality benchmarks derived from standards and guidelines established by USEPA, toxicity values from USEPA pesticide risk assessments, and selected guidelines from other sources. The characteristics and limitations of screening-level assessments are summarized in the accompanying sidebar on page 89. The USEPA standards, guidelines, and toxicity values were developed by USEPA as part of the Federal process for assessing and regulating pesticides, as summarized in the sidebar on page 90.

NAWQA studies were not designed to evaluate specific effects of pesticides on humans, aquatic life, or fish-eating wildlife. The screening-level assessment is not a substitute for either risk assessments, which include many more factors (such as additional avenues of exposure), or site-specific studies of effects. Rather, comparisons of measured concentrations with water-quality benchmarks provide a perspective on the potential for adverse effects, as well as a framework for prioritizing additional investigations that may be warranted. Measured concentrations that exceed a benchmark do not necessarily indicate that adverse effects are occurring—they indicate that adverse effects *may* occur and that sites where benchmarks are exceeded may merit further investigation.

Screening-level assessments should be considered as a first step toward addressing the question of whether or not pesticides are present at concentrations that may affect human health, aquatic life, or wildlife. They provide a perspective on where effects are most likely to occur and what pesticides or degradates may be responsible. As improved data on toxicity and environmental concentrations are developed, benchmarks and exposure estimates can be updated, and the assessments can be improved and expanded. USGS works closely with USEPA to assist them with incorporating NAWQA findings into their risk assessments.

NAWQA screening-level assessments for pesticides are presented in this chapter for human health (concentrations in water), aquatic life (concentrations in water and bed sediment), and fish-eating wildlife (concentrations in whole fish). The selection of benchmarks for each of these assessments is described below along with results and the specific values and sources for benchmarks used are provided in Appendix 3. Each type of benchmark selected for use in the screening-level assessment applies to a specific sampling medium (such as water or bed sediment) and to a specific use of the water resource (such as for drinking water or to support aquatic life). Priority was given to (1) benchmarks based on USEPA standards, guidelines, or toxicity values; (2) benchmarks that are nationally relevant because of the nature or breadth of toxicity data on which they are based; and (3) systematically derived suites of benchmarks that share a common methodology and are available for a large number of NAWQA analytes.

A012085

Characteristics and Limitations of the Screening-Level Assessment of Potential Effects

The NAWQA screening-level assessment provides an initial perspective on the potential importance of pesticides to water quality in a national context by comparing measured concentrations with water-quality benchmarks. The screening-level assessment is not a substitute for risk assessment, which includes many more factors, such as additional avenues of exposure. The screening-level results are primarily intended to identify and prioritize needs for further investigation and have the following characteristics and limitations.

- Most benchmarks used in this report are estimates of no-effect levels, such that concentrations below the benchmarks are expected to have a low likelihood of adverse effects and concentrations above a benchmark have a greater likelihood of adverse effects, which generally increases with concentration.
- The presence of pesticides in streams or ground water at concentrations that exceed benchmarks does not indicate that adverse effects are certain to occur. Conversely, concentrations that are below benchmarks do not guarantee that adverse effects will not occur, but indicate that they are expected to be negligible (subject to limitations of measurements and benchmarks described below).
- The potential for adverse effects of pesticides on humans, aquatic life, and fish-eating wildlife can only be partially addressed by NAWQA studies because chemical analyses did not include all pesticides and degradates. In addition, some compounds analyzed by NAWQA do not have benchmarks.
- Most benchmarks used in this report are based on toxicity tests of individual chemicals, whereas NAWQA results indicate that pesticides usually occur as mixtures. Comparisons to single-compound benchmarks may tend to underestimate the potential for adverse effects.
- Water-quality benchmarks for different pesticides and media are not always comparable because they have been derived by a number of different approaches, using a variety of types of toxicity values and test species.
- For some benchmarks, there is substantial uncertainty in underlying estimates of no-effect levels, depending on the methods used to derive them and the quantity and types of toxicity information on which they are based. This is especially true of fish-tissue benchmarks for the protection of fish-eating wildlife, for which there is no consensus on national-scale benchmarks or toxicity values.
- Estimates of pesticide exposure derived from NAWQA concentration measurements are also uncertain—particularly estimates of short-term exposure of aquatic organisms to pesticides in stream water. Generally, short-term average concentrations in stream water, such as 4-day values, are underestimated from NAWQA data.

Screening-Level Assessment for Human Health

NAWQA studies, as emphasized in Chapter 3, characterized the quality of untreated water from streams and ground water, whether or not that water was used as a source of drinking water during the study period. More than half of the wells sampled for ground-water studies, but none of the stream sites that were sampled, were sources of domestic or public water supplies. In this report, measured concentrations of pesticides in all wells and streams sampled, whether or not they were sources of drinking water during the study period, are compared with human-health benchmarks derived from available USEPA drinking-water standards and guidelines as a starting point for understanding the potential importance of pesticides in a human-health context. The benchmarks are described in the accompanying sidebar on page 91 and values are listed in Appendix 3A.

Comparisons of human-health benchmarks to the concentrations observed in NAWQA studies provide a perspective on the potential importance to human health as use of water resources expands, but they are not appropriate for assessing current compliance with drinking-water regulations. A measured concentration or computed annual mean that is greater than a benchmark indicates the potential need for further investigation if such water either is presently used as a drinking-water source, or may be used as a source in the future. A concentration greater than a Maximum Contaminant Level (MCL), even in water that is now a source of drinking water, does not indicate violation of a standard. For water currently used as a drinking-water source, pesticide concentrations in finished water may be lower than those measured in untreated

A012086

Federal Regulation of Pesticides in Water

The potential effects of pesticides on humans and the environment are managed under several Federal Acts and regulated through a combination of Federal, State, and Tribal responsibilities. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), the Federal Food, Drug and Cosmetic Act (FFDCA), the Food Quality Protection Act (FQPA), the Safe Drinking Water Act (SDWA), and the Clean Water Act (CWA)—all of which are administered by USEPA and partner agencies—provide the regulatory framework that affects the assessment and control of pesticides and their degradates in water resources.

The FIFRA, first enacted in 1947 and amended most recently by the FQPA in 1996, provides the original framework for the Federal pesticide licensing program administered by USEPA and covers the evaluation and registration of pesticides for specific uses. Before a pesticide may be registered it must be shown, among other things, that it will not generally cause "unreasonable adverse effects" to water, air, land, plants, and man and other animals. The FFDCA authorizes USEPA to set maximum residue levels, or tolerances, for pesticides used in or on foods or animal feed, and mandates strong provisions to protect infants and children. Before a pesticide registration may be granted for use on a food commodity, a tolerance must be set or an exemption from a tolerance granted. The FQPA amended the FIFRA and FFDCA to set more stringent safety standards for new and old pesticides. Among its provisions are that (1) human-health assessments must consider aggregate exposures, including all dietary, drinking-water, and nonoccupational exposure; and (2) assessments leading to tolerance decisions must consider, relative to human health, the cumulative effects and common mode of toxicity among related pesticides, the potential for endocrine-disrupting effects, and appropriate safety factors to further protect infants and children. Through application of the FIFRA, FFDCA, and FQPA, USEPA determines the specific conditions under which a pesticide can be legally sold, distributed, and used in the United States, including where, how, and at what application rates pesticides may be used.

The SDWA was originally passed by Congress in 1974 to protect public health by regulating the Nation's public drinking-water supply. The law was amended in 1986 and 1996 and requires protection of drinking water and its sources, including rivers, lakes, reservoirs, springs, and wells (the SDWA does not regulate private wells that serve fewer than 25 individuals). The SDWA authorizes the USEPA to set national health-based standards for drinking water to protect against both naturally occurring and manmade contaminants that may be found in drinking water. The USEPA works with States and water utilities to make sure that these standards are met.

The CWA (originally the Federal Water Pollution Control Act Amendments of 1972, and subsequently amended several times) provides for protection against releases of toxic chemicals. Section 101(a)(3) of the CWA states that "it is national policy that the discharge of toxic pollutants in toxic amounts be prohibited." Section 303(c) of the CWA requires States to develop water-quality standards to protect the public health or welfare, enhance the quality of water, and serve the purposes of the CWA. The control of the discharge of toxic substances is a key objective of the National Pollutant Discharge Elimination System (NPDES) and water-quality standards programs. Section 304(a) of the CWA requires USEPA to develop and publish and, from time to time, revise ambient water-quality criteria for the protection of both human health and aquatic life. When final, these criteria provide USEPA's recommendations to States and authorized Tribes as they develop their own water-quality standards. USEPA-recommended criteria are not regulations, and they do not impose legally binding requirements on USEPA, States, authorized Tribes, or the regulated community. However, USEPA-recommended criteria may form the basis for State or Tribal water-quality standards and become enforceable through NPDES permits or other environmental programs. USEPA's role in this process, in addition to providing criteria recommendations, is to review and approve the water-quality standards developed by States and Tribes.

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water (depending on whether and how the water is treated), because some drinking-water treatment processes reduce pesticide concentrations. In addition, NAWQA sampling methods were not designed to meet the specific sampling and analytical requirements for determining compliance with an MCL.

Streams

Annual mean concentrations of pesticides in the 186 streams sampled by NAWQA were seldom greater than human-health benchmarks during 1992–2001, and most exceedances were in streams draining agricultural and urban watersheds (fig. 6–1). Specifically, pesticide concentrations exceeded one or more human-health benchmarks in about 10 percent of agricultural streams, 7 percent of urban streams, and in 1 of the 65 mixed-land-use streams sampled by NAWQA. No benchmarks were exceeded in the eight undeveloped streams that were sampled.

The streams sampled by NAWQA that had concentrations of a pesticide greater than a human-health benchmark were clustered in a few regions. Specifically, 6 agricultural streams and 1 mixed-land-use stream with concentrations greater than one or more benchmarks (5 of 7 streams for atrazine and 4 of 7 for cyanazine) were in the Corn Belt or southern Mississippi River Basin, where atrazine and cyanazine use was high during the study period (fig. 6–2). Two agricultural streams, 1 in California and 1 in Washington, had concentrations of dieldrin that were greater than its benchmark. The 2 urban streams in which benchmarks were exceeded are in Texas (diazinon) and Hawaii (dieldrin).

A new analysis of atrazine's potential risks has been developed by USEPA as part of the reregistration process (USEPA, 2003a). The analysis is based on the concentrations of atrazine and three of its chlorinated degradates, referred to, collectively, as "total atrazine." The human-health benchmarks from this new analysis are 37.5 µg/L for the 90-day moving average if the monitoring frequency is at least weekly and 12.5 µg/L if monitoring is less frequent. Comparison of these benchmark values to 90-day moving averages determined from NAWQA data for the sum of atrazine and deethylatrazine (NAWQA did not measure the 2 other chlorinated degradates) indicates that 4 of the 5 sites that exceeded the MCL-based benchmark also had 90-day averages that exceeded the 12.5 µg/L level. Of these 4 sites, however, 3 had at least weekly sampling frequencies during the high-concentration period of the year and concentrations would thus be compared with the 37.5 µg/L benchmark. Of the 3 sites with at least weekly sampling, 1 exceeded the 37.5 µg/L benchmark. Use of benchmarks from the new risk analysis would, therefore, result in screening-level exceedances for 2 sites instead of 5 sites, although inclusion of the other chlorinated degradates could increase the number of sites with exceedances. Further analysis of the distribution of atrazine concentrations in streams nationwide is presented in Chapter 7.

Human-Health Benchmarks for Pesticides in Water

Benchmarks for assessing the potential for pesticides in water to affect human health were derived from three types of USEPA drinking-water standards and guidelines developed by USEPA's Office of Water (USEPA, 2004c, 2005e). One or more drinking-water standards or guidelines are available for 47 of the 83 pesticides and degradates analyzed by NAWQA (Appendix 3A).

Maximum Contaminant Level (MCL)—The maximum permissible concentration of a contaminant in water that is delivered to any user of a public water system. This is an enforceable standard issued by USEPA under the Safe Drinking Water Act and established on the basis of health effects and other factors (analytical and treatment technologies, and cost).

Lifetime Health Advisory (HA-L)—The concentration of a chemical in drinking water that is not expected to cause any adverse, noncarcinogenic effects over a lifetime exposure. A health advisory is not a legally enforceable Federal standard, but serves as technical guidance to assist Federal, State, Tribal and local officials. The HA-L is based on toxicity (dose-response) information for the chemical. It assumes lifetime consumption of 2 liters (L) of water per day by a 70-kilogram (kg) adult, and that 20 percent of total exposure to the contaminant comes from drinking water (80 percent is assumed to come from other sources).

10^{-6} Cancer Risk Concentration—The concentration of a chemical in drinking water corresponding to an excess estimated lifetime cancer risk of 1 in 1 million (10^{-6}). These values are calculated from the estimated cancer potency, which is derived using a conservative (protective) model of carcinogenesis, so that the cancer risk is an upper-limit estimate. The definition of "acceptable" level of cancer risk is a policy issue, not a scientific one. USEPA reviews individual State and Tribal policies on cancer risk levels as part of its oversight of water-quality standards under the Clean Water Act. USEPA's policy is to accept measures adopted by States to limit cancer risk to the range of 10^{-6} to 10^{-4} (USEPA, 1992a). The concentration corresponding to a cancer risk of 10^{-6} was used as the benchmark for the NAWQA screening-level assessment, consistent with the conservative (protective) nature of such assessments.

Application of Human-Health Benchmarks for Water

If available, the MCL was used as the human-health benchmark for a given pesticide. For pesticides with no MCL, the lower of the HA-L and the 10^{-6} cancer risk concentration was used. Human-health benchmarks were compared with time-weighted annual mean concentrations of pesticides in streams, as well as with concentrations measured in individual wells for ground water.

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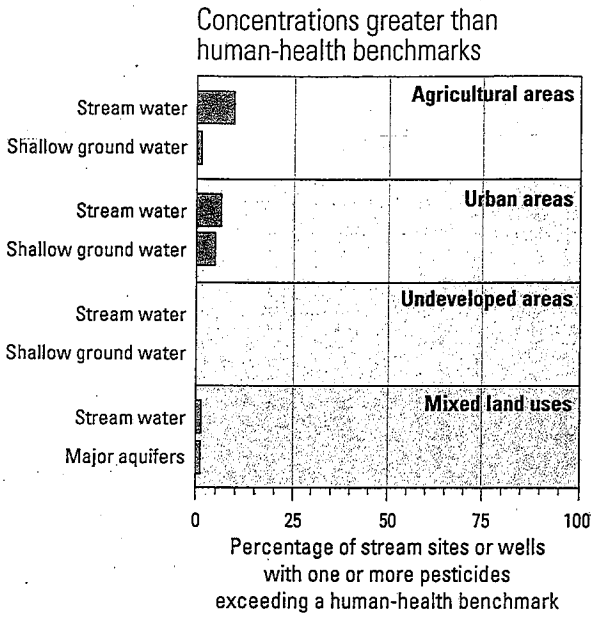

Figure 6–1. Annual mean concentrations of one or more pesticides were greater than a human-health benchmark in about 10 percent of agricultural streams and about 7 percent of urban streams that were sampled. No streams draining undeveloped watersheds, and only 1 stream with mixed land uses in its watershed, had concentrations greater than a benchmark. About 1 percent of all domestic and public-supply wells sampled had concentrations greater than a benchmark. More than half of the wells sampled for ground-water studies, but none of the stream sites sampled, were sources of domestic or public water supplies during the study period.

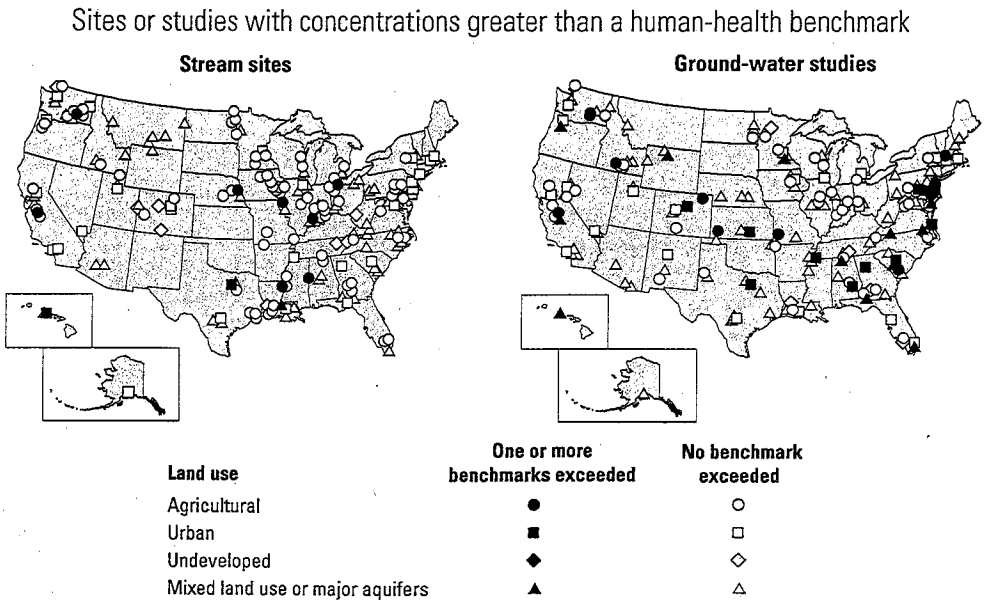

Figure 6–2. Most streams sampled by NAWQA that had concentrations of a pesticide greater than a human-health benchmark were agricultural streams in the Corn Belt and lower Mississippi River Basin, where atrazine and cyanazine accounted for the exceedances. Two urban streams in Texas and Hawaii had concentrations greater than benchmarks for diazinon and dieldrin, respectively. Wells with concentrations greater than benchmarks were widely scattered among 36 of the 187 ground-water study areas, with the highest proportion in urban areas. Dieldrin accounted for most benchmark exceedances in ground water. Streams are indicated if the annual mean concentration of one or more pesticides was greater than a benchmark, and ground-water studies are indicated if one or more wells had a concentration greater than a benchmark.

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Although NAWQA findings for streams are not directly applicable to drinking-water supplies because no NAWQA stream sites were located at water-supply intakes, a perspective on potential significance to human health is provided by comparing streams sampled by NAWQA with streams that serve as sources of drinking water and that have similar land uses in their watersheds. The Nation's 1,679 public water-supply intakes on streams were classified using NAWQA's land-use definitions (table 3–1 and fig. 3–1). The stream sites where intakes are located are composed of 12 percent agricultural streams (194 intakes); 1 percent urban streams (22 intakes); 55 percent undeveloped streams (926 intakes); and 32 percent streams that drain watersheds with mixed land use (537 intakes). As a group, however, agricultural streams with drinking-water intakes have proportionally less agricultural land in their watersheds than do the agricultural streams sampled by NAWQA (see Chapter 3). Thus, the finding that 10 percent of agricultural streams sampled by NAWQA had concentrations of pesticides greater than one or more benchmarks indicates that probably fewer than 10 percent of the 194 drinking-water intakes on agricultural streams used source waters with concentrations greater than human-health benchmarks during the study period. In addition, source water may be treated or mixed with other water sources to reduce pesticide concentrations prior to consumption.

Overall, the human-health screening-level assessment for streams sampled by NAWQA during the study period indicates that few of the drinking-water intakes that currently withdraw water from streams are likely to be located on streams with pesticide concentrations greater than a benchmark. This broad finding is derived from combined data from multiple sites sampled in different sampling periods from 1993 to 2000. In addition, there are sufficient NAWQA stream sites with primary sampling years distributed throughout the study period to assess changes over time in benchmark exceedances for agricultural streams in the corn-and-soybeans crop setting (fig. 4–6) and for urban streams. Although there were too few exceedances of human-health benchmarks at urban sites for meaningful assessment of trends, agricultural streams in the corn-and-soybeans crop setting had the highest frequencies of benchmark exceedances by atrazine and cyanazine. In this agricultural setting, the changes in percentages of stream sites that had concentrations that exceeded a benchmark were different for the two herbicides (fig. 6–3). Observations about changes shown in figure 6–3, however, are preliminary because they are based on different groups of sites for each sampling period and site-to-site variability in conditions may distort actual trends. There was no clear pattern of change through the study period for atrazine, but the highest proportion of sites with exceedances by atrazine occurred near the end of the study period, during 1998–2000. In contrast, there was a consistent decrease in exceedances for cyanazine during the study period, with none during 1998–2000. Data on the agricultural use of these two pesticides in the Corn Belt show that these changes in frequencies of benchmark exceedances are consistent with their use (fig. 6–3).

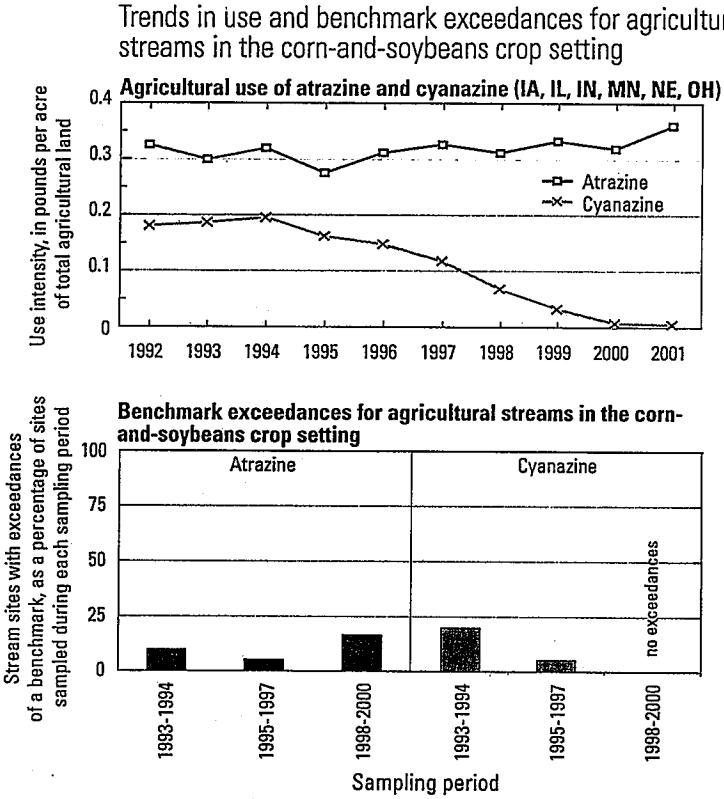

Figure 6–3. Changes over time in the percentage of agricultural stream sites in the corn-and-soybeans crop setting that had exceedances of human-health benchmarks for atrazine and cyanazine generally followed trends in use. Sites were grouped according to the year of sampling. The 1993–1994 sampling period included 10 sites, the 1995–1997 period included 19 sites, and the 1998–2000 period included 6 sites.

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Potential Effects of Fish Consumption on Human Health

In addition to drinking water, humans also can be exposed to pesticides through consumption of contaminated fish. When persistent, hydrophobic compounds, such as organochlorine pesticides, enter a stream, they tend to bioaccumulate in fish and other aquatic organisms. Because USEPA sets tolerances only for currently registered pesticides, there are no tolerances for the cancelled organochlorine pesticides in fish. However, 48 States, the District of Columbia, American Samoa, and three Tribes have issued active fish-consumption advisories and safe-eating guidelines to inform people about the recommended level of consumption for fish caught in local waters. Fish advisories are advice to limit or avoid eating certain fish. USEPA has published guidance to States, Territories, Tribes, and local governments to use in establishing fish-consumption advisories (USEPA, 2000a). As of 2004, there were a total of 79 active fish-consumption advisories for chlordane, 67 advisories for DDT and its degradation products DDE and DDD, and 22 for dieldrin (USEPA, 2005f,g). Although some advisories for organochlorine pesticides have been rescinded in recent years, as residues of these pesticides continue to degrade slowly in the environment (see chapter 8), new advisories were issued in 2004 for DDT, toxaphene, mirex, and chlorinated pesticides (USEPA, 2005f).

USEPA guidelines include recommended screening values, which are "concentrations of target analytes in fish or shellfish tissue that are of potential public health concern and that are used as threshold values against which levels of contamination in similar tissue collected from the ambient environment can be compared" (USEPA, 2000a). Screening values were derived separately for carcinogenic and noncarcinogenic effects, and USEPA recommends that the lower of the two screening values be used for pesticides that have both types of effects. USEPA screening values are intended to protect the majority of the United States population and are based on average fish and shellfish consumption rates by recreational fishers. For potential carcinogens, the recommended screening value is based on a maximum acceptable cancer risk of 10^{-5} (1 in 100,000). USEPA screening values are available for 9 of the 12 organochlorine pesticides and pesticide groups (such as total chlordane) measured by NAWQA in whole fish.

Comparisons of concentrations of organochlorine pesticide compounds measured in NAWQA fish samples with USEPA screening values are limited in two ways. First, NAWQA analyzes contaminants in whole fish, whereas USEPA screening values apply to edible fish tissue. Organochlorine compounds have high affinities for the lipid (fat) in fish and other biota. Whole fish generally have higher lipid content and, therefore, may have higher organochlorine concentrations than the part of the fish that is consumed (fillets). Thus, comparisons of NAWQA measurements with USEPA screening values are probably, in this sense, worst-case assessments. Second, most fish sampled by NAWQA are bottom-feeding species, such as carp and white sucker, which are not consumed as frequently as game fish. Depending on the compound, however, the difference between game-fish fillets and the whole bodies of bottom-feeders may not be significant. For example, in a national study of bioaccumulative chemicals in fish, the USEPA (1992b) found that some organochlorine compounds (including dieldrin, oxychlordane, and DDE) were roughly similar in average concentrations in game-fish fillets and whole-fish samples of bottom-feeders, whereas other compounds (including chlordane, nonachlor, and heptachlor epoxide) had higher average concentrations in whole-fish samples of bottom feeders than in game-fish fillets.

NAWQA results for whole fish, with these caveats considered, may be useful for screening-level assessment of streams for which there are no data specifically on edible tissue of fish commonly consumed in that area. If pesticide concentrations measured in a whole-fish sample are less than a screening value for edible tissue, then residues in the edible portion of the fish are likely to be less than the screening value, suggesting low human-health concern. On the other hand, if a concentration in whole fish exceeds the screening value, the level in edible tissue may not exceed the value, but additional sampling and analysis of fillets for species that are commonly consumed may be warranted to determine whether or not the concentration in edible fish tissue exceeds the screening value.

The NAWQA analysis provides the following general perspective:

- Organochlorine concentrations measured by NAWQA in whole fish exceeded USEPA screening values most often in agricultural and urban streams (67 percent of sites), followed by streams draining areas of mixed land use (55 percent).
- Concentrations greater than screening values in agricultural streams were dominated by dieldrin, total DDT, and heptachlor epoxide, whereas these same compounds plus total chlordane accounted for most concentrations greater than screening values in urban streams.
- If people commonly consume fish from a stream where screening values were exceeded by NAWQA-measured concentrations in whole fish, and no prior monitoring of the commonly consumed fish has been done, then further investigation of organochlorine pesticide compounds in edible fish tissue may be warranted.

A012091

Ground Water

Concentrations of one or more pesticides were greater than human-health benchmarks in about 1 percent of sampled wells that are used for drinking water—including 17 of 2,356 domestic wells and 8 of 364 public-supply wells (table 6–1). Many public-supply wells have some level of water treatment, which may or may not affect pesticide concentrations, whereas domestic wells generally have no treatment, so that samples usually represent the actual quality of water consumed. Shallow ground water in urban areas had the greatest proportion of sampled wells with concentrations of pesticides that were greater than one or more benchmarks, including 1 of 9 public-supply wells, 3 of 17 domestic wells, and 37 of 835 observation wells, for a total of about 5 percent. About 1 percent of wells sampled in agricultural areas and about 1 percent of wells sampled in major aquifers had concentrations greater than one or more benchmarks. Wells with concentrations greater than benchmarks were widely scattered among 36 of the 187 ground-water studies across the Nation, including 11 of 33 urban land-use studies, 10 of 53 agricultural land-use studies, and 15 of 92 major aquifer studies (fig. 6–2). Most of these studies with one or more benchmark exceedances had only 1 or 2 wells with exceedances. All concentrations greater than benchmarks were accounted for by dieldrin (72 wells) and four other pesticides: dinoseb (4 wells), atrazine (4), lindane (2), and diazinon (1).

Human-health benchmarks were seldom exceeded in domestic and public-supply wells.

Of the pesticides analyzed by NAWQA, dieldrin is the primary pesticide identified by the screening-level assessment for further consideration regarding ground water. Of the 72 wells with dieldrin concentrations greater than its screening-level benchmark, 39 were shallow wells in urban areas (including 3 domestic wells and 1 public-supply well), 12 were shallow wells in agricultural areas (including 5 domestic wells), and 21 were wells in major aquifers (including 7 domestic and 6 public-supply wells). Although aldrin (which transforms to dieldrin) and dieldrin are no longer used in the United States, the screening-level assessment indicates that some wells may still be affected by dieldrin from historical uses.

Table 6–1. Most wells sampled for agricultural and urban land-use studies were shallow observation wells that are not used for drinking water, but about 29 percent of wells sampled in agricultural areas were domestic wells. Most wells sampled for the major aquifer studies are used for drinking water; about 13 percent were public-supply wells, and 71 percent were domestic wells. Overall, about 1 percent of all domestic and public-supply wells had concentrations of a pesticide greater than a human-health benchmark.

Type of ground-water study	Public-supply wells		Domestic wells		Observation wells	
	Number sampled	Percentage of samples exceeding a benchmark	Number sampled	Percentage of samples exceeding a benchmark	Number sampled	Percentage of samples exceeding a benchmark
Agricultural land use	1	0.0	406	1.2	1,005	1.1
Urban land use	9	11	17	18	835	4.4
Major aquifers	354	2.0	1,933	0.5	453	2.0

A012092

Screening-Level Assessment for Aquatic Life in Streams

The potential for pesticides to adversely affect aquatic life in streams was evaluated by comparing measured concentrations in water and bed sediment with their respective water-quality benchmarks. The benchmarks are described in the accompanying sidebars (p. 97 and 105) and benchmark values are listed in Appendix 3.

Water

NAWQA findings indicate that pesticides detected in stream water, most of which were in use during the study period, had the potential to adversely affect aquatic life in many of the streams sampled. Of 186 stream sites sampled nationwide, 57 percent of 83 agricultural streams, 83 percent of 30 urban streams, and 42 percent of 65 streams with mixed-land-use watersheds had concentrations of at least one pesticide that exceeded one or more aquatic-life benchmarks during the selected year of sampling (fig. 6–4). One of 8 undeveloped streams that were sampled for pesticides in water had concentrations that were greater than an aquatic-life benchmark. Concentrations greater than benchmarks occurred throughout the study period. Agricultural streams had benchmark exceedances at 68 percent of sites sampled during 1993–1994, 43 percent during 1995–1997, and 50 percent during 1998–2000. Urban streams had benchmark exceedances at 90 percent of sites sampled during 1993–1994, 100 percent during 1995–1997, and 64 percent during 1998–2000. Streams with mixed land uses in their watersheds had benchmark exceedances at 38 percent of sites sampled during 1993–1994, 40 percent during 1995–1997, and 46 percent during 1998–2000.

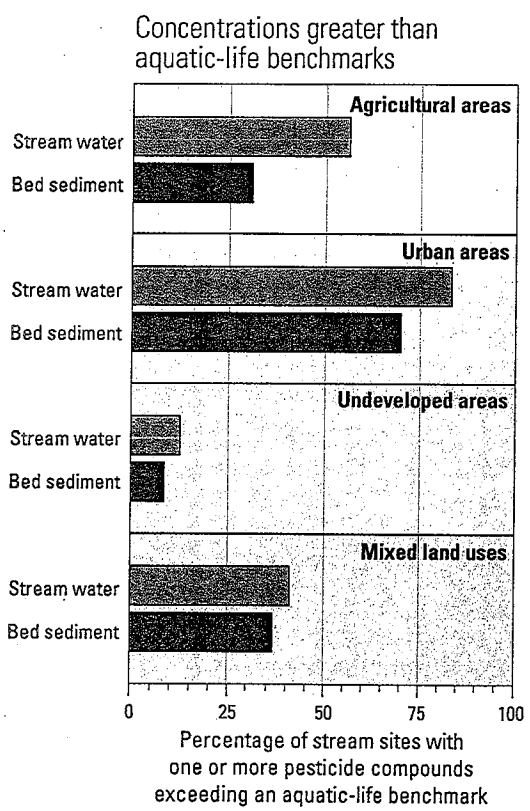

Figure 6–4. Pesticides have the potential to adversely affect aquatic life in many streams, particularly in urban areas, as indicated by the relatively high proportions of sites with measured concentrations greater than aquatic-life benchmarks for both water and bed sediment.

Streams in which one or more pesticides exceeded an aquatic-life benchmark for water are distributed throughout the country in agricultural, urban, and mixed-land-use settings (fig. 6–5). Most concentrations that exceeded benchmarks, particularly by the greatest amounts, occurred during seasonal periods of high concentrations, as illustrated by results for diazinon in Arcade Creek, an urban stream in the Sacramento River Basin (fig. 6–6). The number, type, and degree of benchmark exceedances vary widely among sites indicated in figure 6–5 and meaningful generalizations are difficult. Some streams, such as Arcade Creek (fig. 6–6), exceeded one or more benchmarks by substantial margins for a sustained period during the year. Other sites briefly exceeded a benchmark for one pesticide. Of the 100 sites with one or more benchmark exceedances, 46 sites exeeded 1 benchmark to varying degrees and frequencies, and 30 sites exceeded 3 or more different benchmarks to varying degrees and frequencies. Because of this variability and the complexity of translating exceedances of screening-level benchmarks into specific potential for effects, the screening-level results, as noted earlier should be used as the starting point for further site-specific investigation. Streams in which concentrations did not exceed a benchmark included most undeveloped streams, plus streams in agricultural and mixed-land-use settings in regions where pesticide use was low, such as the Yellowstone River Basin and the Ozark Plateaus.

A012093

Aquatic-Life Benchmarks for Pesticides in Water

Benchmarks for assessing the potential for pesticides in stream water to adversely affect aquatic life were of two general types: (1) ambient water-quality criteria for the protection of aquatic life (AWQC-AL), which were developed by USEPA's Office of Water (OW), and (2) benchmarks derived from toxicity values obtained from registration and risk-assessment documents developed by USEPA's Office of Pesticide Programs (OPP). Toxicity data from OPP documents were used to supplement OW criteria to expand the coverage of pesticides and to incorporate the most recent toxicity information used by USEPA. AWQC-AL are available for 7 of the 83 pesticides and degradates analyzed by NAWQA. One or more toxicity values from OPP documents are available for 60 of the 83 NAWQA analytes, including 5 of the 7 that have AWQC-AL. A total of 62 of the pesticide compounds analyzed in water by NAWQA have one or more aquatic-life benchmarks (Appendix 3A).

Ambient Water-Quality Criteria for Aquatic Organisms

USEPA's OW derives both acute and chronic criteria, each of which specifies a threshold concentration for unacceptable potential for effects, an averaging period, and an acceptable frequency of exceedances.

Acute AWQC-AL—The highest concentration of a chemical to which an aquatic community can be exposed briefly without resulting in an unacceptable effect. Except where a locally important species is very sensitive, aquatic organisms should not be unacceptably affected if the 1-hour average concentration does not exceed the acute criterion more than once every 3 years, on average. The intent is to protect 95 percent of a diverse group of organisms (USEPA, 2004d).

Chronic AWQC-AL—The highest concentration of a chemical to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect. Except where a locally important species is very sensitive, aquatic organisms should not be unacceptably affected if the 4-day average concentration does not exceed the chronic criterion more than once every 3 years, on average. The intent is to protect 95 percent of a diverse group of organisms (USEPA, 2004d).

Toxicity Values from Risk Assessments

Seven types of aquatic toxicity values were compiled from OPP's registration and risk-assessment documents. The OPP toxicity values are for specific types of organisms. Acute and chronic values were compiled for fish and invertebrates, and acute values for vascular and nonvascular plants. A value for aquatic-community effects was available only for atrazine. The types and amounts of toxicity data available for different pesticides were highly variable. USEPA estimates the toxicity or hazard of a pesticide by selecting the most sensitive endpoints from multiple acute and chronic laboratory and field studies. For many pesticides, USEPA has completed a screening-level ecological risk assessment, which includes acute and chronic assessments for both fish and invertebrates. For some pesticides, acute assessments have also been completed for nontarget aquatic plants. NAWQA derived benchmarks from OPP toxicity values, generally following OPP procedures (USEPA, 2005h).

In recent years, USEPA has developed methods for conducting refined risk assessments, in which probabilistic tools and methods are incorporated to predict the magnitude of the expected impact of pesticide use on nontarget organisms, as well as the uncertainty and variability involved in these estimates. The screening-level benchmarks used in NAWQA analysis and summarized below were derived from the toxicity values reported in USEPA registration and risk-assessment documents.

In the few cases where refined assessments were available, these were given preference. In deriving a benchmark for a given type of organism (such as fish) and a given exposure duration (acute or chronic), the lowest of the available toxicity values was selected for each benchmark, unless a preferred toxicity value was specified in a refined risk assessment—in which case that preferred toxicity value was used instead. For two of the benchmarks—acute-fish and acute-invertebrates—the selected toxicity values were multiplied by the USEPA level of concern (LOC) of 0.5, so that the benchmark for NAWQA screening corresponds to the acute risk level defined by USEPA (2005h).

Six benchmarks were based directly on toxicity endpoints used in OPP screening-level assessments (USEPA, 2005i):

Acute fish—The lowest tested 50-percent lethal concentration (LC_{50}) for acute (typically 96-hour) toxicity tests with freshwater fish, multiplied by the LOC of 0.5.

Acute invertebrate—The lowest tested LC_{50} or 50-percent effect concentration (EC_{50}) for acute (typically 48 or 96-hour) toxicity tests with freshwater invertebrates, multiplied by the LOC of 0.5.

Acute vascular plant—The lowest tested EC_{50} for freshwater vascular plants in acute toxicity tests (typically < 10 days).

Acute nonvascular plant—The lowest tested EC_{50} for freshwater nonvascular plants (algae) in acute toxicity tests (typically < 10 days).

Chronic fish—The lowest no-observed-adverse-effects concentration (NOAEC), or the lowest-observed-adverse-effects concentration (LOAEC) if a NOAEC is not available, for freshwater fish in early lifestage or full life-cycle tests.

Chronic invertebrate—The lowest NOAEC, or LOAEC if a NOAEC is not available, for freshwater invertebrates in life-cycle tests.

One additional benchmark, a benchmark for aquatic-community effects, was derived from the refined risk assessment for atrazine. This endpoint for atrazine incorporates community-level effects on aquatic plants and indirect effects on fish and aquatic invertebrates that could result from disturbance of the plant community (USEPA, 2003b).

Application of Aquatic-Life Benchmarks for Water

Acute AWQC-AL values and all acute benchmarks were compared with each measured concentration for the most complete year of data for each NAWQA stream site. Chronic AWQC-AL values were compared with 4-day moving average concentrations. This approach matches the time periods in the definitions of acute and chronic AWQC-AL, which are 1-hour average and 4-day average concentrations, respectively (Stephan and others, 1985). Chronic benchmarks for invertebrates were compared with 21-day moving averages, and chronic benchmarks for fish and the aquatic-community benchmark for atrazine were compared with 60-day moving averages. These time periods are those used or recommended by USEPA in OPP risk assessments (USEPA, 2003b; USEPA, 2005g). Moving average concentrations for 4-, 21-, and 60-day periods were computed for each day of the year for each stream site from hourly concentration estimates determined by straight-line interpolation between samples. This method was tested using data on pesticide concentrations in Ohio streams studied by Richards and Baker (1993) and Richards and others (1996), using an approach similar to that used by Crawford (2004). Results indicate that all three averages, but particularly the 4-day averages, are consistently underestimated when computed from data collected at frequencies similar to the NAWQA sampling design (indicating a tendency to also underestimate the potential for toxicity to aquatic life in this respect).

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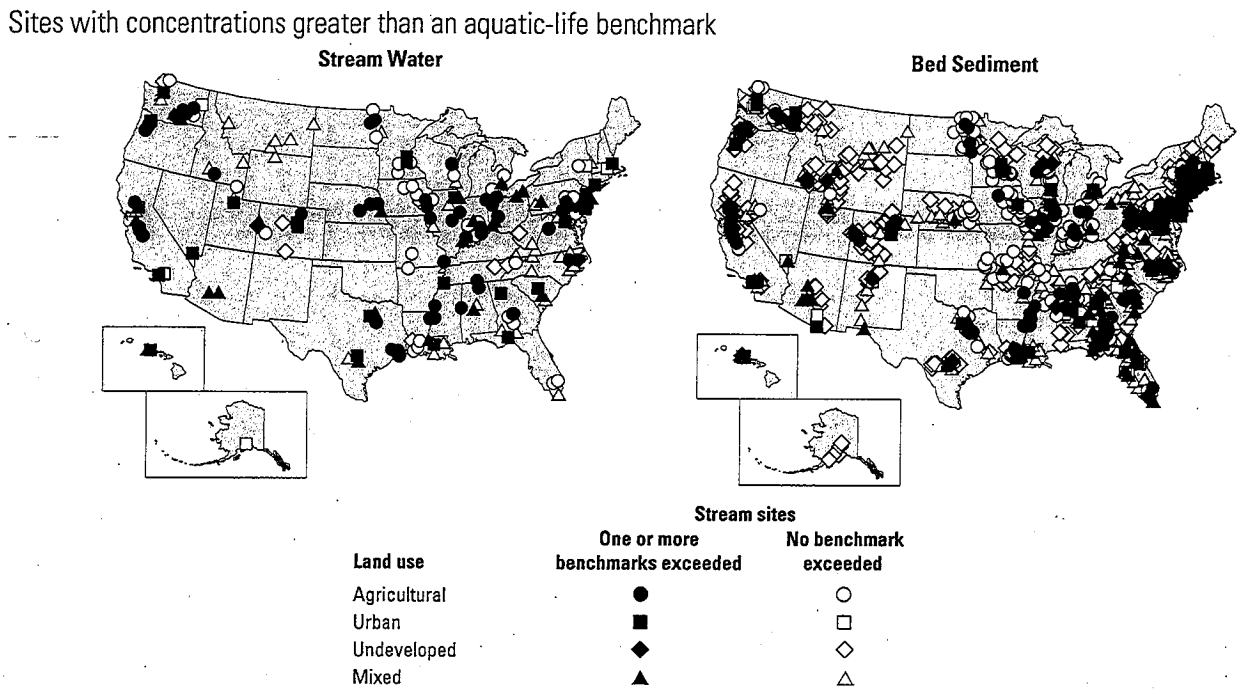

Figure 6–5. Aquatic-life benchmarks for pesticides in water and bed sediment were exceeded by concentrations measured in many agricultural, urban, and mixed-land-use streams throughout the Nation.

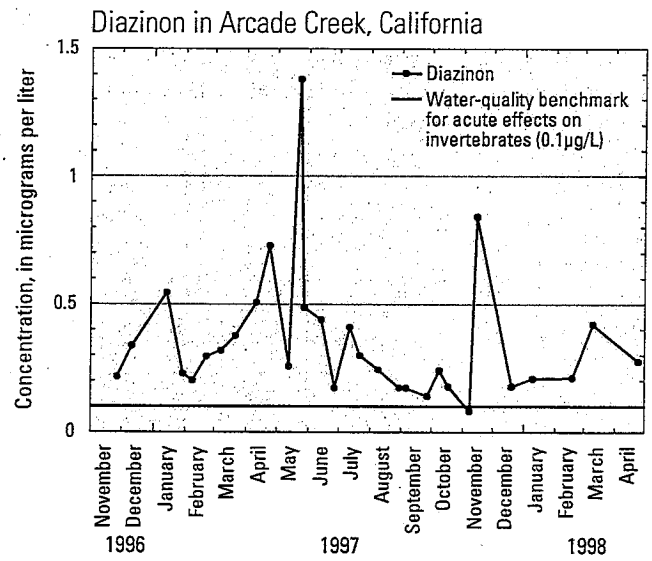

Figure 6–6. Concentrations of diazinon in Arcade Creek, an urban creek in Sacramento, California (Sacramento River Basin), exceeded the aquatic-life benchmark for acute effects on invertebrates (0.10 µg/L) by the greatest amounts during seasonal pulses of high concentrations in the winter and spring. (Modified from Domagalski and others, 2000.)

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The insecticides diazinon, chlorpyrifos, and malathion accounted for most concentrations that were greater than aquatic-life benchmarks in water from urban streams, whereas chlorpyrifos, azinphos-methyl, atrazine, *p,p'*-DDE, and alachlor accounted for most concentrations greater than benchmarks in water from agricultural streams (fig. 6–7). Streams draining watersheds with mixed land uses reflected a combination of urban and agricultural influences. Generally, the types of benchmarks most frequently exceeded by the herbicides atrazine and alachlor were those for acute effects on either vascular or nonvascular plants, whereas the insecticides diazinon, chlorpyrifos, malathion, azinphos-methyl, and carbaryl most frequently exceeded acute or chronic benchmarks for invertebrates or benchmarks based on chronic ambient water-quality criteria.

The geographic distributions of benchmark exceedances for atrazine (fig. 6–8), diazinon (fig. 6–9), and chlorpyrifos (fig. 6–10) illustrate the varying distributions and types of potential effects on aquatic life. Concentrations of atrazine were greater than one or more aquatic-life benchmarks in 18 percent of agricultural streams, but in only one stream with a predominantly nonagricultural watershed. As discussed in Chapter 4, concentrations of atrazine in agricultural streams matched the geographic distribution of corn cultivation, where applications are greatest (fig. 4–9). As noted above, the atrazine benchmarks most frequently exceeded were the acute benchmarks for vascular and nonvascular plants, although the benchmark for aquatic community effects and the chronic benchmark for invertebrates also were exceeded at about 35 and 12 percent, respectively, of the sites where one or more atrazine benchmarks were exceeded (fig. 6–8).

Diazinon concentrations were greater than one or more aquatic-life benchmarks in 73 percent of the urban streams that were sampled, compared with 37 percent for chlorpyrifos (fig. 6–7). The urban stream sites where diazinon exceeded a benchmark were distributed throughout the country (fig. 6–9). Benchmarks for both of these insecticides were exceeded in smaller proportions of agricultural streams, although chlorpyrifos exceeded one or more of its benchmarks in 21 percent of the agricultural streams. The highest concentrations of chlorpyrifos in agricultural streams, as discussed in Chapter 4, were in streams within the corn-growing areas of the central United States; in the lower Mississippi River Basin, where both corn and cotton are grown; and in streams draining agricultural areas in the West, where fruits, nuts, and vegetables are grown.

The diazinon benchmarks most frequently exceeded (fig. 6–9) were the acute and chronic benchmarks for invertebrates reported by USEPA (USEPA, 2004e). As shown in figure 6–10, the chlorpyrifos benchmarks most frequently exceeded were the acute and chronic benchmarks for invertebrates and also the acute and chronic ambient aquatic-life criteria (Appendix 3A). While none currently exists, USEPA is drafting ambient aquatic-life criteria for diazinon. During

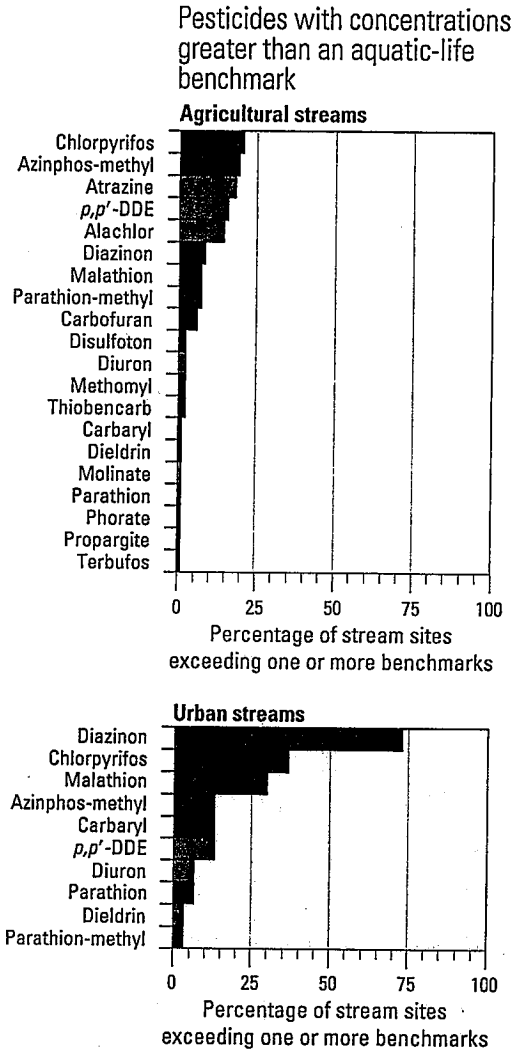

Figure 6–7. Contributions of individual pesticides to exceedances of aquatic-life benchmarks for water show the significance of insecticides in urban streams, particularly diazinon, chlorpyrifos, and malathion during the 1992–2001 study period. In agricultural streams, most exceedances of benchmarks were by chlorpyrifos, azinphos-methyl, atrazine, *p,p'*-DDE, and alachlor. Water-quality benchmarks are provided in Appendix 3A.

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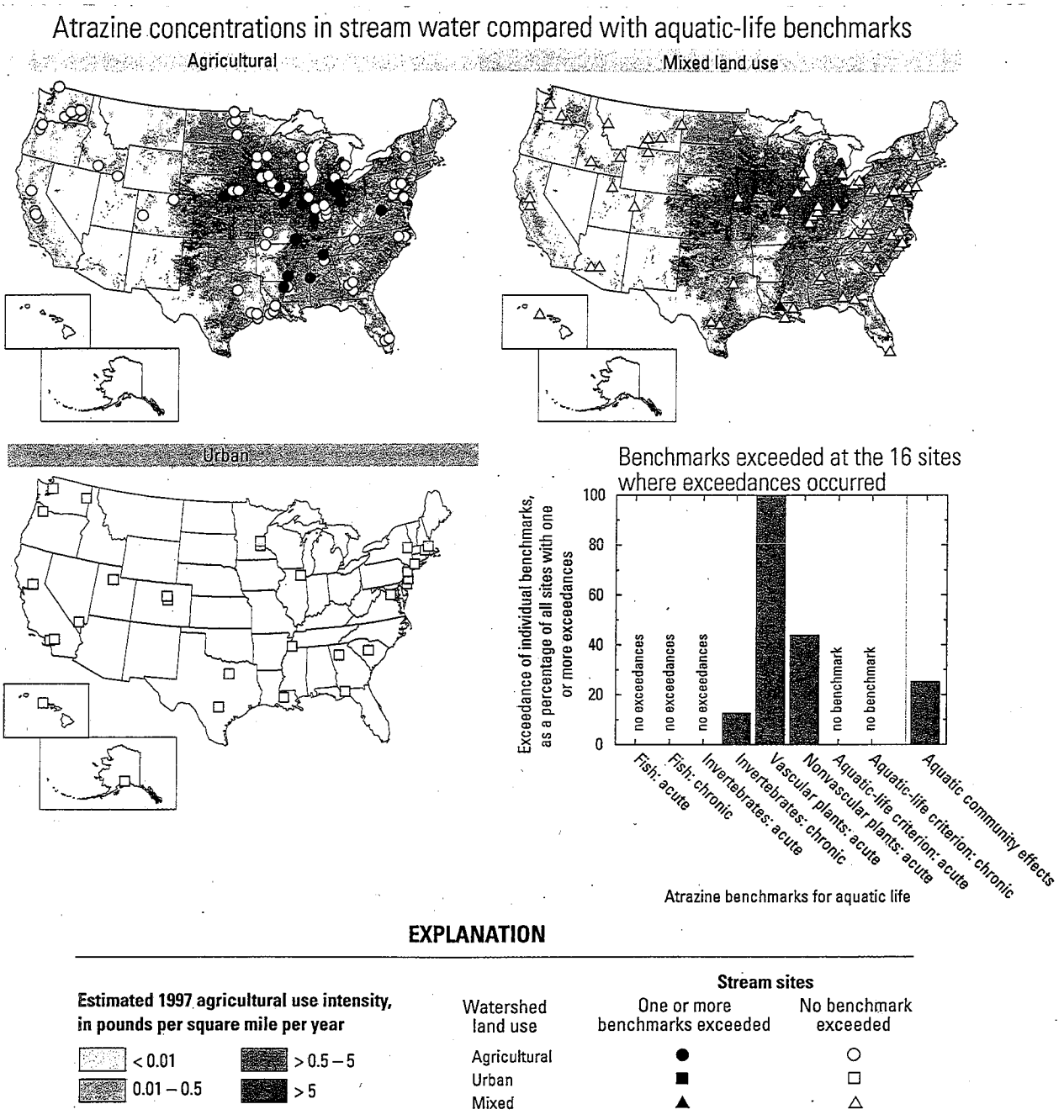

Figure 6–8. Streams in which atrazine concentrations were greater than at least one of its aquatic-life benchmarks were predominantly agricultural streams in areas where applications were greatest. The aquatic-life benchmarks most frequently exceeded by atrazine concentrations were those for vascular and nonvascular plants. Water-quality benchmarks are provided in Appendix 3A.

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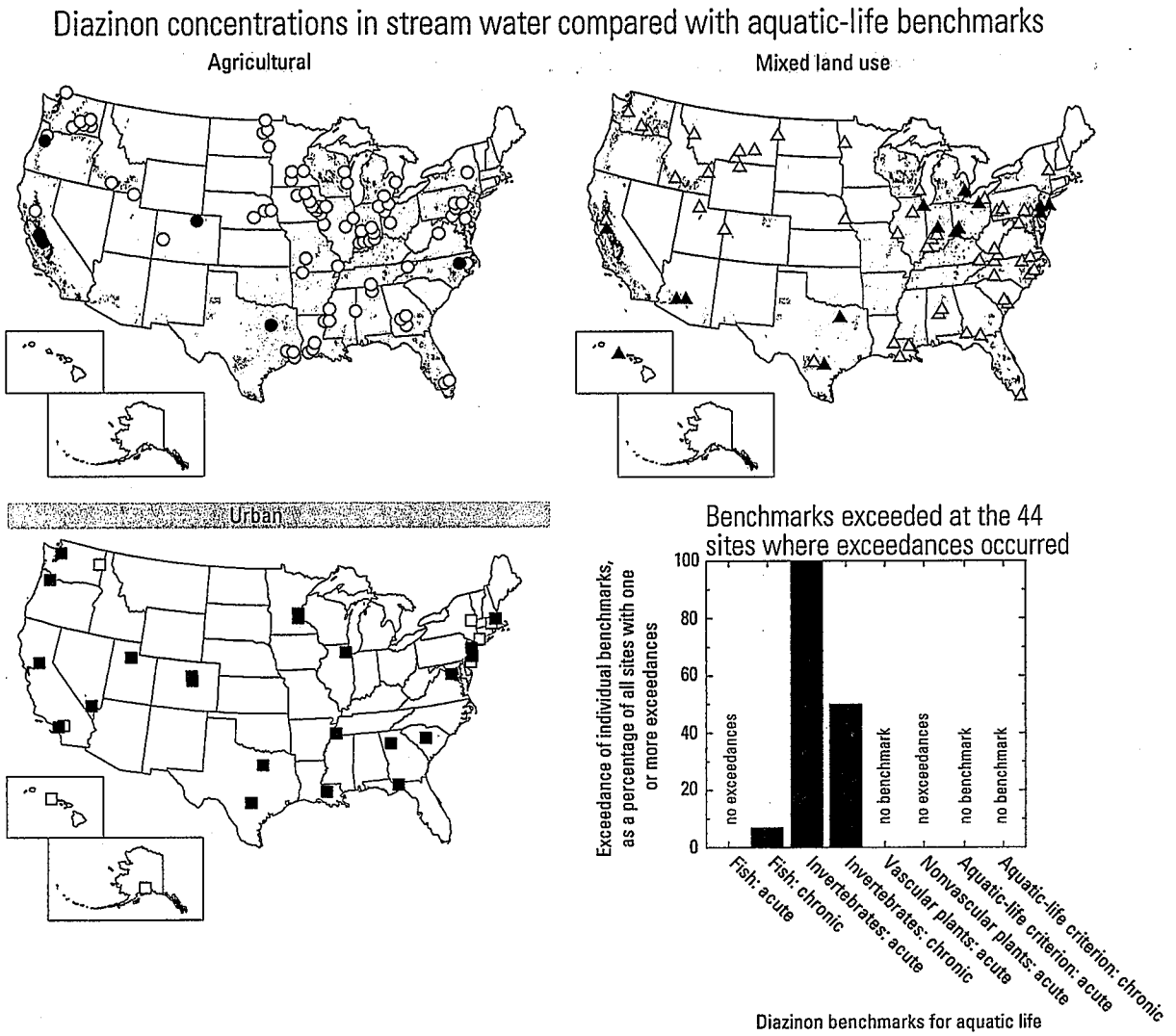

Figure 6–9. Most streams in which diazinon concentrations were greater than at least one aquatic-life benchmark were urban streams, but concentrations in some agricultural streams in areas where applications were greatest also exceeded a benchmark. The aquatic-life benchmarks most frequently exceeded by diazinon were those for invertebrates. Water-quality benchmarks are provided in Appendix 3A.

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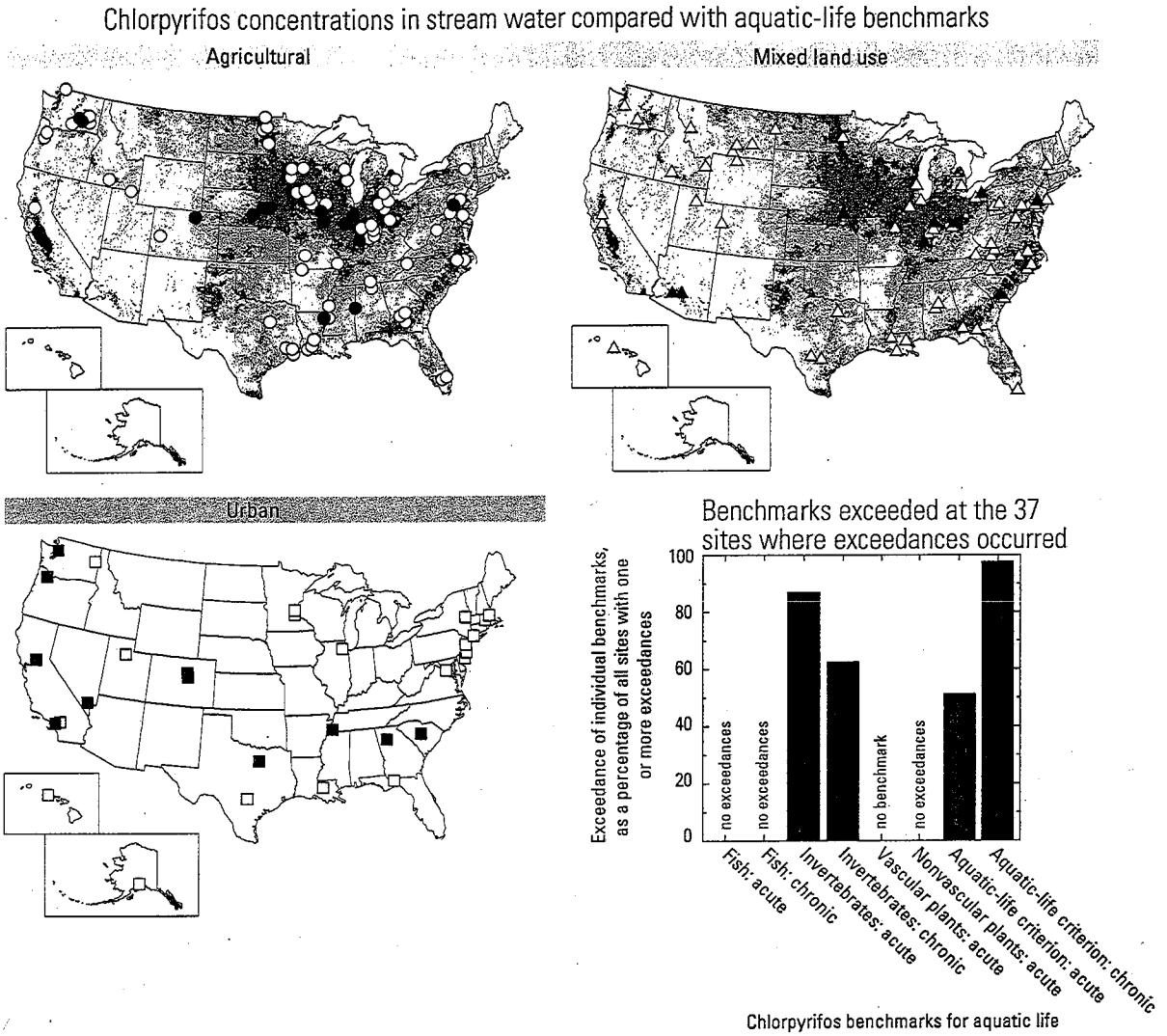

Figure 6–10. Most streams in which chlorpyrifos concentrations were greater than at least one aquatic-life benchmark were agricultural streams in areas where applications were greatest, or urban streams. The aquatic-life benchmark most frequently exceeded by chlorpyrifos was the USEPA chronic aquatic-life criterion. Chlorpyrifos concentrations also frequently exceeded acute and chronic benchmarks for invertebrates at the same sites where the chronic aquatic-life criterion was exceeded. Water-quality benchmarks are provided in Appendix 3A.

A012099

this development process, and in response to USEPA's diazinon risk assessment, public comment noted an atypical distribution of the acute toxicity data for invertebrates. If data from the second most sensitive study were used (USEPA, 2000b), rather than the most sensitive study, then the calculated acute invertebrate benchmark for diazinon would change from its original 0.1 µg/L to a value of 0.4 µg/L. The result of using a benchmark of 0.4 µg/L would be a reduction in the proportions of sites with diazinon exceedances from 73 to 40 percent for urban streams and from 8 to 6 percent for agricultural streams.

Overall, the screening-level assessment for potential effects of pesticides in stream water on aquatic life indicates that 56 percent of the 178 sampled streams that have watersheds dominated by urban, agricultural, or mixed land uses had concentrations of one or more pesticides that exceeded an aquatic-life benchmark during the study period. Pesticide use and occurrence were not constant during 1992–2001, however, and NAWQA data can be used, as for human-health benchmarks, to characterize changes that may have occurred for some pesticides in the land-use settings for which there are adequate data.

As noted for analysis of human-health benchmarks, there are sufficient NAWQA data for limited analysis of changes over time in benchmark exceedances for urban streams and for agricultural streams in the corn-and-soybeans crop setting. When grouped by sampling period, the percentages of urban stream sites that had concentrations of diazinon, chlorpyrifos, or malathion that exceeded a benchmark were lowest for urban sites sampled during the last part of the study (fig. 6–11). Observations about changes shown in figures 6–11 and 6–12, however, are preliminary because they are based on different groups of sites for each sampling period and site-to-site variability in conditions may distort actual trends. Although there are no consistent data available on the trends in the urban use of these pesticides during the study period, these results indicate the possibility that some reductions in urban use may have occurred. As mentioned earlier and discussed in Chapter 8, nonagricultural uses and some agricultural uses of diazinon and chlorpyrifos have declined since 2001 because of use restrictions initiated by USEPA. If concentrations of these insecticides are, in fact, declining in urban streams, the potential for effects on aquatic life in urban streams likely will also decline if their uses are replaced with pesticides that reach streams in less toxic amounts (or with alternative approaches to pest control).

In agricultural streams, most exceedances of aquatic-life benchmarks were by chlorpyrifos, azinphos-methyl, atrazine, *p,p'*-DDE, and alachlor (fig. 6–7). The greatest potential for effects on aquatic life was generally in areas where one or more of these pesticides were intensively used, or in the case of *p,p'*-DDE, where its parent compounds were intensively used in the past. For the purpose of characterizing changes over time in benchmark exceedances, there were sufficient agricultural stream sites with sampling years distributed throughout the study period only for streams in the corn-and-soybeans crop setting (fig. 4–6). This agricultural setting had the highest use during the study period of chlorpyrifos, atrazine, and alachlor. The changes in the percentages of stream sites in this setting that had concentrations exceeding benchmarks were different for the three pesticides during the study period (fig. 6–12). There was no clear trend for chlorpyrifos, an increasing number of exceedances for atrazine, and a decrease in exceedances for alachlor (with none during 1998–2000). Data on the agricultural use of these three pesticides from 1992 to 2001 in the Corn Belt show that these changes over time in benchmark exceedances are consistent with changes in their use (fig. 6–12).

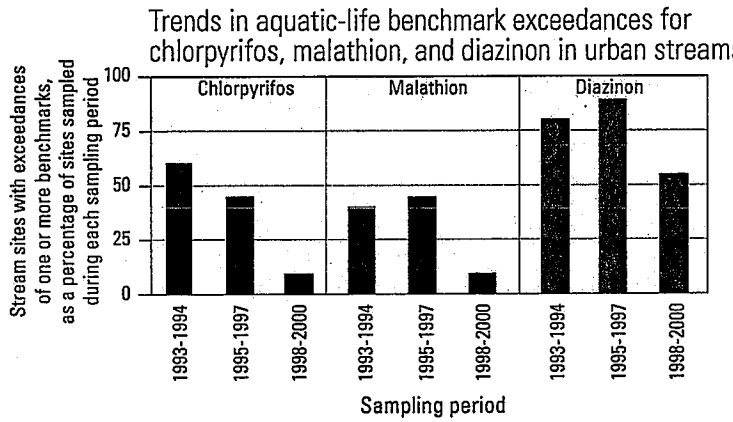

Figure 6–11. The percentages of urban streams that had exceedances of aquatic-life benchmarks for chlorpyrifos, malathion, and diazinon were lowest for each insecticide during the last sampling period. Sites were grouped according to the year of sampling. The 1993–1994 sampling period included 10 sites, the 1995–1997 period included 9 sites, and the 1998–2000 period included 11 sites.

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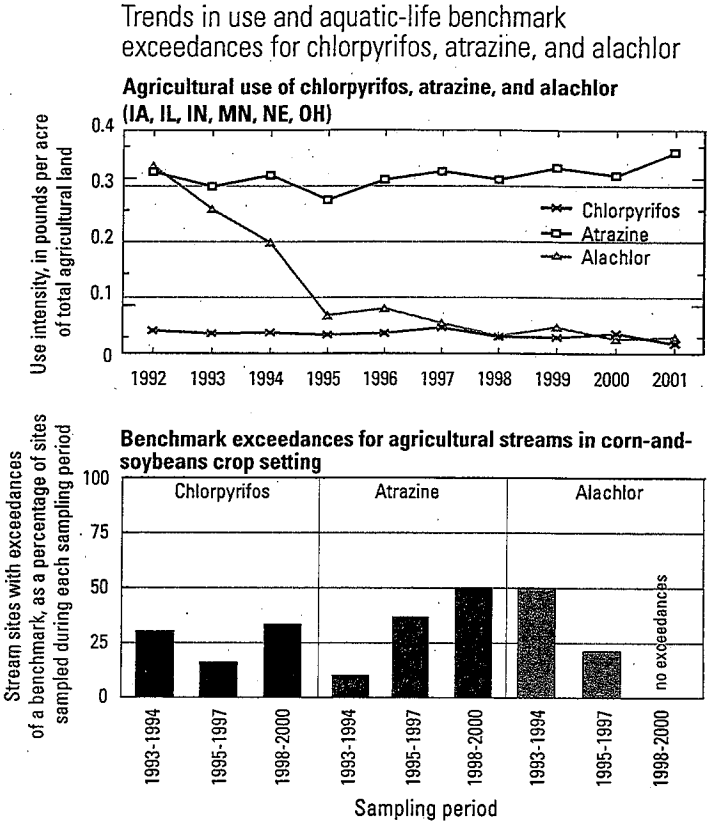

Figure 6–12. Changes over time in the percentage of agricultural stream sites in the corn-and-soybeans crop setting that had exceedances of aquatic-life benchmarks for chlorpyrifos, atrazine, and alachlor generally followed trends in use. Sites were grouped according to the year of sampling. The 1993–1994 sampling period included 10 sites, the 1995–1997 period included 19 sites, and the 1998–2000 period included 6 sites.

Bed Sediment

Concentrations of organochlorine pesticide compounds measured in bed sediment were greater than one or more aquatic-life benchmarks at 70 percent of urban sites, 31 percent of agricultural sites, 36 percent of mixed-land-use sites and 8 percent of undeveloped sites (fig. 6–4). The geographic distribution of sites where aquatic-life benchmarks for bed sediment were exceeded is similar to findings for water in many respects, including urban streams distributed throughout the country and many agricultural and mixed-land-use streams in the Southeast, East, and irrigated areas of the West (fig. 6–5).

In urban streams, concentrations of DDT or one or more of its degradates or by-products were greater than benchmarks at 58 percent of sampled sites, total chlordane at 57 percent of sites, and dieldrin at 26 percent of sites (fig. 6–13). In agricultural streams, compounds in the DDT group exceeded benchmarks at 28 percent of sites and dieldrin at 8 percent of sites.

The geographic distributions of concentrations that were greater than benchmarks are different for DDT compounds (fig. 6–14) compared with dieldrin (fig. 6–15), following their historical use patterns. Concentrations of one or more DDT compounds were greater than benchmarks for aquatic life in 58 percent of urban streams and about 28 percent of agricultural and mixed-land-use streams that were sampled. As discussed in Chapter 4, historical use of DDT for agriculture was highest in the Southeast, where cotton, tobacco, and peanuts were grown, and in a number of areas of the Nation where orchard crops, potatoes, vegetables, or specialty crops were grown. Dieldrin concentrations did not exceed its aquatic-life benchmark as frequently as DDT compounds, with 26 percent of urban streams

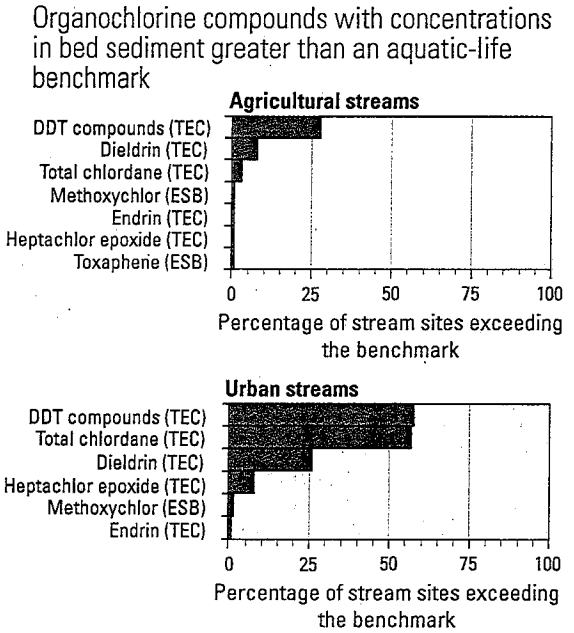

Figure 6–13. Contributions of individual pesticide compounds and groups to exceedances of aquatic-life benchmarks for bed sediment show the importance of historically used insecticides in urban streams, particularly DDT compounds, chlordane, and dieldrin. In agricultural streams, DDT compounds and dieldrin accounted for most exceedances of benchmarks. The type of benchmark is listed after each compound name as ESB for equilibrium partitioning sediment benchmark, or as TEC for threshold effect concentration. Water-quality benchmarks are provided in Appendix 3B.

A012101

Aquatic-Life Benchmarks for Organochlorine Compounds in Bed Sediment

Benchmarks for assessing the potential for organochlorine pesticides compounds in bed sediment to adversely affect aquatic life were selected from consensus-based sediment-quality guidelines developed for sediment-dwelling aquatic organisms (MacDonald and others, 2000). These benchmarks are available for 6 of the 16 individual organochlorine pesticide compounds and compound groups (such as total chlordane) measured in sediment, including all of the most commonly detected ones. Threshold effect concentrations (TEC), which are concentrations below which harmful effects on sediment-dwelling organisms are not expected, were used as the primary screening-level benchmarks. In NAWQA's analysis, the TEC benchmarks were supplemented by USEPA equilibrium partitioning sediment benchmarks (ESB), which are available for 6 of the 16 organochlorine pesticide compounds and groups measured (USEPA, 2003c,d,e). Although ESBs are not available for some of the most commonly detected pesticides in sediment (DDT and chlordane), the 6 compounds with ESBs include 3 pesticides that do not have TEC benchmarks—toxaphene, methoxychlor, and endosulfan (Appendix 3B). Therefore, sediment benchmarks are available for a total of 9 of the 16 organochlorine pesticides or pesticide groups analyzed by NAWQA.

The two types of sediment benchmarks are quite different from one another. The TECs are empirically derived and are effective predictors of toxicity (or nontoxicity) in field-collected sediment, but they cannot be used to infer cause and effect related to individual contaminants. The TEC was selected as the primary benchmark because it meets the objectives of a screening-level assessment. The ESB is mechanistically based and is not designed to predict toxicity in field-collected sediment that contains multiple contaminants. A concentration greater than an ESB indicates a high likelihood of toxicity resulting from the specific contaminant. ESBs were used to provide some information on potential toxicity for pesticides that do not have TEC benchmarks.

Consensus-based threshold effect concentration (TEC)—The concentration of sediment-associated contaminants below which adverse effects on sediment-dwelling organisms are not expected to occur. The consensus-based TEC benchmarks are empirically based and indicate the likelihood that field-collected samples containing a given pesticide concentration will be toxic or nontoxic, but they do not necessarily indicate cause-and-effect. The particular pesticide upon which the benchmark is based is not necessarily the source of the toxicity because sediment may contain multiple contaminants. Validation data showed that 15–29 percent of sediment samples, depending on the pesticide, had measurable toxicity at organochlorine pesticide concentrations below their respective TECs (MacDonald and others, 2000). The incidence of toxicity above the TEC was consistently higher, with 40 percent of samples for one pesticide (endrin), and 70–100 percent for the rest, showing measurable toxicity above their respective TECs.

Equilibrium partitioning sediment benchmark (ESB)—The concentration of a chemical in sediment that USEPA expects will not adversely affect most benthic organisms. ESBs are mechanistic benchmarks based on the equilibrium partitioning model, which assumes that the toxicity of an organic contaminant in sediment is causally related to bioavailability and that bioavailability is controlled by contaminant sorption to sediment organic carbon. ESBs further assume that the contaminant is in equilibrium with sediment particles and sediment pore water. In the natural environment, including areas with highly erosional or depositional bed sediment, contaminants may not attain equilibrium. Each ESB is designed to predict toxicity caused by a specific contaminant (or group) only, and it is not expected to correctly predict toxicity when other contaminants are present in toxic amounts, such as may occur in field-collected samples containing contaminant mixtures. Thus, when a contaminant concentration exceeds its ESB in field-collected sediment, the sediment is predicted to be toxic because of the presence of that contaminant.

Application of Aquatic-Life Benchmarks for Bed Sediment

Aquatic-life benchmarks for sediment, both TECs and ESBs, were compared with pesticide concentrations measured by NAWQA in composite bed-sediment samples collected from depositional areas in streams (one sample per site). TECs, which are expressed on a total sediment basis, were compared directly with NAWQA-measured pesticide concentrations in sediment. Because ESBs are in units of micrograms of contaminant per gram of sediment organic carbon, NAWQA-measured pesticide concentrations (micrograms of contaminant per kilogram of total sediment) were first divided by the measured organic carbon content (grams of organic carbon per kilogram of total sediment) of the sediment sample, before comparison with ESBs.

and 8 percent of agricultural and mixed-land-use streams having concentrations greater than the benchmark. For dieldrin, a cluster of agricultural sites with concentrations greater than the benchmark is located in the Corn Belt, where use of aldrin and dieldrin on corn was most intensive. In urban areas, these pesticides were used for such purposes as mosquito and termite control.

The screening-level assessment for organochlorine compounds in bed sediment indicates that most urban streams sampled by NAWQA (70 percent), and about one-third of sampled streams with watersheds dominated by agricultural or mixed land uses, had concentrations of organochlorine compounds that exceeded one or more aquatic-life benchmarks during the study period. Although DDT, aldrin, dieldrin, and chlordane are no longer used in the United States, the screening-level assessment indicates that these compounds and their degradates continue to be present at levels in bed sediment that may have adverse effects on aquatic life in some streams.

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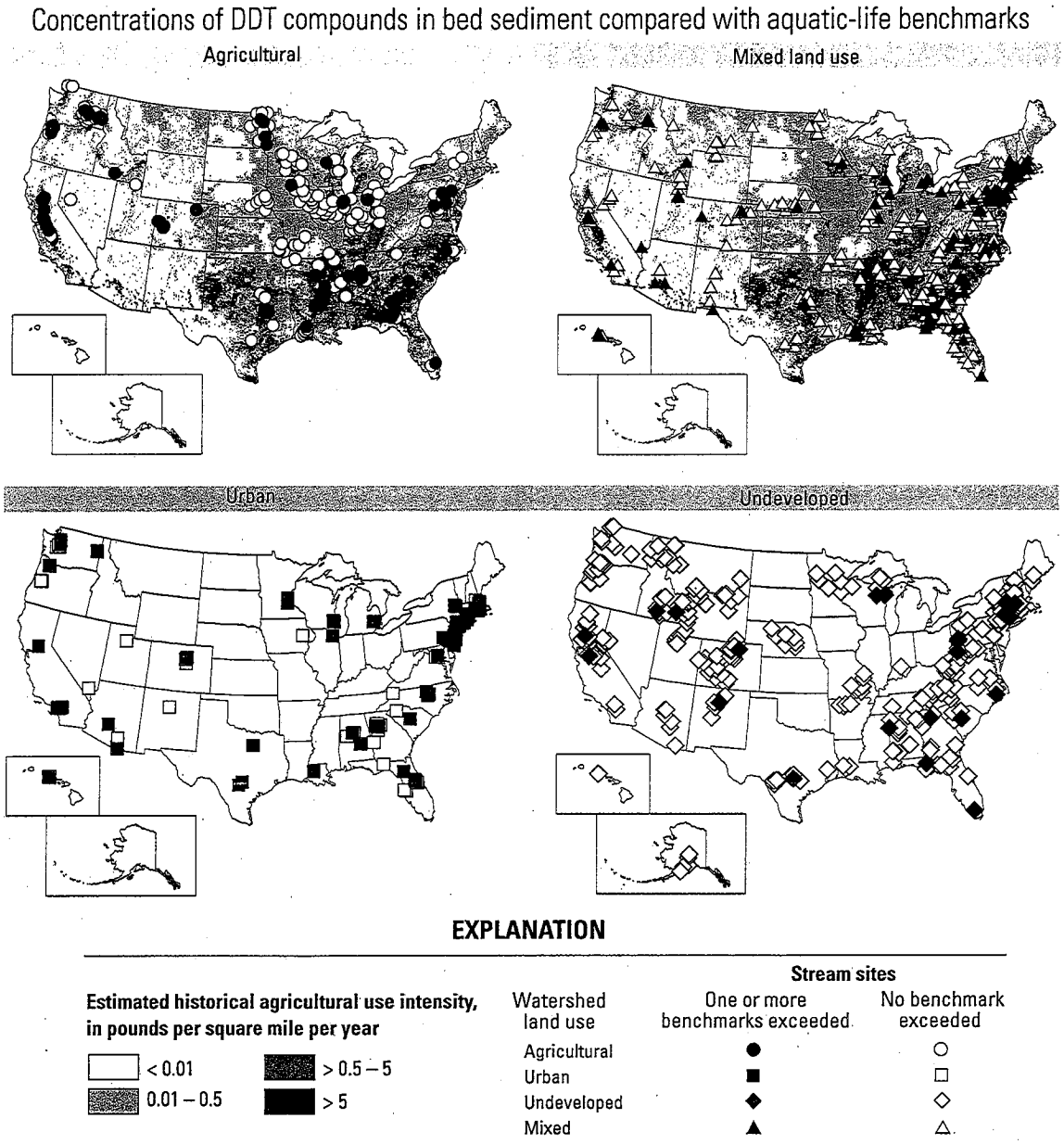

Figure 6–14. Streams in which concentrations of one or more DDT compounds in bed sediment exceeded an aquatic-life benchmark were predominantly urban streams, or agricultural and mixed-land-use streams in areas where historical use of DDT plus DDD was greatest. Water-quality benchmarks are provided in Appendix 3B.

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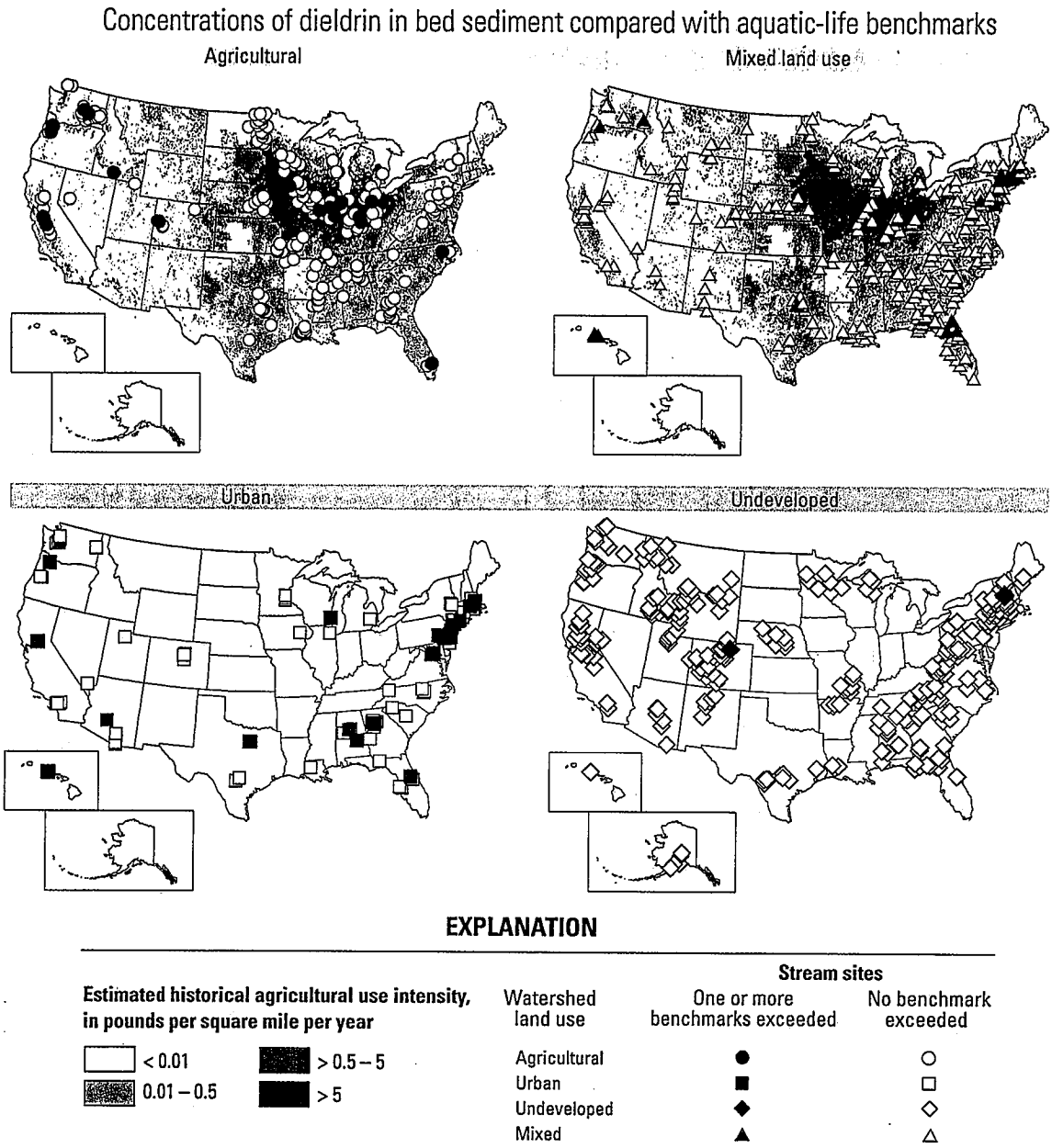

Figure 6–15. Streams in which dieldrin concentrations in bed sediment exceeded its aquatic-life benchmark were predominantly urban streams or agricultural and mixed-land-use streams in areas where historical use of aldrin plus dieldrin was greatest. Water-quality benchmarks are provided in Appendix 3B.

A012104

Screening-Level Assessment for Fish-Eating Wildlife

NAWQA data on pesticides in whole fish were compared with both the low and high values of the range in available benchmarks, because there is no consensus on a national-scale suite of wildlife benchmarks (see accompanying sidebar, p. 109). Comparisons of measured concentrations of organochlorine pesticide compounds in whole-fish tissue with wildlife benchmarks indicate a correspondingly wide range of potential for effects, depending on whether the low or high benchmark values are used (fig. 6–16). The high benchmarks for fish tissue were exceeded most frequently in streams in the populous Northeast; in high-use agricultural areas in the upper and lower Mississippi River Basin; in high-use irrigated agricultural areas of the West, such as eastern Washington and the Central Valley of California; and in urban streams distributed throughout the country (fig. 6–17). Few fish samples were analyzed in the Southeast. The low (more protective) benchmarks generally show an expanded proportion of sites in the same regions and land uses.

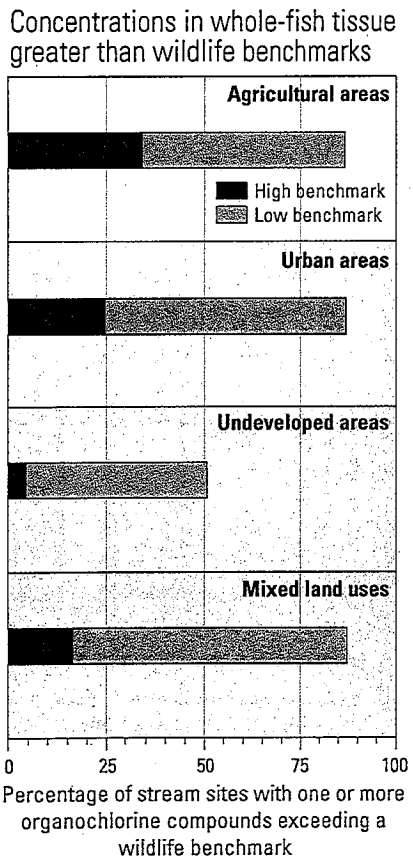

Figure 6–16. Wildlife benchmarks for concentrations of organochlorine pesticides in fish tissue were often exceeded, but the range of results for high and low benchmark values indicates that there is considerable uncertainty in wildlife benchmark values. Water-quality benchmarks are provided in Appendix 3B.

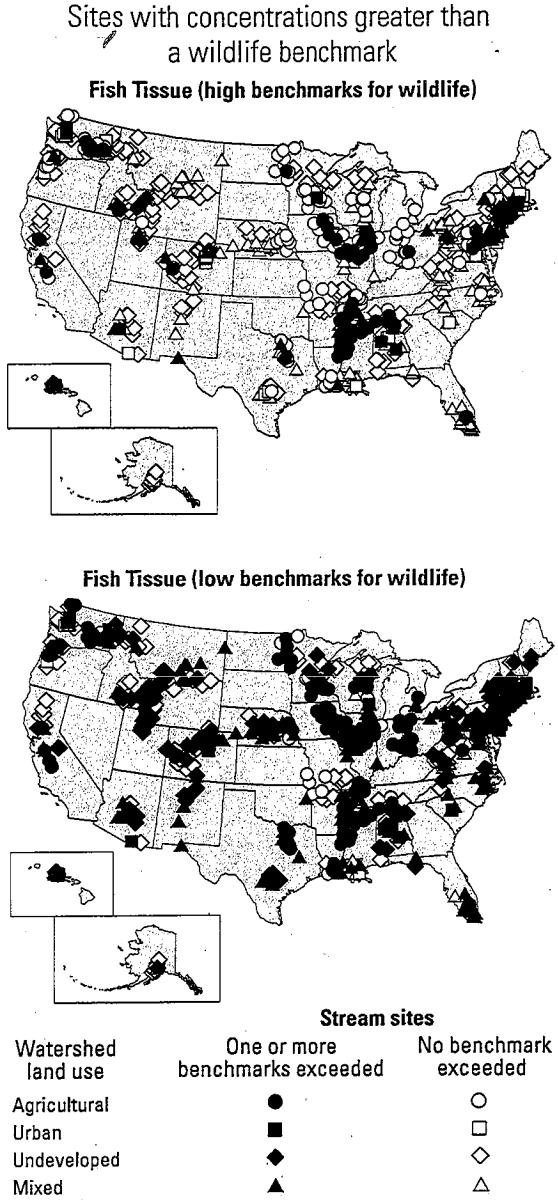

Figure 6–17. Wildlife benchmarks were exceeded by organochlorine pesticide compounds in whole fish most frequently in urban and mixed-land-use streams in the populous Northeast, in agricultural streams in areas with high historical use, and in urban streams distributed throughout the country. Water-quality benchmarks are provided in Appendix 3B.

A012105

Wildlife Benchmarks for Pesticides in Whole Fish

Benchmarks for assessing the potential for organochlorine pesticide compounds in fish tissue to adversely affect wildlife that consume either fish or other fish-eating wildlife were selected from several sources (Appendix 3B). USEPA is developing tissue-based criteria for bioaccumulative contaminants, but the process is not complete (USEPA, 2005i).

Currently, there is no broad consensus on a single system of national-scale, fish-tissue benchmarks for wildlife. Relatively few tissue-based wildlife benchmarks are available, some of which were developed for State or regional applications. Most available benchmarks have, however, been derived using similar methodologies (based on the same USEPA methodology for using laboratory animal test data to develop human-health benchmarks). First, a no-observed-adverse-effects level (NOAEL) for wildlife is estimated from the NOAEL for the most sensitive test species. Then the concentration of a contaminant in food that would result in a dose equivalent to the NOAEL (assuming no exposure through other environmental media) is calculated from estimates of the food consumption rate and body weight for multiple representative wildlife species. Calculations usually are done for both mammalian and avian species, and the lowest is commonly selected as a screening-level benchmark. Benchmark values from different sources vary considerably for a given compound, despite similar methodologies. The extreme case is total DDT, for which tissue-based wildlife benchmarks range from 6 to 200 µg/kg wet weight. Different values for a particular pesticide may result from the use of different test species in toxicity tests, the use of different uncertainty factors to account for interspecies differences, and differences in the duration of exposure or test endpoints measured. In addition, results may be extrapolated to different representative wildlife species, which typically are selected to reflect the geographic location and objectives of the program or organization setting the benchmarks.

Because of the lack of consensus on tissue-based benchmarks for protection of wildlife, whole-fish concentrations measured by NAWQA were compared with a range of available benchmark values for each compound. First, systematically derived wildlife benchmarks were compiled, resulting in four sets of wildlife benchmarks (described below). Second, the lowest and highest benchmark values for each organochlorine pesticide or group were selected and used in two separate analyses of NAWQA fish data. Each wildlife benchmark used in this report represents the concentration of a pesticide or group in fish, below which adverse effects on fish-eating wildlife are not expected to occur (100 percent of exposure to the pesticide is assumed to be from consumption of fish). One or more fish-eating wildlife benchmarks were available for 10 of the 12 organochlorine pesticides and groups measured by NAWQA in fish tissue.

NOAEL-based toxicological benchmark for fish-eating wildlife—This benchmark is the NOAEL-equivalent concentration in food derived for the most sensitive fish-eating wildlife species for which data are available. NOAEL-equivalent concentrations in food were derived for a variety of wildlife species by Sample and others (1996) for the Department of Energy, Oak Ridge National Laboratory, for use in ecological risk assessments at waste sites. Endpoints such as reproductive and developmental toxicity and reduced survival were used whenever possible, but for some contaminants, data were limited and other endpoints (such as organ-specific toxic effects) were used. The representative wildlife species used by Sample and others (1996) represent a wide range of diets and body weights and have wide geographic distributions within the United States. These include several fish-eating species: mink, river otter, belted kingfisher, osprey, and great blue heron. For this report, the lowest value was selected from the available NOAEL-equivalent concentrations in food that were derived for fish-eating species and used as the benchmark for each compound. These benchmarks are available for 8 of the 12 organochlorine pesticides and pesticide groups measured by NAWQA in fish.

Canadian Tissue Residue Guideline (TRG)—This benchmark is designed to protect all life stages of all wildlife during a lifetime exposure to a substance present as a contaminant in aquatic food sources (CCME, 1998). TRGs are calculated from the most sensitive of the available toxicity tests and applied to the Canadian wildlife species with the highest food intake/body weight ratio (CCME, 1998). TRGs are available for two organochlorine pesticides (DDT and toxaphene), which were derived using Wilson's storm petrel and the mink as representative wildlife species (CCME, 1999a,b).

New York fish flesh criteria (FFC) for protection of piscivorous wildlife, noncancer values—These are intended to protect specific wildlife species from adverse effects other than cancer, such as mortality, reproductive impairment, and organ damage (Newell and others, 1987). The New York State Department of Environmental Conservation (NYSDEC) derived these criteria using the same extensive laboratory animal toxicology database that is used to derive criteria for the protection of human health. Instead of extrapolating from laboratory animals to humans, the NYSDEC extrapolated from laboratory animals to wildlife. To represent birds and mammals, the NYSDEC selected a generic bird (with a body weight of 1 kg and a food consumption rate of 0.2 kg/day) and the mink. New York FFC are available for 8 of the 12 organochlorine pesticides and pesticide groups measured by NAWQA in fish.

Proposed criteria from the Contaminant Hazard Review series—Proposed tissue-based criteria for wildlife are included among recommendations for protection of natural resources in the Contaminant Hazard Review series developed by the U.S. Fish and Wildlife Service. Proposed criteria are available from this series for two organochlorine pesticides, toxaphene and chlordane. For chlordane (Eisler, 1990), the criterion is based on birds only—Eisler noted that criteria for protection of mammalian wildlife were lacking, and criteria for birds were incomplete and still required NOAELs from lifetime exposures. Wildlife benchmarks for toxaphene (Eisler and Jacknow, 1985) are based on criteria for human-health protection (ranging in various foods from 0.1 to 7.0 mg/kg), which are expected to protect sensitive species of wildlife.

Application of Fish-eating Wildlife Benchmarks for Fish

Fish-eating wildlife benchmarks for fish tissue were compared with concentrations of organochlorine pesticide compounds or groups measured by NAWQA in composite samples of whole fish (one sample per site). Concentrations measured by NAWQA were compared with both the lowest and the highest benchmark values available for each pesticide compound and group. The analysis thus reflects the degree of uncertainty in estimating the potential for adverse effects on wildlife.

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Most of the concentrations that exceeded a benchmark, as well as most of the variance between high and low benchmarks, were due to total DDT. Using the high and low ends of the range of benchmark values available for different pesticides (or pesticide groups), wildlife benchmarks were exceeded at 11 to 88 percent of urban stream sites for total DDT, 15 to 18 percent for dieldrin, and 0 to 10 percent for total chlordane. In agricultural streams, total DDT exceeded wildlife benchmarks at 29 to 87 percent of sites, dieldrin at 7 to 11 percent, and toxaphene at 0 to 9 percent (fig. 6–18).

The wildlife screening-level assessment for organochlorine compounds in fish tissue indicates that these compounds still occur at some sites at concentrations that have the potential to adversely affect fish-eating wildlife. Although there is relatively high uncertainty in benchmark values, total DDT and dieldrin accounted for most benchmark exceedances, and there were 34 percent of agricultural sites and 25 percent of urban sites with concentrations that exceeded both low and high benchmark values for one or more pesticide compounds or groups.

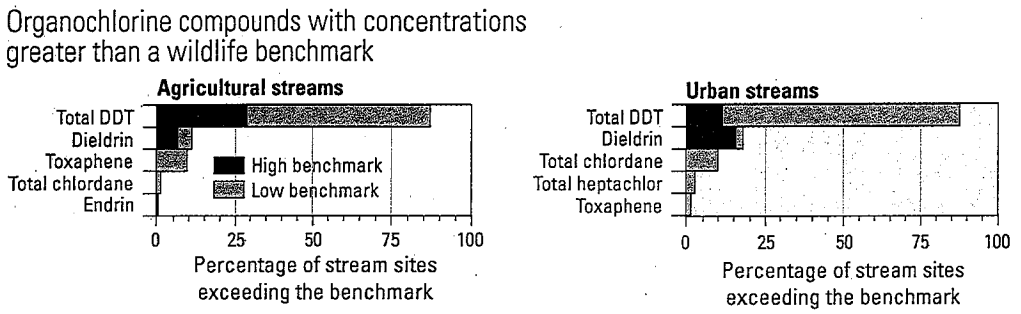
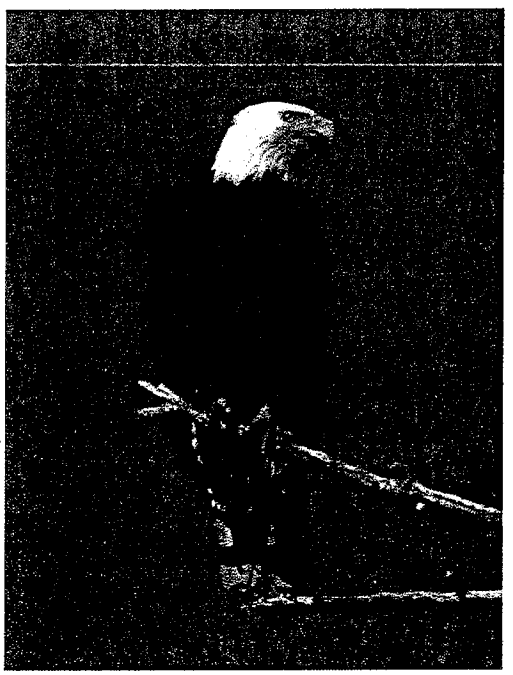


Figure 6–18. Contributions of individual organochlorine pesticide compounds or groups to exceedances of whole-fish tissue benchmarks for fish-eating wildlife show the potential significance of total DDT and dieldrin. Water-quality benchmarks are provided in Appendix 3B.



Organochlorine compounds from historical pesticide use are still a concern for fish-eating wildlife in some streams (Photograph by W.H. Mullins © 1974).

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Emerging Issues for Assessment of Pesticide Effects

Although pesticides are among the most intensively studied of environmental contaminants, and many studies of fate and effects are required to register a pesticide for use, comprehensive assessment of their potential effects continues to present challenges. Two issues receiving particular attention by the scientific and regulatory communities are the potential effects of pesticide mixtures, the occurrence of which was examined in Chapter 5, and the potential effects of pesticides on endocrine systems.

Approaches for Assessing Potential Effects of Pesticide Mixtures on Humans and Aquatic Life

Understanding the potential effects of chemical mixtures on humans and the environment is one of the most complex problems facing scientists and regulatory agencies. USEPA identified this issue as a priority in its research strategy for 2000 and beyond (USEPA, 2000b). Although guidelines and detailed procedures for evaluating potential effects from exposure to chemical mixtures have been provided by USEPA (USEPA, 1986, 2000b) and other agencies (ATSDR, 2004b), implementation has been difficult because of the complexity of mixtures that occur in the environment and the inadequacy of data on the toxicity of the mixtures. Most toxicological testing is performed on single chemicals—usually at high exposure levels—whereas most human and ecological exposures are to chemical mixtures at relatively low doses (USEPA, 2000b; ATSDR, 2004b).

Humans can be exposed to mixtures of pesticides and their degradates that occur in streams and ground water if such water is used as a source of drinking water and if treatment does not eliminate the pesticide compounds. Aquatic organisms are exposed to mixtures that occur in streams. Pesticide mixtures may be derived from common sources (such as point sources) or from multiple nonpoint sources, and may include several different types of pesticide compounds with different mechanisms of toxicity. Although a review of recent research on the effects of pesticide mixtures is beyond the scope of this report, the present approaches taken by USEPA and other agencies for regulating and assessing pesticide mixtures provide an indication of present knowledge and information gaps.

Evaluation and management of potential risks to humans of pesticide mixtures that may occur in drinking water are primarily addressed at the Federal level by USEPA and the Agency for Toxic Substances and Disease Registry (ATSDR). Much of the attention to potential effects of chemical mixtures on human health has been associated with risk assessments required for hazardous waste sites as part of implementing the Comprehensive Environmental Recovery, Compensation, and Liability Act (CERCLA), but specific assessment of pesticide mixtures is also now occurring to meet requirements of the Food Quality Protection Act (FQPA) of 1996. Under the FQPA, USEPA must assess the cumulative risks of pesticides that share a common mechanism of toxicity, or act the same way in the body. These cumulative assessments consider exposures from food, drinking water, and residential sources. USEPA also incorporates regional exposures from residential and drinking-water sources to account for the considerable variation in potential exposures across the country. To date, USEPA has determined that within each of four different chemical classes (organophosphates, N-methyl carbamates, triazines, and chloroacetanilides), several specific pesticide compounds have a common mechanism of toxicity and require cumulative risk assessments to better define the potential effects of exposure of humans to multiple pesticides within each class.

The potential effects of chemical mixtures on aquatic life have not received as much attention as for human health, although USEPA's Office of Research and Development, National Center for Environmental Assessment, has completed ecological risk-assessment guidelines that support the cumulative risk-assessment approach (USEPA, 2003f). The pesticide registration and reregistration processes require ecological risk assessment, which includes evaluation by USEPA of the likelihood that exposure to more than one pesticide and its degradates may cause harmful ecological effects.

Potential effects of pesticide mixtures on aquatic life also may be considered as part of assessments for National Pollutant Discharge Elimination System (NPDES) permits or hazardous waste sites. Procedures developed by USEPA for conducting assessments for NPDES permits involve a battery of tests, referred to as "whole effluent toxicity" (WET) tests, for both effluents and receiving waters. The WET tests are toxic-

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ity tests applied to actual or simulated effluent and receiving water and, therefore, assess the combined toxicity to aquatic life of all contaminants present in water (USEPA, 2004f). Although the WET test procedures provide a methodology for directly testing ambient waters that contain mixtures, they have not yet been applied more broadly to assess mixtures of pesticides from nonpoint sources that do not involve NPDES permits. Similarly, the risk-assessment methods developed for mixtures that occur at hazardous waste sites (USEPA, 2003f) provide a systematic approach to assessing potential effects of pesticide mixtures on aquatic life, but they are generally not applied to ambient water-quality conditions.

In addition to these various approaches to addressing mixtures as part of the regulatory process, researchers are studying the effects of specific mixtures of pesticides and degradates and relating the occurrence of mixtures to their potential effects on aquatic ecosystems. The accompanying sidebar by Lydy and Belden (p. 114) provides a perspective on current understanding and the status of research regarding the potential effects of pesticide mixtures on aquatic life. NAWQA has begun to examine relations between biological measures of stream quality and the range of stresses introduced by agricultural and urban activities, including exposure to pesticides. The accompanying sidebar on the Pesticide Toxicity Index (p. 116) summarizes how the index is used by NAWQA as a relative indication of the potential toxicity of a mixture to aquatic life and illustrates its applications with examples from NAWQA studies.

Although an array of approaches has been developed for assessing the potential effects of mixtures using the best available data on exposure and effects, progress toward understanding the potential effects of pesticide mixtures on humans and aquatic life has been hampered, in part, by sparse data on the composition and concentrations of mixtures that actually occur in streams and ground water. As examined in Chapter 5, pesticide degradates are potentially important components of pesticide mixtures that need to be considered when evaluating potential effects. Improved data on the occurrence and composition of mixtures from NAWQA and other studies can help to characterize the potential exposure of humans, aquatic life, and wildlife to mixtures and provide a basis for systematically prioritizing mixtures that may occur in streams and ground water.

Endocrine Disruption and Pesticides

Endocrine systems are present in mammals, birds, fish, and other organisms. They are comprised of glands that produce hormones, which act as chemical messengers, and receptors in various organs and tissues that recognize and respond to the hormones. The endocrine system regulates all body functions from conception through adulthood, including the development of the brain and nervous system, the growth and function of the reproductive system, and metabolism and blood-sugar levels. Disruption of the endocrine system by a contaminant can occur in a number of ways, such as by mimicking a natural hormone, blocking the effects of a hormone, or causing overproduction or underproduction of hormones (Gross and others, 2003).

More than 50 synthetic chemical compounds, including a number of pesticides, have been identified as potential endocrine disruptors in various studies over the past several years (National Academy of Sciences, 1999). The studies include bioassays demonstrating estrogenic or anti-estrogenic activity and field studies correlating contaminants with hormone-related effects. Examples of such field studies include feminization of gull embryos linked to elevated DDT (Fry and Toone, 1981), population declines of alligators in some Florida Lakes with elevated concentrations of organochlorine pesticides (including DDT) (Guillette and others, 1994), and feminization of fish in water bodies receiving municipal discharges or industrial effluents (Purdom and others, 1994).

In 1994, the NAWQA Program investigated the potential influence of contaminants on sex steroid hormones and other biomarkers in common carp (Goodbred and others, 1997). Abnormal ratios of sex steroid hormones in both male and female carp were found at some sites, and the ratio of estrogen to testosterone, an indicator of potential abnormalities in the endocrine system, was significantly lower at sites where some of the highest pesticide concentrations were detected (fig. 6–19). Further investigation is needed to determine whether (1) reduced hormone ratios are caused by pesticides, and (2) the reduced hormone ratios are associated with significant effects on fish populations.

The 1996 Food Quality Protection Act requires USEPA to screen and assess pesticides and other environmental contaminants for potential effects on human endocrine systems, an assessment which USEPA is extending to wild-

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life as well. A review of NAWQA pesticide data compared with a list of potential endocrine disrupting compounds (Keith, 1997) indicates that 17 pesticides measured by NAWQA in water are possible endocrine disruptors (USEPA has not yet designated pesticides that it considers to be potential endocrine disruptors). Eleven of these pesticides were among those most frequently found in NAWQA stream samples (fig. 6–20).

Research on the effects of chemicals on endocrine systems is in its relatively early stages. Several important aspects are still unclear, including the degree to which such effects occur in the environment; whether effects on individual organisms translate to effects on populations and communities; and at what concentrations effects on populations become significant. There is considerable scientific uncertainty about the causes of reported effects (Kavlock and others, 1996). A major effort is underway by USEPA and other agencies to systematically identify and better understand endocrine disruptors (USEPA, 1998).

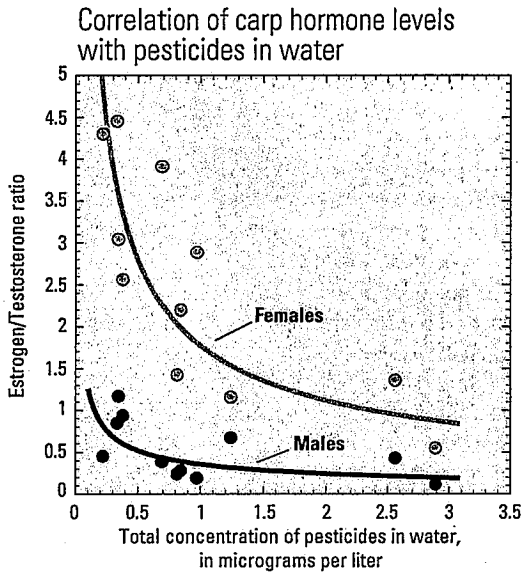

Figure 6–19. Ratios of estrogen-to-testosterone in carp from 11 streams sampled by NAWQA in 1994 were inversely correlated with pesticide concentrations. Low ratios indicate potential abnormalities in carp endocrine systems (Goodbred and others, 1997).

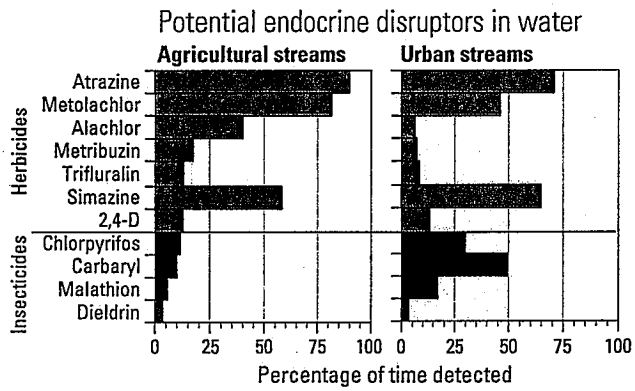

Figure 6–20. Eleven pesticides that have been identified as potential endocrine disruptors (Keith, 1997) were among the pesticides most frequently detected in NAWQA water samples from agricultural and urban streams.

A012110

Assessing Potential Effects of Pesticide Mixtures

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NAWQA studies show that the most common form of pesticide exposure for aquatic organisms is simultaneous exposure to multiple pesticides. More than 50 percent of all stream samples contained five or more pesticides. Yet, most pesticide research, historically and currently, has evaluated the effects of individual pesticides as if they occurred alone. Scientists and risk assessors are only in the beginning stages of developing the knowledge base and procedures for evaluating the potential environmental effects of pesticide mixtures in aquatic ecosystems.

Conceptual Models of Mixture Effects

Research on mixtures indicates that a wide array of possible interactions among pesticides may occur, but they all fall into one of four categories:

Independent—Co-occurring pesticides act independently of one another, with each causing the degree of effects on a population as would be expected from its individual concentration. This might occur for pesticides with different target organs and modes of action.

Additive—Co-occurring pesticides act in an additive manner, with effects on a population as would be expected by summing the toxicity-normalized concentrations of multiple individual pesticides that are present. This might be expected for pesticides with similar chemical structures and a common mode of action.

Antagonistic—Co-occurring pesticides have a combined toxicity that is less than that predicted from the additive model.

Synergistic—Co-occurring pesticides have a combined toxicity that is greater than that predicted from the additive model.

The additive model, also called the Concentration Addition Model, is the most common baseline used for assessing effects of pesticide mixtures, although not all mixtures strictly follow it. In a 2-compound mixture, the concentration of chemical A and the concentration of chemical B would be normalized (weighted) by toxicity as follows: the concentration of each chemical present in the sample is divided by its toxicity value (usually the concentration needed to cause a 50-percent effect in a population) and the toxicity-weighted concentrations are then added together. The effect expected would then be based on this normalized total concentration. For example, if two pesticides that have the same toxicity are each present in a stream at 10 µg/L, then the expected effect would be the same as the effect of 20 µg/L of either one of the compounds alone.

Experimentally, additive toxicity has been observed for several groups of mixtures, including 2-compound mixtures of the s-triazine herbicides atrazine and cyanazine in reproductive tests with the green alga *Chlorella fusca* (Faust and others, 1993) and 2-compound mixtures of several organophosphate insecticides, including chlorpyrifos, diazinon, and azinphos methyl, in tests with midges (Lydy and Austin, 2004). In addition, the organophosphate insecticides chlorpyrifos and diazinon were strictly additive in their toxicity to the cladoceran, *Ceriodaphnia dubia*, in toxicity studies performed in natural, storm, and laboratory waters (Bailey and others, 1996, 1997, 2000).

Several studies have shown that pesticide interaction can result in less (antagonistic) or more (synergistic) toxicity than predicted by the Concentration Addition Model. For example, researchers have demonstrated that simultaneous exposure to esfenvalerate (a pyrethroid insecticide) and diazinon (an organophosphate insecticide) resulted in greater than additive toxicity to fathead minnows (Denton and others, 2003). The likely reason for this synergism is that diazinon inhibits the esterase enzymes, thus reducing the organism's capability to detoxify pyrethroids. Other studies have shown that the herbicide atrazine, when present at concentrations above 40 µg/L, increases the toxicity of the organophosphate insecticides chlorpyrifos (fig. 6–21) and diazinon to aquatic invertebrates (Belden and Lydy, 2000; Anderson and Lydy, 2002). Note that atrazine itself is not acutely toxic to these invertebrates, even at high concentrations in water. In this case, the reason for the increased toxicity is that atrazine induces (increases production of) specific oxidative enzymes, resulting in a higher transformation rate of chlorpyrifos into a more toxic metabolic product (Belden and Lydy, 2000). In both of these examples, one contaminant changed the organism's capacity to metabolize the other contaminant, thus increasing or decreasing the amount of pesticide or pesticide breakdown products within the organism, and leading to large changes in the degree of toxicity.

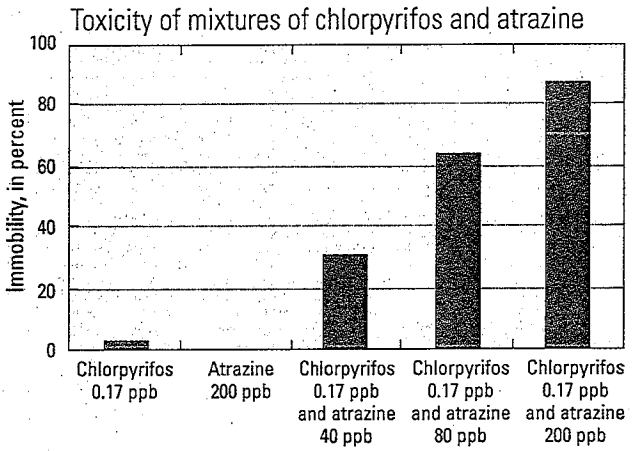

Figure 6–21. Although atrazine itself was not acutely toxic to the aquatic invertebrates tested in this study (chironomids), an increase in atrazine concentration caused an increase in the toxicity observed for chlorpyrifos (a synergistic interaction), as indicated by increased immobility (Belden and Lydy, 2000). (Concentrations are shown in ppb [parts per billion] as in the original report, which is equivalent to micrograms per liter.)

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Studies of the toxicity of pesticide mixtures have resulted in the full spectrum of additive, synergistic, and antagonistic responses. Generally, pesticides within the same pesticide class and that have similar structures and a common mode of action (for example, organophosphate insecticides) are more likely to follow the additive model, while pesticides from different classes (for example, herbicides and insecticides) have more varied effects. Table 6–2 summarizes the results from selected studies of mixtures containing the organophosphate insecticide diazinon. Because of the complexity of the modes of action and chemical transformations that occur for each pesticide, the toxicity of most pesticide mixtures will deviate from the simple additive model. It is not known how likely such deviations from additivity are, nor is there consensus on how large a deviation from the model is significant. In many cases, this deviation may be smaller than that obtained from testing the organisms under slightly different conditions (intraspecies toxicity testing), indicating that other sources of uncertainty may be more significant than errors in mixture models. However, until a more thorough understanding of pesticide interactions is achieved, the possibility of pesticide combinations resulting in greater toxicity than predicted by the additive model needs to be considered.

Implications

In most situations, a mixture of pesticides presents a greater risk to aquatic organisms than do any of the individual components of the mixture. The ecological effects caused by mixtures of pesticides, however, are highly uncertain and are in the relatively early stages of investigation. Further research must be conducted before the possible impacts that pesticide mixtures may have on the environment can be determined. The large numbers of chemicals and varying exposure routes that occur in the environment make testing every possible exposure scenario impossible. For example, in a mixture of 20 compounds, there are 190 pairs of compounds, and more than a million possible combinations (pairs, triples, and so on). Thus, it makes sense for researchers assessing mixture effects to prioritize and test those combinations with a high probability of environmental occurrence and those that are useful in developing refined models to predict the toxicity of similar pesticide mixtures.

Ultimately, aquatic toxicologists need to understand the dynamic world that organisms encounter. Besides pesticides, organisms are exposed to other types of chemical contaminants (such as metals and industrial contaminants) and also biological and physical stressors (such as changes in flow rate, temperature, habitat, food availability, and predation) simultaneously. It is likely that these stressors interact. However, until we better understand the biology of aquatic systems, from the molecular to the ecosystem level, we will continue to struggle in predicting the existence and significance of chemical interactions.

Table 6–2. Selected studies of pesticide mixtures containing diazinon illustrate the spectrum of possible responses for such mixtures. The types of compounds included are two organophosphate insecticides (OP), a pyrethroid insecticide (P), a triazine herbicide (T), and a nutrient.

Mixture	Type of compound	Species tested	Result	Deviation from concentration addition	Reference
Diazinon and chlorpyrifos	OP OP	Midges (aquatic invertebrate)	Additive	None	Lydy and Austin (2004)
Diazinon and chlorpyrifos	OP OP	*Ceriodaphnia dubia* (aquatic invertebrate)	Additive	None	Bailey and others (1996, 1997)
Diazinon and esfenvalerate	OP P	Fathead minnows	Synergistic	140 to 170 percent greater toxicity	Denton and others (2003)
Diazinon and atrazine	OP T	Midges, amphipods (aquatic invertebrates)	Synergistic	Up to 400 percent greater toxicity	Anderson and Lydy (2002); Belden and Lydy (2000)
Diazinon and ammonia	OP Nutrient	*Ceriodaphnia dubia* (aquatic invertebrate)	Antagonistic	27 to 32 percent less toxic	Bailey and others (2001)

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Pesticide Toxicity Index

To expand the assessment of potential effects of pesticides in stream water on aquatic life, NAWQA developed a Pesticide Toxicity Index (Munn and Gilliom, 2001). The Pesticide Toxicity Index (PTI) accounts for multiple pesticides in a sample, including pesticides without established benchmarks for aquatic life. The PTI combines information on exposure of aquatic biota to pesticides (measured concentrations of pesticides in stream water) with toxicity estimates (results from laboratory toxicity studies) to produce a relative index value for a sample or stream. The PTI value is computed for each sample of stream water by summing the toxicity quotients for all pesticides detected in the sample. The toxicity quotient is the measured concentration of a pesticide divided by its toxicity concentration from bioassays (such as an LC_{50} or EC_{50}). For each sample, separate PTI values are computed for fish and benthic invertebrates. This approach follows the Concentration Addition Model of toxicity described by Lydy and Belden (accompanying sidebar, p 114). Although simple additivity is unlikely to strictly apply for complex mixtures of pesticides from different classes and with different effects and modes of action, the PTI is still useful as a relative index. Deneer (2000) reported that "for more than 90 percent of 202 mixtures in 26 studies, concentration addition was found to predict effect concentrations correctly within a factor of two." While the PTI does not indicate whether water in a sample is toxic, its value can be used to rank or compare the relative potential toxicity of different samples or different streams.

The PTI provides a means to rank different stream sites compared with each other and is a tool for investigating relationships between pesticide levels and the quality of aquatic ecosystems. For example, pesticides were commonly detected in agricultural streams and drains throughout the Yakima River Basin, often at concentrations exceeding one or more aquatic-life benchmarks for individual pesticides (Fuhrer and others, 2004). Data for 24 stream sites in the Yakima River Basin showed that the number of pollution-tolerant

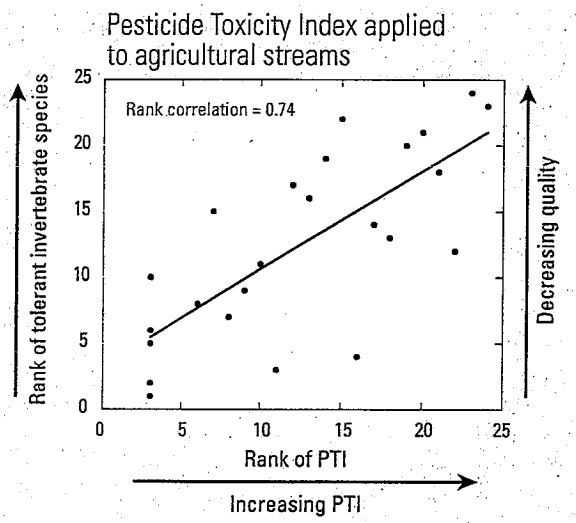

Figure 6–22. Streams and drains in the Yakima River Basin with the highest PTI values tended to have the highest numbers of pollution-tolerant benthic invertebrates, indicating lower water quality. The ranks were significantly correlated at a 95-percent confidence level. (Modified from Fuhrer and others, 2004.)

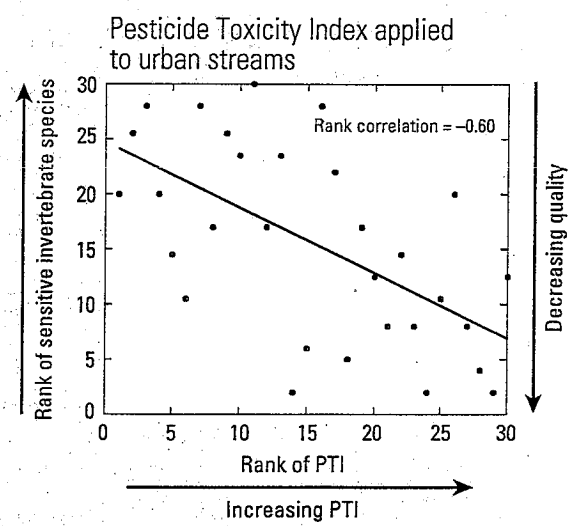

Figure 6–23. Streams in the Dayton and Cincinnati, Ohio areas with the highest PTI values tended to have the lowest numbers of sensitive invertebrate species, indicating lower water quality. The ranks were significantly inversely correlated at a 95-percent confidence level. (Modified from Rowe and others, 2004.)

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benthic invertebrates (higher numbers indicate a stressed ecosystem) significantly increased with the rank of PTI values (fig. 6–22). Pesticides, however, are only one of many factors that may affect aquatic communities—other factors include physical habitat quality, food availability, and the presence of other contaminants. Detailed studies are required to distinguish the relative roles of different chemical and physical factors.

Another example is for streams in the Dayton and Cincinnati, Ohio, urban areas, which were studied in the Great and Little Miami River Basins (Rowe and others, 2004). Results for 30 streams with varying degrees of urban land use in their watersheds indicated that the number of sensitive invertebrates (lower numbers indicate a stressed ecosystem) significantly decreased with increasing PTI values (fig. 6–23). As with the Yakima River Basin example, this correlation does not demonstrate a cause-and-effect relationship between pesticides and the benthic invertebrate community. The PTI was one of several factors found to correlate with degree of urbanization—which also included chloride levels in water and synthetic chemicals in bed sediment—that may affect benthic invertebrates (Rowe and others, 2004).

For a national-level perspective, the PTI was used to rank NAWQA stream sites by the potential toxicity of measured pesticide concentrations to fish and benthic invertebrates. Invertebrate PTI values generally were more than 10 times higher than those for fish, as shown by frequency distributions of the 95th percentile PTI values for streams in all land-use settings (fig. 6–24). The higher toxicity values for invertebrates reflect greater sensitivity of invertebrates compared with fish, particularly to insecticides. A large proportion of benthic invertebrates are insects, which explains the high relative toxicity of insecticides to this taxonomic group. PTI values for both fish and invertebrates are highest for samples collected from agricultural and urban streams, lowest for undeveloped streams, and intermediate for mixed-land-use streams. These results are consistent with the results of the screening-level assessment (using aquatic-life benchmarks) of the potential effects of pesticides in water on aquatic life.

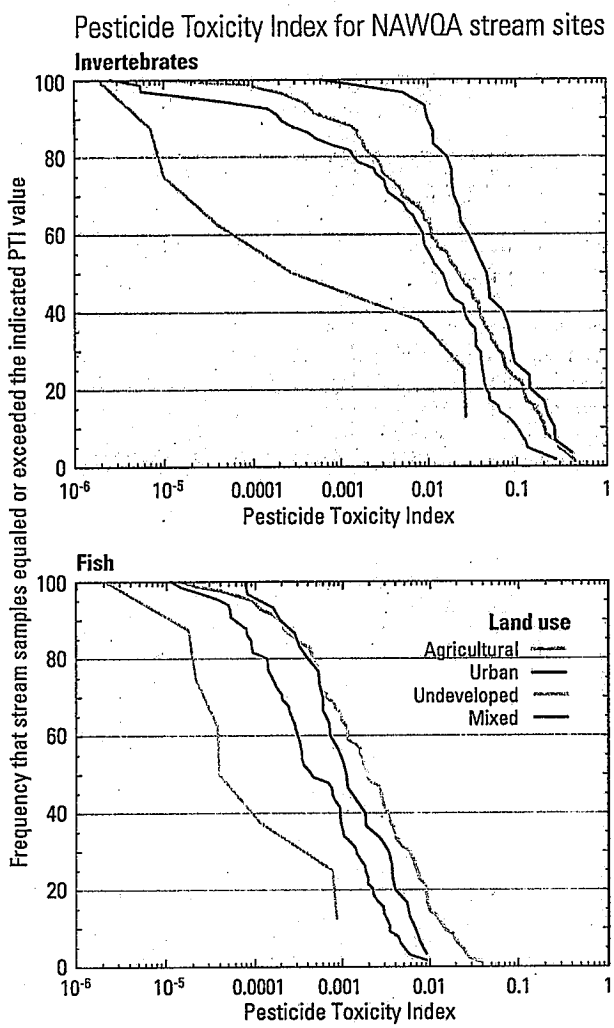

Figure 6–24. Invertebrate PTI values for all land-use categories were more than 10 times higher than fish PTI values. Urban and agricultural streams had the highest PTI values. This analysis is based on the 95th percentile PTI value for each site, which is an estimate of the PTI value that was exceeded by 5 percent of samples at the site.

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Prediction Where Data are Inadequate

Strategies for managing pesticides require far more information than we can afford to directly measure for all the places, times, and pesticides of interest. In addition, many strategic decisions—such as setting monitoring priorities, approving a pesticide registration, and determining how much to spend on a management strategy—inherently depend on predicting the potential effects of pesticides on water quality for locations that have never been directly assessed. In these situations, statistical models and other types of models can be useful for predicting water-quality conditions at unmonitored locations under a range of possible circumstances. Such tools are essential for efficient water-quality management.

Photograph by Albert E. Becher

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Approach to Prediction

NAWQA pesticide data collected from 1992 to 2001 support the development and testing of a wide range of models, particularly statistical models. Statistical models have been developed by NAWQA to predict pesticide levels in streams and ground water for locations where pesticide concentrations have not been measured. This expansion of water-quality assessment from individual monitoring sites to unstudied locations by use of models for prediction, or spatial extrapolation, is fundamental to extending the targeted local and regional studies of NAWQA to a comprehensive national assessment (Alaska and Hawaii have not been included in these models because there are no suitable pesticide-use data for these States).

The NAWQA statistical models for pesticides use linear regression methods to establish quantitative linkages between pesticide concentrations measured at NAWQA sampling sites and a variety of anthropogenic (human-related) and natural factors that affect pesticides. Such factors include pesticide use, soil characteristics, hydrology, and climate—collectively referred to as explanatory variables. Model-development data consist of measured pesticide concentrations or detection frequencies, together with the associated values of the explanatory variables for the sampling sites. The models are built using the explanatory variables that best correlate with, or explain, the concentrations or frequencies of occurrence of pesticides observed in streams and ground water. Although explanatory variables included in the models are significantly correlated with pesticide concentrations or detection frequencies, the specific cause-and-effect relations responsible for the observed correlations are not always clear, and inferences regarding causes should be considered as hypotheses.

In developing the pesticide models, all potential explanatory variables were required to have values available from existing data sources for all locations in the conterminous United States, so that national extrapolation would be possible (the only exception, as explained below, was fish lipid content for the dieldrin model). Overall, 30 to 60 possible variables were considered, depending on the specific model; these were reduced to the 4 to 6 explanatory variables that were most significant and yielded optimal model formulations. Each model incorporates an uncertainty analysis, which allows assessment of the reliability of the model predictions and also the expression of model predictions as probabilities that concentrations will exceed a specific value, such as a water-quality benchmark, at a particular location.

The three NAWQA models and nationally extrapolated results presented in this chapter are those developed for (1) concentrations of atrazine in stream water; (2) concentrations of dieldrin in whole fish; and (3) detection frequencies for atrazine in shallow ground water underlying agricultural settings. The extrapolations for atrazine concentrations in stream water and dieldrin concentrations in fish tissue are for streams included in the USEPA River Reach file (Nolan and others, 2003), which includes more than 600,000 miles of streams and more than 60,000 individual stream reaches with watersheds. The extrapolations of detection frequencies for atrazine in shallow ground water were made for all areas of the Nation where at least 50 percent of the land is in agricultural use. More detailed information on model development methods and supporting data, as well as uncertainty analyses, are provided by Larson and others (2004), Nowell and others (2006), and Stackelberg and others (2006). Additional work is currently underway on (1) a multi-pesticide model for stream water that incorporates selected chemical and physical properties of each compound, (2) expanding the models for fish tissue to include additional organochlorine compounds, and (3) site-specific, concentration-based models for atrazine in ground water.

Atrazine Concentrations in Streams

Model predictions of atrazine levels in streams across the Nation show the highest annual mean concentrations throughout the high-use areas of the Corn Belt and the Mississippi Valley and Delta regions, and in some areas of Texas, Pennsylvania, and Maryland. Figure 7–1 shows measured concentrations used to develop the model and figure 7–2 shows predicted concentrations. As noted along with other model details in the accompanying sidebar (p. 121), the model is based on the time-weighted annual mean for each model-development site. Annual means for a few streams in the Ohio and Mississippi Valleys and in southern Louisiana are predicted to exceed 3 µg/L, the human-health benchmark used for atrazine (Chapter 6 and Appendix 3A). The benchmark for atrazine is the USEPA MCL for drinking water. As a drinking-water standard, the MCL applies to finished water in public water supplies, whereas the predictions shown in figure 7–2 are for untreated

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stream water. Comparisons of model predictions with human-health benchmarks, however, serve as screening-level assessments of the suitability of potential drinking-water sources, as discussed in Chapter 6.

For more than half of the streams with a predicted annual mean atrazine concentration exceeding 0.3 µg/L (fig. 7–2), there is at least a 5-percent chance that the actual annual mean concentrations will exceed the human-health benchmark of 3 µg/L (fig. 7–2). Model estimates of probabilities shown in figure 7–2 indicate that at least 1 out of 20 (5 percent) of the streams shown in yellow, orange, or red would be expected to have annual mean atrazine concentrations greater than 3 µg/L. These streams may not be suitable as sources of drinking water without treatment or other management strategies to reduce atrazine concentrations. The streams with a greater than 5-percent probability of exceeding the benchmark represent about 7 percent of the Nation's stream miles (45,704 of 649,935 mi). Approximately 192 stream miles (less than 1/10th of 1 percent of the Nation's stream miles) are predicted to have more than a 50-percent probability of exceeding 3 µg/L.

The model indicates that atrazine use intensity is the most important factor explaining atrazine concentrations in streams—the more intensive the use of atrazine in a watershed, the higher the atrazine concentration in the stream. Specifically, estimated atrazine use intensity within each watershed explains 64 percent of the variance in annual mean atrazine concentrations in streams across the Nation. Four additional variables explain another 13 percent of the variability, most of which is accounted for by rainfall erosivity and soil erodibility—factors used in the revised Universal Soil Loss Equation (Renard and others, 1997). Rainfall erosivity and soil erodibility quantify, respectively, the energy of storms in a specific area (averaged over several years), and the susceptibility of soils to erosion by runoff. As these two factors increase, atrazine concentrations also increase, indicating that transport of atrazine is highest in areas of high-energy rain storms and in areas where soils are most susceptible to erosion. Alternatively, soil erodibility may indicate high surface runoff, rather than actual transport of atrazine with soil particles. Overall, the complete model explains a total of 77 percent of the variance in observed annual mean atrazine concentrations.

Development and Application of the Atrazine Model for Stream Water

As described by Larson and others (2004), the model for estimating atrazine concentrations in streams is based on time-weighted annual mean concentrations measured by NAWQA from 1992 to 2001 at 112 sites (fig. 7–1). The single most complete year of data was used to calculate the annual mean concentration for each site. The predicted values in figure 7–2 are median estimates of the annual mean, such that 50 percent of the actual annual means are expected to be greater than, and 50 percent less than, the predicted value. Nonagricultural uses of atrazine are not included and, as a result, predictions may represent underestimates for watersheds with substantial nonagricultural use. To illustrate a practical example of how such models can be applied to water-quality assessment, model estimates are compared with the human-health benchmark for atrazine, USEPA's Maximum Contaminant Level (MCL) for drinking water (Chapter 6 and Appendix 3). The model also was used to estimate the probability, after accounting for model uncertainty, that any particular stream site may have an annual mean atrazine concentration greater than 3 µg/L (fig. 7–2).

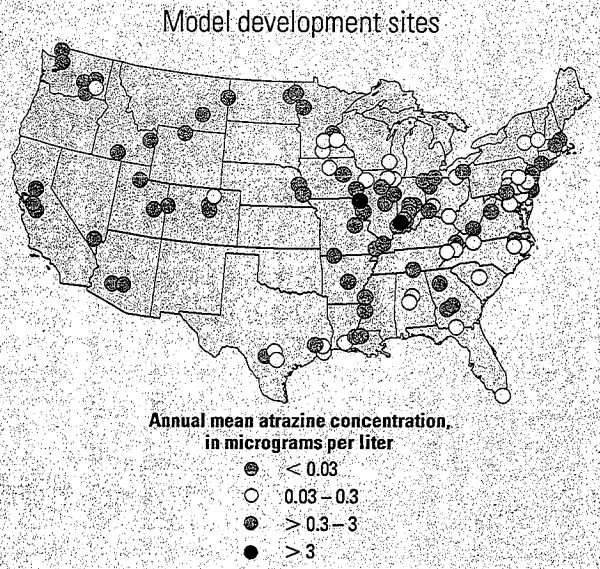

Figure 7–1. The model for annual mean concentrations of atrazine in streams was developed from data for 112 sites distributed across the country, which represent a wide range of hydrologic settings and atrazine concentrations.

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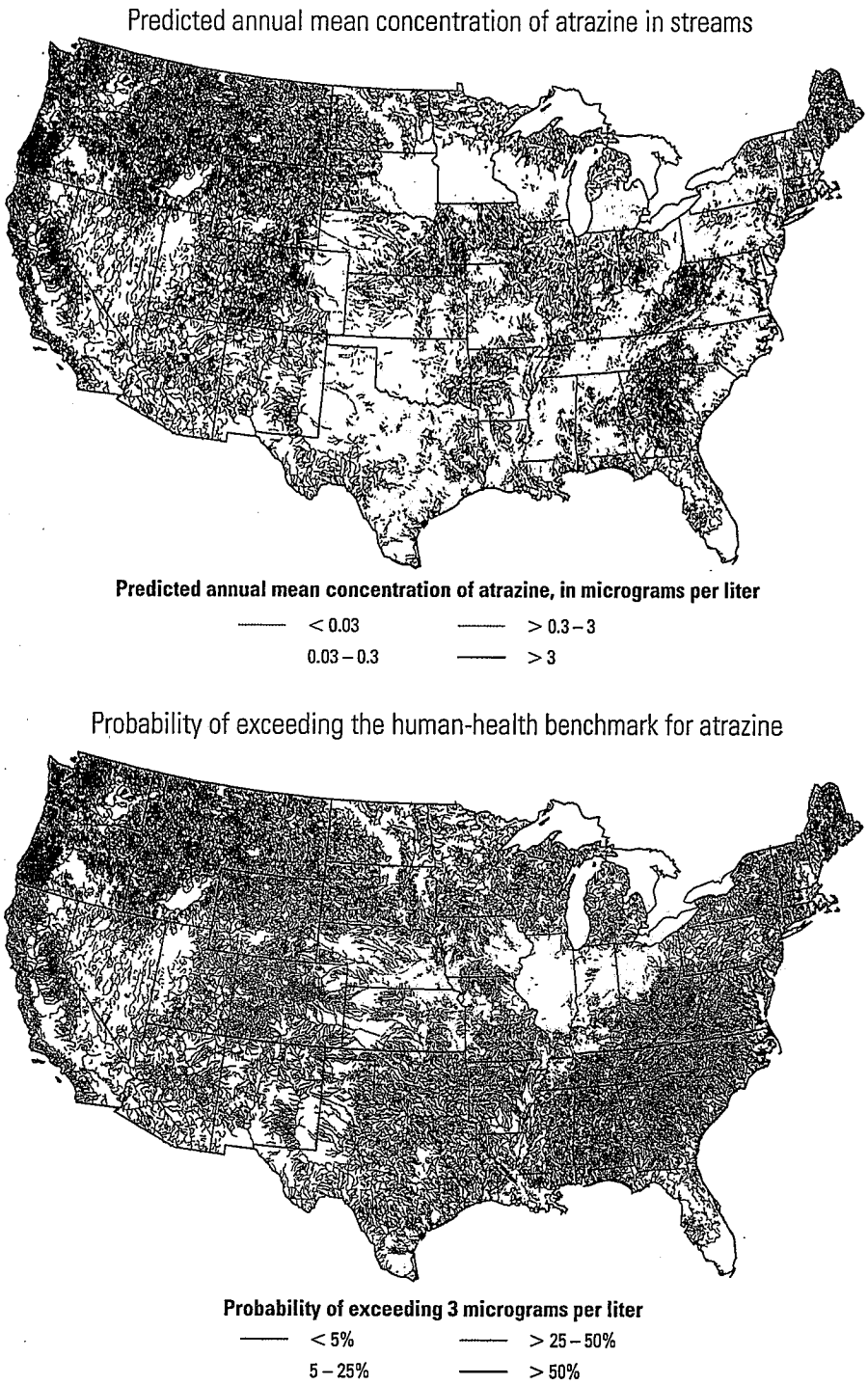

Figure 7–2. Model predictions of annual mean atrazine concentrations in streams across the Nation show the highest concentrations (orange and red streams) throughout the high-use areas of the Corn Belt and the Mississippi Valley, and in some areas of Texas, Pennsylvania, and Maryland. Model predictions of the probability that atrazine concentrations are greater than the human-health benchmark of 3 µg/L for drinking water indicate that many streams in the Corn Belt and Mississippi Valley and Delta regions have greater than a 5-percent probability of having annual mean concentrations greater than the benchmark.

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Dieldrin Concentrations in Fish

Model predictions of dieldrin concentrations in whole fish show the highest concentrations in the Corn Belt—especially in Illinois—where aldrin was heavily used on cropland. Figure 7–3 shows measured concentrations used to develop the model and figure 7–4 shows predicted concentrations. Dieldrin is an organochlorine compound that was used as an insecticide until its agricultural use was discontinued in the early 1970s, and it is also a degradate of aldrin, another insecticide that was used for agricultural purposes through the early 1970s. As noted along with other model details in the accompanying sidebar, model predictions are for fish with a 6.2 percent lipid content, the national average lipid content for all whole fish sampled. Most streams that are predicted to have a dieldrin concentration greater than 25 µg/kg (micrograms per kilogram of fish tissue, wet weight) also have a 5 percent or greater chance (more than 1 in 20) of exceeding 120 µg/kg (fig. 7–4), which is a wildlife benchmark for dieldrin in fish tissue (120 µg/kg is the highest of the dieldrin benchmarks compiled for this report; see Chapter 6 and Appendix 3B). These streams represent about 6 percent of the Nation's stream miles (40,222 out of 649,935 mi). Approximately 627 stream miles (about 1/10th of 1 percent of the Nation's stream miles) are predicted to have a 50-percent or greater probability of exceeding the dieldrin wildlife benchmark of 120 µg/kg.

The dieldrin model indicates that the amount of forested land in a watershed is the most important factor explaining the concentrations of dieldrin observed in fish—the greater the proportion of forested land (where historical use would have been least), the lower the dieldrin in fish tissue. Fish lipid content was also an important variable, which is consistent with the fact that organochlorine pesticides are hydrophobic compounds, which have a strong affinity for lipids, and thus tend to accumulate in high-lipid tissues. Two additional factors in the dieldrin model that, like forested land, are related to past use of dieldrin and aldrin represent (1) the estimated historical use of the compounds in agriculture and (2) their use for termite control. Dieldrin concentrations decrease with increasing amounts of forested land and increase with increasing historical use in agriculture or for termite control. Together, these three use-related factors and lipid content explain 58 percent of the variability in dieldrin concentrations measured in whole fish in streams across the Nation. With the addition of two other less influential variables, the complete model explains 64 percent of this variability.

Development and Application of the Dieldrin Model for Whole Fish

As described by Nowell and others (2006), the model for estimating dieldrin concentrations in fish is based on concentrations measured in whole fish sampled by NAWQA from 1992 to 2001 at 648 sites across the country. The 514 sites shown in figure 7–3 are limited to the subset of model development sites with whole-fish samples having 2.3–10.4 percent lipid content (the lowest and highest 10 percent of lipid levels were excluded from the map, but not model development). One composite sample (each composed of 5–10 fish of a single species) was collected at each site. The national data include 59 different species of fish, most frequently common carp (29 percent of samples) and white sucker (26 percent). One effect of compositing is to reduce variability in contaminant concentrations caused by differences in age and size among individual fish. An important explanatory variable in the dieldrin model is fish lipid content, which is not nationally available for all streams because it is a characteristic of the fish, rather than the stream or watershed. The inclusion of fish lipid content in the model accounts—to some extent—for differences among fish in age, size, and species because lipid content generally varies among species and increases (within a species) with increasing fish age and size (Nowell and others, 1999).

Model predictions were made using the national average lipid content for whole fish, which was 6.2 percent for samples collected by NAWQA and the U.S. Fish and Wildlife Service (Schmitt and Bunck, 1995). Predicted concentrations of dieldrin in fish, shown in figure 7–4, are median estimates for fish with 6.2 percent lipid content. Consequently, actual concentrations are expected to be lower than the predicted value at 50 percent of sites and higher at 50 percent of sites. Also, fish with lipid content greater than 6.2 percent would likely have higher dieldrin concentrations, and fish with lower lipid content would likely have lower dieldrin concentrations, than those shown in figure 7–4. As examples, lipid content values typical of common fish species in the United States are lake trout, 15 percent; channel catfish, 7.5 percent; common carp, 6.5 percent; white sucker, 5.8 percent; largemouth bass, 4.2 percent; and bluegill, 3.1 percent. See Nowell and others (2006) for further discussion of uncertainty in model predictions.

To illustrate a practical example of how such models can be applied to water-quality assessment, model estimates are compared with the New York guideline for the protection of fish-eating wildlife, which was the highest wildlife benchmark compiled for dieldrin in fish tissue (Chapter 6 and Appendix 3B). The model also was used to estimate the probability, after accounting for model uncertainty, that any particular stream site may have a dieldrin concentration greater than 120 µg/kg in whole fish with a 6.2 percent lipid content (fig. 7–4).

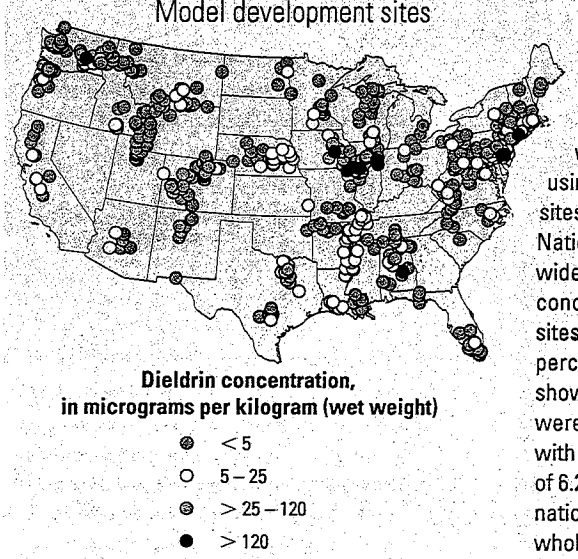

Figure 7–3. The model for dieldrin concentrations in whole-fish tissue was developed using data from 648 sites throughout the Nation, representing a wide range of dieldrin concentrations (514 sites with 2.3–10.4 percent fish lipid are shown). Predictions were made for fish with a lipid content of 6.2 percent, the national average for whole fish.

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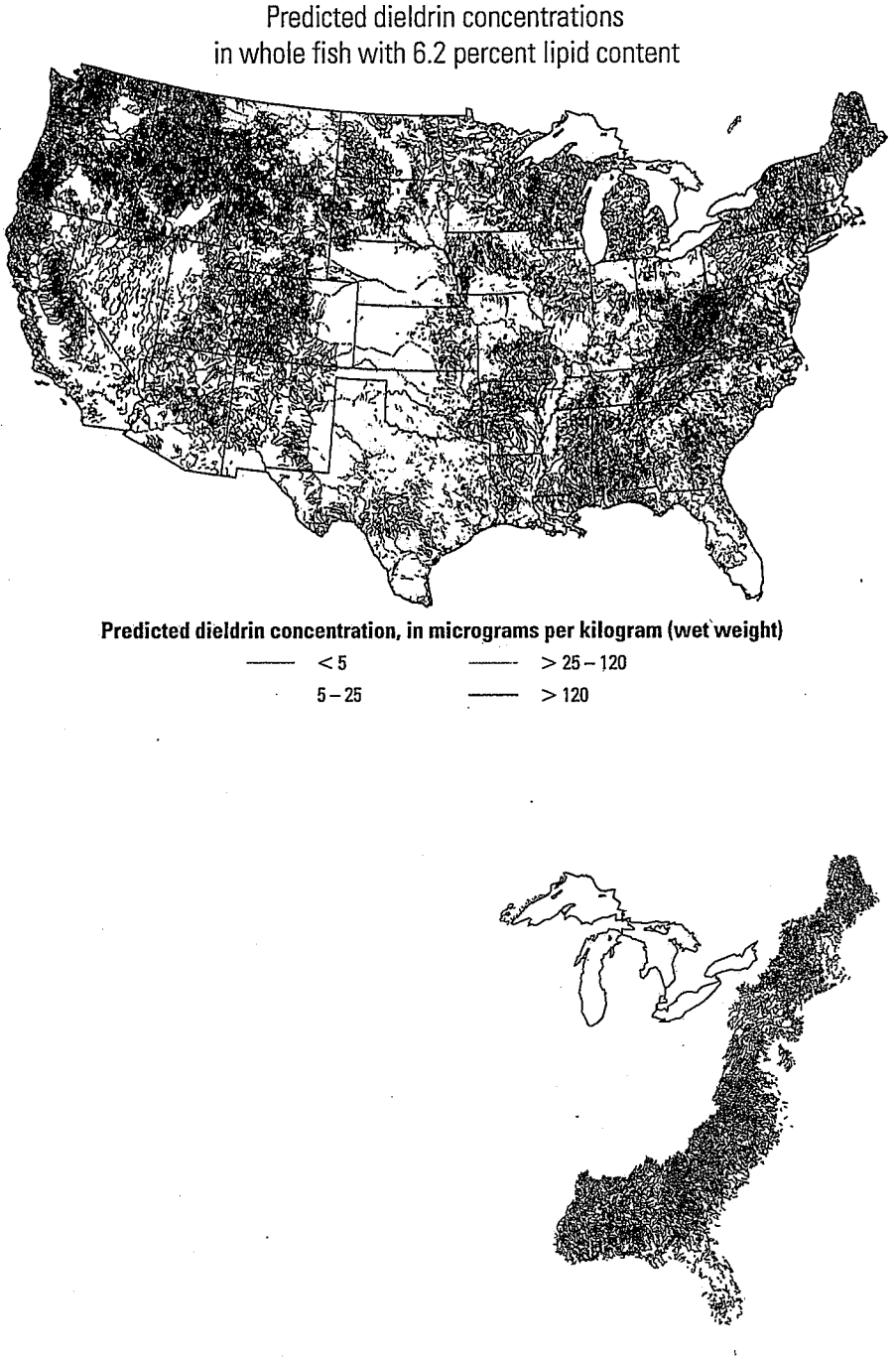

Figure 7–4. Model predictions of dieldrin concentrations in whole fish in streams across the Nation show the highest concentrations in the Corn Belt, particularly Illinois, where aldrin (which degrades to dieldrin) was heavily used on cropland. Model predictions of the probability that dieldrin concentrations exceed the wildlife benchmark of 120 µg/kg indicate that there is greater than a 5-percent probability in many Corn-Belt streams that whole fish (with 6.2 percent lipid) contain dieldrin concentrations that exceed the benchmark.

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Atrazine Detection Frequencies in Shallow Ground Water

Model predictions show that the highest frequencies of atrazine detection in shallow ground water beneath agricultural areas are expected in parts of the western Corn Belt, eastern Great Plains, Pacific Northwest (eastern Washington), and Mid-Atlantic regions (especially southeastern Pennsylvania). Figure 7–5 shows measured detection frequencies used to develop the model and figure 7–6 shows predicted detection frequencies for each square kilometer of land with 50 percent or more agricultural land. The areas with the highest frequencies of detection are those with relatively high atrazine use in hydrologic settings that also favor the transport of pesticides to ground water.

In contrast to the model for atrazine concentrations in stream water, atrazine use is not the most important factor for predicting atrazine occurrence in ground water. This finding is consistent with results from an earlier study of relations between atrazine in ground water and various land-use factors by Kolpin (1997), in which atrazine use was not found to be significantly correlated with atrazine occurrence in ground water. In the model presented herein, atrazine use explains only about 7 percent of the overall variability in the frequency of its detection in ground water. The two most important factors were found to be the proportion of land with subsurface tile drain systems and other artificial drainage, and the average vertical permeability of soil, which together explain 48 percent of the variability in atrazine detection frequencies. As the amount of artificial drainage increases, predicted detection frequencies decrease—a finding consistent with the fact that artificial drainage systems divert water and pesticides away from the ground-water system. Conversely, as the average vertical permeability of soils increases, predicted detection frequencies also increase because water and pesticides at the land surface are more likely to move vertically to ground water in areas with high-permeability soils. The influential role of these factors is particularly evident in Indiana and Ohio, where atrazine use is intense, but NAWQA studies, like several other previous studies (Barbash and Resek, 1996), found relatively low atrazine detection frequencies in ground water. Soils in these areas tend to be poorly drained and require artificial drainage to dewater the agricultural fields, thus reducing atrazine transport to ground water. With the addition of two other less influential variables, the complete model explains 58 percent of the variability in atrazine detection frequencies observed in shallow ground water beneath the agricultural areas studied.

Development and Application of the Atrazine Model for Ground Water

As described by Stackelberg and others (2006), the model for predicting atrazine occurrence in shallow ground water within agricultural areas is based on the frequencies of detection measured by NAWQA from 1992 to 2001 in 52 studies, each of which sampled about 20 to 30 shallow wells in agricultural areas (fig. 7–5). The model was used to predict the frequency of atrazine occurrence in shallow ground water in agricultural areas of the United States (fig. 7–6). Predictions were made for each 1 square kilometer area with 50 percent or more agricultural land use. Nonagricultural use of atrazine was not included in use estimates, and thus, predictions may underestimate occurrence in areas where nonagricultural use is substantial.

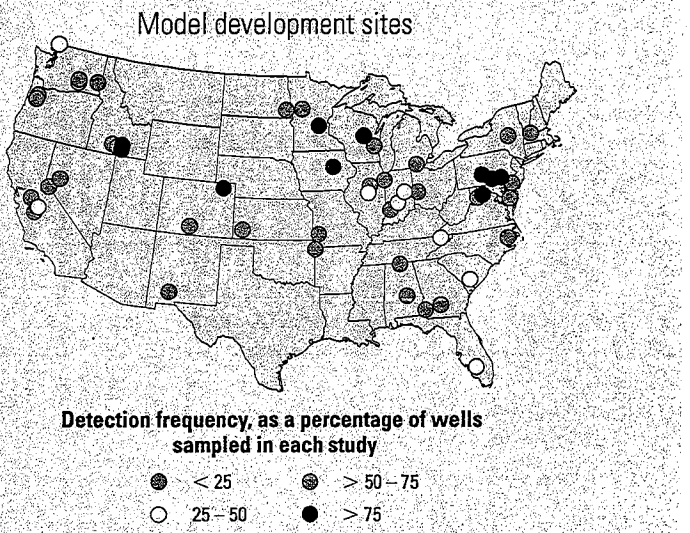

Figure 7–5. The model for atrazine occurrence in shallow ground water within agricultural areas was developed from frequencies of detection in wells sampled for studies of shallow ground water in 52 agricultural areas across the country. The ground-water studies represent a wide range of agricultural and hydrologic settings, as well as atrazine detection frequencies.

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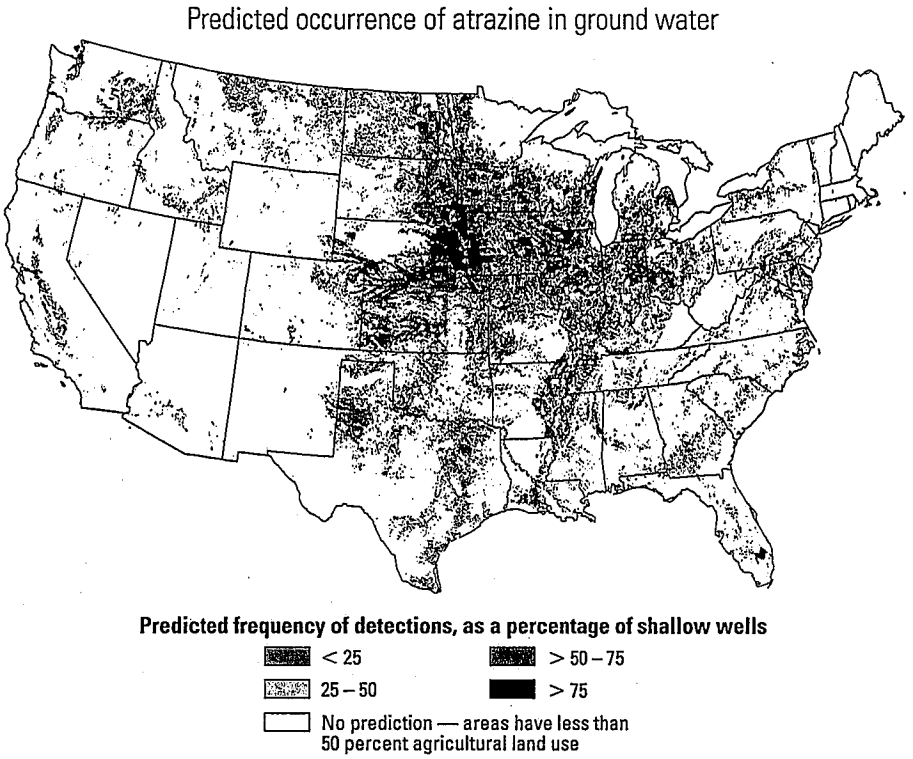

Figure 7–6. Model predictions show that the highest frequencies of atrazine detection in shallow ground water beneath agricultural areas are expected in parts of the western Corn Belt, eastern Great Plains, Pacific Northwest (eastern Washington), and Mid-Atlantic regions (especially southeastern Pennsylvania). These areas represent relatively high atrazine use in hydrologic settings that favor the transport of pesticides to ground water.

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8 Long-Term Trends

Long-term trends and changes in pesticide concentrations in streams and ground water are controlled largely by shifts in pesticide use, but the rates and geographic distributions of changes are also influenced by the chemical and physical properties of the pesticides and characteristics of the hydrologic settings. The first decade of NAWQA assessments focused primarily on establishing baseline conditions for comparison with future measurements as part of a long-term approach to tracking trends. Many trends, particularly those on a national scale, cannot yet be evaluated because not enough time has elapsed. Trends and changes are already evident, however, for some pesticides in selected localities and regions.

Photograph used with permission from Larry Mayer

This chapter provides several examples of trends and illustrates the range of different factors that affect trends for various pesticides in surface water and ground water.

A012123

Organochlorine Pesticide Compounds in Fish

One of the most striking trends evident from historical data and more recent NAWQA findings is a national reduction in concentrations of organochlorine insecticides in fish tissue, as illustrated by concentrations of total DDT, total chlordane, and dieldrin measured by NAWQA and the U.S. Fish and Wildlife Service. NAWQA data from 1992 to 2001 for whole fish in streams draining watersheds with mixed land use were combined with 1969–1986 data from the U.S. Fish and Wildlife Service's National Contaminant Biomonitoring Program (NCBP), which sampled mainly large streams in watersheds with mixed land use.

The median and 90th-percentile concentrations of total DDT in whole fish declined markedly from 1969 to about the mid-1970s, with less dramatic declines through the 1990s (fig. 8–1). Concentrations of total chlordane in fish, for which consistent data were not available until 1978, declined similarly during the 1980s and appeared to level off during the 1990s. For dieldrin, the median and particularly the 90th percentile concentrations varied substantially during the early 1970s, but concentrations during the late 1970s were lower than in 1969, and then continued to decline slowly through the early 1990s. Variability in trends in organochlorine pesticides during the 1990s, which is evident in figure 8–1, probably represents differences among groups of NAWQA sites rather than actual trends.

The observed trends reflect the regulatory history of these three insecticides in the United States. Agricultural uses of all three were cancelled during the early 1970s, whereas use of aldrin, dieldrin, and chlordane was permitted for termite control through the late 1980s. The declines shown in figure 8–1 are consistent with an exponential rate of decline in which concentrations decrease by half within a constant interval of time (half-life), following the elimination of use. Nationally, the half-lives in whole fish, as estimated either from the NCBP data alone or from the combined NCBP and NAWQA data, are about 7 years for total DDT, 11–13 years for total chlordane, and about 30 years for dieldrin. The declines in concentrations of total DDT, total chlordane, and dieldrin in whole-fish tissue over the past three decades reflect past regulatory actions to discontinue their use, yet also illustrate that changes can take a long time to occur for pesticides with long half-lives.

Data Used to Evaluate Trends in Organochlorine Concentrations in Fish Tissue

Although few sites were sampled by both the NCBP and the NAWQA Programs, the sites used in this comparison had similar land uses, and the fish-sampling and compositing strategies of the two programs were comparable. Of the 117 NCBP sites, most were sampled every 1–3 years during 1969–1986 (Schmitt and Bunck, 1995). Each of the 228 NAWQA sites was sampled only once during 1992–2001, and sites generally were sampled in three groups corresponding to the rotational investigations of NAWQA Study Units (see Chapter 3). NAWQA sites plotted as 1992 in figure 8–1 actually were sampled during the period 1992–1994 (with most sampled during the first year), sites plotted as 1995 were sampled during 1995–1997, and sites plotted as 1998 were sampled during 1998–2001. Because NAWQA sampled three groups of sites in three different time periods, the variability in NAWQA results includes differences among sites as well as differences over time.

There were also some differences in analytical methods between NAWQA and NCBP. The NCBP measured only concentrations of *p,p'* isomers of DDT, DDD, and DDE in whole fish. For consistency, therefore, NAWQA data for the *o,p'* isomers of DDT, DDD, and DDE were not included when computing total DDT for evaluating trends in whole fish (fig. 8–1). On average, the *p,p'* isomers of DDT, DDD, and DDE made up 99 percent of total DDT (the sum of *o,p'* and *p,p'* isomers DDT, DDD, and DDE) in whole fish.

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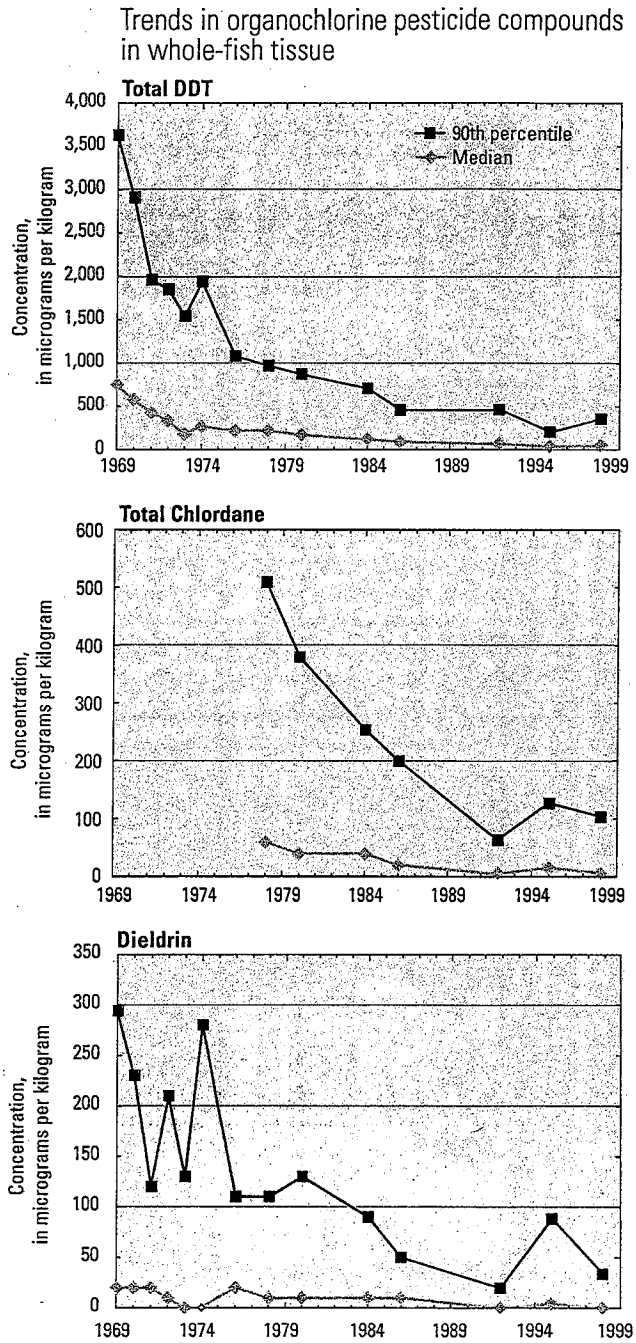

Figure 8–1. Concentrations of total DDT, total chlordane, and dieldrin in whole fish collected from streams draining watersheds with mixed land use throughout the United States have declined over the last 20 to 30 years. The declines followed discontinuation of their uses during the 1970s (agricultural uses of all three) and 1980s (use of aldrin, dieldrin, and chlordane for termite control). Despite the national decline in concentrations, these persistent compounds still are frequently detected in fish. (Data from 1969 to 1986 are from the U.S. Fish and Wildlife Service, Schmitt and Bunck, 1995; and data shown from 1992 to 1998 are from NAWQA. All concentrations are for wet weight of fish tissue.)

A012125

Trends in Total DDT and Chlordane in Lake Sediments

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In addition to the studies of organochlorine pesticides in fish and bed sediment from streams, NAWQA also assessed long-term trends in the concentrations of these compounds through the analysis of sediment cores from lakes and reservoirs, which "record" a history of contaminant concentrations. As soils in a watershed erode, they are deposited as sediment in layers on the bottom of downstream lakes and reservoirs, along with organic particles from aquatic plants and animals. Age-dated sediment cores that penetrate these layered deposits can be used to track trends in total DDT and total chlordane, as well as other sediment-associated contaminants that are relatively stable over time.

Sediment cores from 41 lakes and reservoirs in 16 States—collectively referred to as lakes for the purposes of this report—were analyzed by Van Metre and Mahler (2005). The study included 31 lakes in urban settings, 7 lakes in undeveloped settings, and 3 additional lakes in watersheds dominated by agriculture. Urban lakes were selected to represent watersheds with primarily residential and commercial land uses; only a few of the sites are known to be influenced by significant point-source discharges. The statistical significance of trends (assessed at the 90-percent confidence level) was determined using the Kendall's tau test for trends in concentrations with depth in the core (which is directly related to sediment age). Trends were also evaluated by comparing mean decadal concentrations for 1965–1975 with those for the period from 1990 to approximately 2000 (the top of the core).

Concentrations of total DDT (defined by Van Metre and Mahler (2005) as the sum of the concentrations of *p,p'*-DDT, *p,p'*-DDE, and *p,p'*-DDD) declined significantly since about 1970 in all three of the agricultural lakes, 58 percent of the urban lakes, and 43 percent of the lakes in undeveloped watersheds (fig. 8–2). No lake had a significant upward trend in total DDT. Decadal mean concentrations declined in most lakes from 1965–1975 to 1990–2000, including the lakes without statistically significant trends within the core samples. Overall, the mean total DDT concentration during 1990–2000 was lower than the

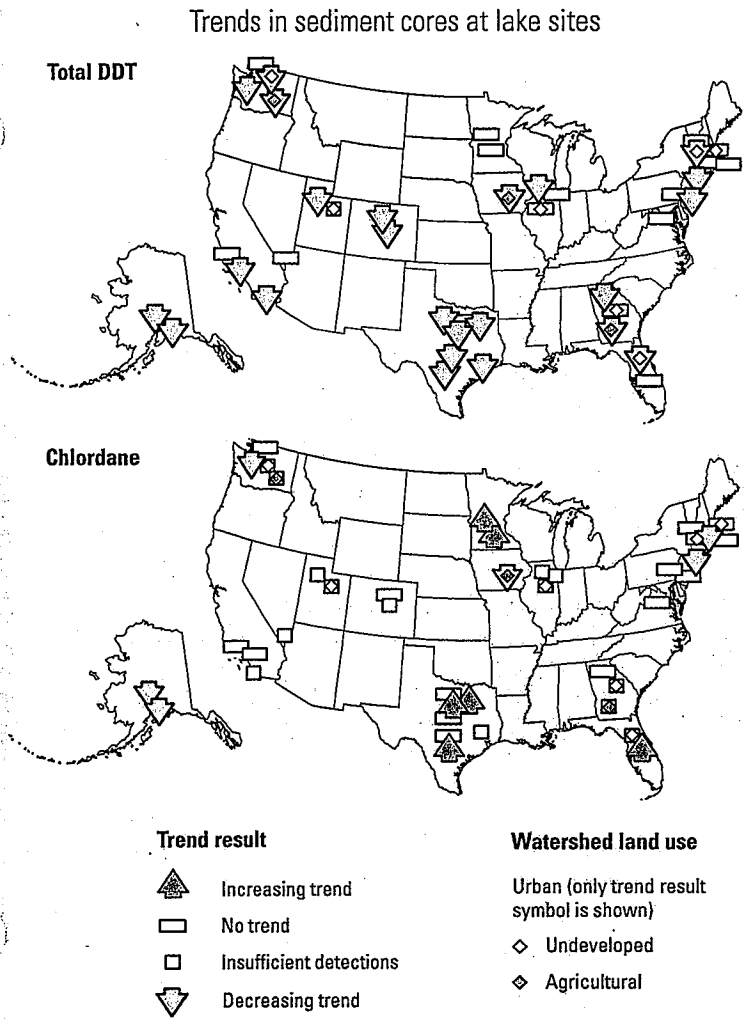

Figure 8–2. Concentrations of total DDT declined in most sediment cores collected from 41 lakes in 16 States, most of which were located in urban areas. The sediment cores were analyzed to track historical changes from about 1970 through 2000. The downward trends are consistent with historical changes in DDT use. Upward and downward trends in the concentrations of chlordane, however, were more evenly distributed, reflecting its continued use to control termites until at least 1990.

Analyses of sediment cores from lakes were used to reconstruct historical trends in DDT, chlordane, and other contaminants.

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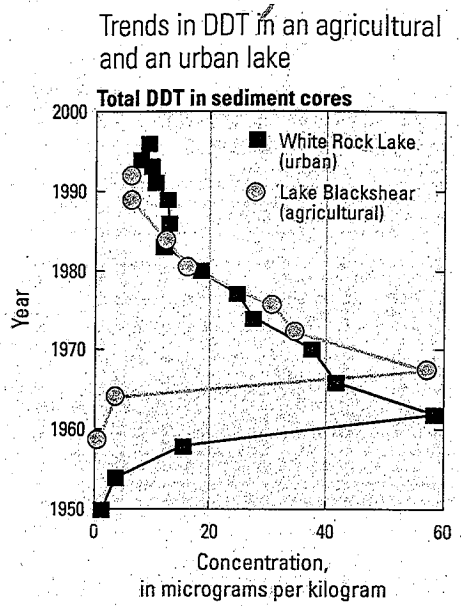

Figure 8–3. Decreases in the concentrations of DDT typically followed an exponential curve after uses began to decline during the 1960s and were cancelled in the early 1970s, as shown in sediment cores collected from White Rock Lake, Texas, and Lake Blackshear, Georgia. The rate of change indicates that an additional 50-percent reduction in concentrations of total DDT is likely to occur by approximately 2015.

mean 1965–1975 concentration in 90 percent of the lakes (37 out of 41). The median change in total DDT concentration was a decrease of 68 percent.

These results are consistent with the historical use and regulatory history of DDT, as well as with trends in total DDT concentrations in whole fish (fig. 8–1). As was observed in fish tissue, the decreases in DDT and other persistent hydrophobic contaminants typically followed an exponential curve after use was discontinued (Van Metre and others, 1998), with a steep initial drop followed by a gradual slowing of the change (fig. 8–3). The resulting half-lives for total DDT concentrations in lake sediment range between about 10 and 15 years (Van Metre and others, 1998; Van Metre and Mahler, 2005). Applied in this way, the half-life does not represent a single specific process (for example, chemical degradation), but is a simple measure of the rate of change in lake sediment concentrations over time as a result of a combination of reduced input, chemical transformations, and dilution. The rate of change observed for total DDT provides an indication of what might be expected in the future—an additional 50-percent reduction from present concentrations of these compounds during the next 10 to 15 years.

Trends in total (technical) chlordane (estimated by Van Metre and Mahler [2005] from the concentrations of *cis*-chlordane, *trans*-chlordane, and *trans*-nonachlor) in the sediment cores were more variable than those for total DDT, with upward and downward trends split evenly, and most showing either no significant trend or insufficient data (fig. 8–2). Sixteen percent of urban lakes showed significant downward trends, 19 percent showed upward trends, 42 percent showed no trend, and 22 percent could not be tested for trends because of insufficient detections. Lakes in undeveloped watersheds either showed no trend (29 percent), or could not be tested for trends because of insufficient detections (71 percent). Only one of the three agricultural lakes could be tested for a trend and it was significantly downward.

As with total DDT, these results for total chlordane are generally consistent with its historical use and regulation. Chlordane use in agriculture, which was primarily for corn, was discontinued in 1978; however, chlordane use for termite control exceeded its use in agriculture (Andrilenas, 1974; Esworthy, 1987) and continued until 1988 or later (USEPA, 2004g). In addition, use of existing chlordane stocks by homeowners was permitted after 1988 and was common in a 1990 survey (Whitmore and others, 1992). Therefore, it is not surprising that most urban lakes did not show significant downward trends from 1970 to 2000. This result for urban lakes, however, contrasts with the clear decline in total chlordane in fish from watersheds with mixed land uses (fig. 8–1). The difference may be caused by the contrasts in land use—the fish data from large watersheds with mixed land use may be influenced more by agricultural lands, where chlordane use stopped in 1978. Another possible explanation for the apparent upward trends in some of the urban lake cores is that chemical degradation of one or more of the chlordane-derived compounds could be occurring in some of the deeper core samples, thus making it appear that concentrations have increased over time (Van Metre and Mahler, 2005).

The cancellation of DDT and chlordane uses has generally resulted in decreased contaminant levels in samples of sediment and fish tissue from lakes. However, the continuing high levels of chlordane in urban areas, the slow rate of decreasing trends for DDT, and the continuing concern for human exposure from consumption of fish and shellfish (USEPA, 2004h, 2005g) indicate that these organochlorine pesticides will remain a concern for many years to come.

A012127

Herbicides in Agricultural Streams of the Corn Belt

Concentrations of modern, relatively short-lived pesticides in stream water generally respond rapidly to changes in use. Concentrations of the most heavily used herbicides in streams in the Corn Belt showed both increases and decreases on a regional scale from 1992 to 2001, correlating with changes in use during the same period (see sidebar on p. 133). For example, concentrations of atrazine, alachlor, acetochlor, cyanazine, and metolachlor in the White River—a large stream in Indiana that drains an extensive agricultural area dominated by corn and soybeans—followed regional trends in use (fig. 8–4). Acetochlor concentrations in the White River rapidly increased following its introduction in 1994, whereas alachlor concentrations decreased to less than one-tenth of its 1994 concentrations by 2001, as acetochlor replaced part of alachlor use (note the logarithmic scale in figs. 8–4 and 8–5). Among these five herbicides, the concentrations of atrazine changed the least through the decade, consistent with its relatively stable use during this time. Cyanazine concentrations declined most dramatically, following the reductions in its use, which began in the mid-1990s. The consistency of these trends in the region is illustrated by cyanazine results from 1996 to 2001 for streams in five different States within the Corn Belt (fig. 8–5).

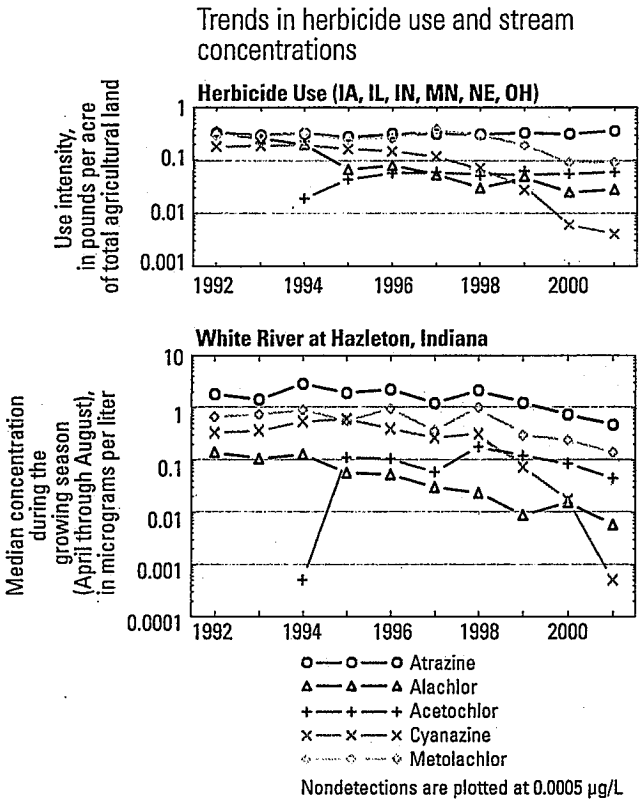

Figure 8–4. Concentrations of herbicides measured in the White River (White River Basin) during 1992–2001 show the correlation between stream concentrations and the regional trends in use intensity in Corn Belt States. The most dramatic examples are the increase in acetochlor concentrations after its introduction in 1994 and the decreases in alachlor and cyanazine that followed reductions in their use. (Pesticide use data are from the National Agricultural Chemical Use Database, accessed January 25, 2006 at *http://www.pestmanagement.info/nass/app_usage.cfm.*)

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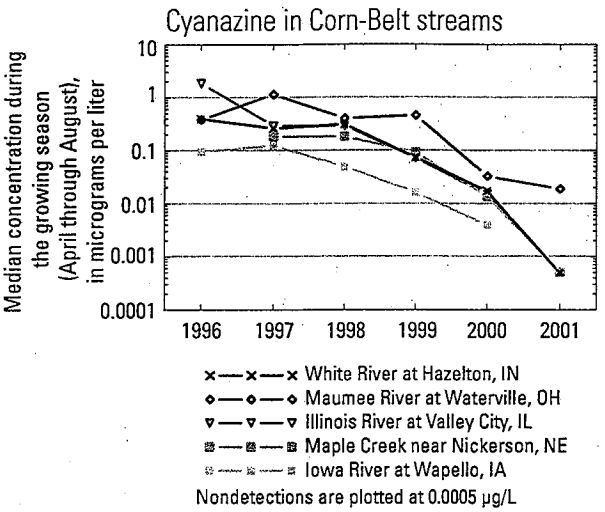

Figure 8–5. The consistency of declines in cyanazine concentrations in streams throughout the Corn Belt is illustrated by results for streams in five different States during 1996–2001. Similar consistency was evident for other major herbicides as well.

Trends in Use of Herbicides in the Corn Belt

From 1992 to 2001, there were major changes in the primary herbicides used for corn and soybean production in the Corn Belt States of Iowa, Illinois, Indiana, Minnesota, Nebraska, and Ohio (see fig. 8–4), even though the total treated crop acreage remained fairly constant. Changes in these herbicides, which combine to account for more than 40 percent of all national herbicide use, exemplify the shifts in use patterns that are typical of pesticides in response to changes in factors such as regulations, monitoring results, effectiveness, and cost.

Throughout the 1990s, atrazine was the herbicide used most widely on corn, and the area treated each year varied little. In the early 1990s, atrazine use decreased slightly because of reduced application rates resulting from regulatory agreements between USEPA and the atrazine manufacturer. This decline, however, was soon offset by increased use of atrazine in tank mixes with other herbicides, and total use remained near the 1990 level in major corn-producing States.

Metolachlor and alachlor were the second and third most heavily used herbicides in 1990, but their use declined substantially by 2001 because of the introduction of new herbicides. In 1994, acetochlor was conditionally registered for use on corn, with the goal of reducing the use of alachlor and other corn herbicides by one-third. By 1997, acetochlor had virtually replaced alachlor use and was rapidly becoming one of the most widely used herbicides (note the logarithmic scale in fig. 8–4). Also in 1997, S-metolachlor was conditionally registered for use. S-metolachlor is the more effective form of two different isomers of metolachlor (both the R- and S-metolachlor isomers were present in metolachlor products). The introduction of S-metolachlor, which has a 30-percent lower application rate, contributed to the decrease in total metolachlor use during the late 1990s. An additional development that probably contributed to the decline in the use of metolachlor and other herbicides was the introduction of bioengineered crops that were genetically modified to be resistant to specific herbicides, such as glyphosate.

The most dramatic decline in herbicide use during the 1990s was for cyanazine. Because of frequent detection of cyanazine in surface and ground water, cyanazine manufacturers began to phase out this product beginning in 1994. This phase-out, which was completed in 2000, shifted cyanazine from the fourth most heavily used herbicide in 1992, to only minor use by 2001.

A012129

Recent NAWQA Data Show that Diazinon Concentrations in Some Northeast Streams have Declined Following Recent Reductions in Use

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Scott W. Ator, U.S. Geological Survey
Elizabeth A. Nystrom, U.S. Geological Survey

Until about 2001, diazinon was one of the most widely used insecticides in the United States for residential lawn and garden pest control (accounting for almost 70 percent of the 11 million lb of diazinon used for all purposes each year), for residential indoor uses (up to 5 percent of total use), and for agricultural pest control (almost 30 percent of total use). In December 2000, USEPA and diazinon registrants agreed to phase out the sale of diazinon for residential uses (both outdoor and indoor), as well as for many agricultural uses. As part of the agreement, indoor uses of diazinon were terminated and all outdoor nonagricultural uses (principally on residential lawns and gardens) were phased out during 2002–2004. Manufacturing of diazinon for application to gardens, lawns, and other turf stopped in June 2003, and sales and distribution to retailers ended in August 2003. Retail sales ended on December 31, 2004, after which a buy-back program helped to remove from the market the remaining diazinon products. USEPA and the registrants also agreed to reduce the uses of diazinon on agricultural crops by about one-third. By 2005, these combined actions eliminated most of the use of diazinon, compared with use in 2000.

Analysis of data from seven NAWQA stream sites in the Northeast—five classified as urban streams and two as mixed land use—using Seasonal Kendall tests at the 95-percent confidence level (Schertz and others, 1991), indicate predominantly downward trends in concentrations of diazinon since the reductions in diazinon use began in 2000 (fig. 8–6). Specifically, concentrations of diazinon decreased by 20 to 41 percent since 1998 at the five sites with statistically significant changes. Concentrations at the two sites with no statistically significant change showed decreases of 13 and 22 percent for the same period. Diazinon concentrations observed in one of the five urban streams (Accotink Creek, VA) provide an illustration of how concentrations have recently declined in some streams—in this case by about 39 percent from 1998 to 2004 (fig. 8–7).

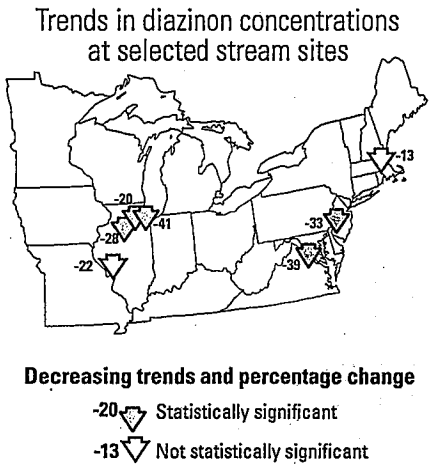

Figure 8–6. Diazinon concentrations decreased significantly from 1998 to 2004 in 5 of 7 urban and mixed-land-use streams in the northeastern United States. Trends were evaluated using the Seasonal Kendall test at the 95-percent confidence level.

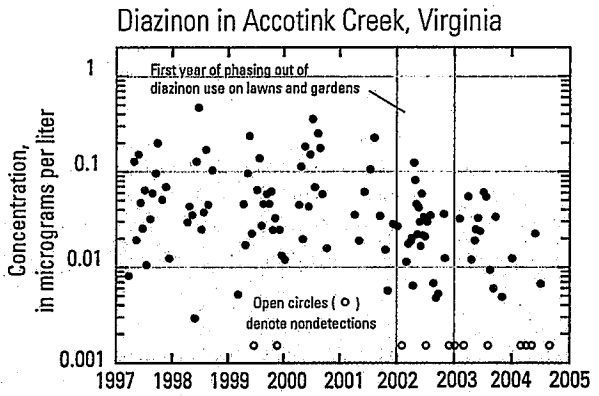

Figure 8–7. From 1997 to 2001, the levels and ranges of diazinon concentrations in Accotink Creek (Potomac River Basin) were relatively similar from year to year, but from 2002 to 2004, diazinon concentrations generally decreased. These decreases correspond to the national reduction in total sales and use of diazinon through this period, although no specific use data were available for the Accotink Creek watershed.

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Ground Water

Pesticide concentrations in ground water, compared with streams, respond more slowly to changes in pesticide use or land-management practices, often lagging by years or decades, depending on the nature of the flow system and the depth and location of wells sampled. During the long periods of time that it takes for water to move through most ground-water flow systems, the types and amounts of pesticides applied at the land surface often change. This makes it difficult to link the concentrations of pesticides detected in specific wells with the locations where the pesticides were used. Evaluation of trends in ground water is also made more difficult by the complex flow paths along which ground water moves, and the resulting uncertainty about where sampled water originally entered the ground-water flow system.

For these reasons—as well as a general shortage of suitable data—trends in pesticide levels in ground water have not been extensively characterized. As noted by Barbash and Resek (1996), few previous studies have used consistent sampling and analytical methods over long enough periods, or developed a sufficient understanding of the flow system and age of sampled ground water, to reliably evaluate long-term trends in ground-water quality. Although NAWQA ground-water studies use consistent sampling and analytical methods, NAWQA monitoring has not yet covered a long enough period of time in most locations to assess trends. Despite these challenges, examples of ground-water trend assessments from USGS studies, conducted in cooperation with other agencies in Iowa and Florida, illustrate the types of trends that may occur over different time scales and demonstrate some of the approaches to trend assessment.

Herbicides in Iowa Ground Water

Results from the Iowa Ground Water Monitoring Program, a joint study by the Iowa Geological Survey, USEPA, and USGS, show that herbicide concentrations have increased in Iowa ground water with increasing herbicide use since the 1950s (Kolpin and others, 2004). Low levels of tritium (less than 0.8 tritium units [TU]) were used as an indicator of water recharged before 1953, which was prior to the onset of substantial herbicide use. All but 1 of 42 samples with detectable concentrations of herbicides or degradates were samples of water that had recharged after 1953 (fig. 8–8), whereas more than 80 percent of the samples with undetectable herbicides or degradates had recharged prior to 1953. The detection of herbicides in one sample with low tritium probably resulted from the mixing of younger and older waters in samples collected from a municipal supply well. The results from this study demonstrate the value of information on ground-water recharge dates and residence times for the analysis of data for trend assessment. Use of estimated recharge dates provided the most reliable means available for determining that most samples without detections were ground water that had recharged before the beginning of major herbicide use. In addition, because the correlations between estimated recharge date and the occurrence of pesticide

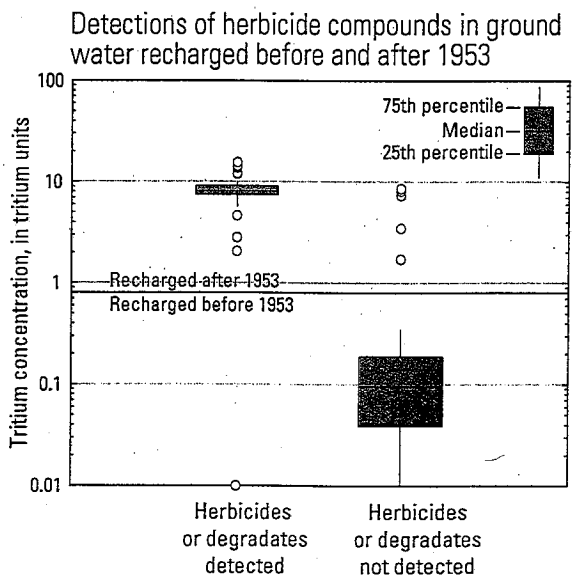

Figure 8–8. The Iowa Ground-Water Monitoring Program showed that herbicides or their degradates were detected in 41 of 42 municipal supply wells in Iowa that tap ground water recharged after 1953 (as indicated by tritium concentrations greater than 0.8 tritium units). Conversely, more than 80 percent of the samples in which herbicide compounds were not detected were samples of ground water recharged prior to 1953, before significant use of herbicides began. (Modified from Kolpin and others, 2004.)

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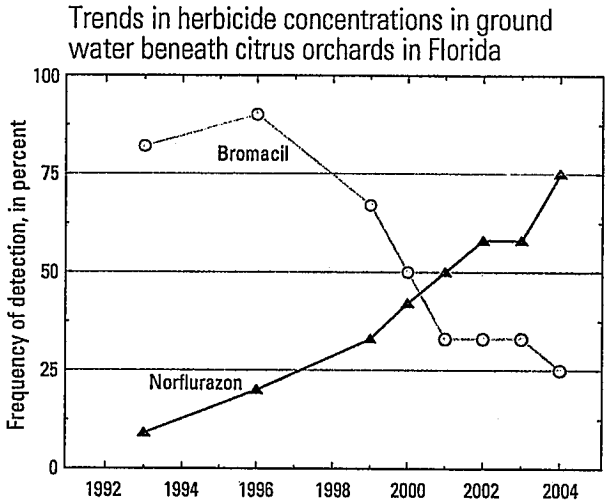

Figure 8–9. In central Florida, applications of bromacil in citrus orchards were discontinued in 1994, yet it was still detected at or above 2 µg/L in 25 percent of the sampled wells 10 years later. The frequency of detecting norflurazon, which began to replace bromacil on citrus in 1994, did not exceed that of bromacil for about 6 years. (Modified from Choquette and others, 2005.)

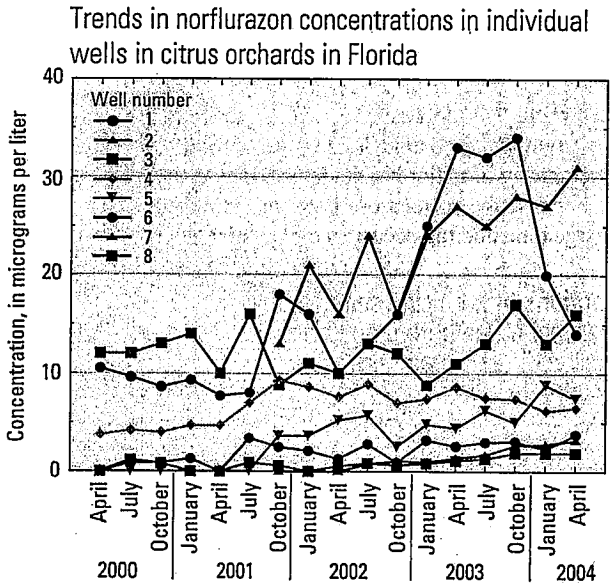

Figure 8–10. Although concentrations of norflurazon increased from 2000 to 2004, there was substantial seasonal and annual variability. Variability among wells was associated with depth to water, depth of the well screen below the water table, the length of the well screen, and the thickness of the aquifer zone sampled. (Modified from Choquette and others, 2005.)

compounds in ground water were more evident when degradates were considered, the study by Kolpin and others (2004) demonstrates the value of incorporating data on degradate occurrence for detecting trends.

Herbicides in Florida Ground Water

A study by the USGS, Florida Department of Agriculture and Consumer Services, and the Southwest Florida Water Management District was undertaken to monitor and assess the quality of shallow ground water in central Florida (Choquette and Sepúlveda, 2000). This region is dominated by citrus production and is characterized by well-drained sandy soils that are conducive to relatively rapid movement of water and pesticides to and within the ground-water flow system (Choquette and others, 2003).

The study found that bromacil, a widely used herbicide, declined but continued to be detected in 25 percent or more of the sampled wells for up to 10 years after its use in the region's citrus orchards was prohibited in 1994 (fig. 8–9). The decline in bromacil detections coincided with an increase in detections of norflurazon, which began to replace bromacil in 1994. The frequency of norflurazon detections, however, did not exceed that of bromacil until the year 2000, about 6 years after the use of bromacil was discontinued (Choquette and others, 2005).

Although figure 8–9 indicates that the overall frequency of norflurazon detection in ground water increased from 1993 to 2004 within the area studied by Choquette and others (2005), concentrations of norflurazon showed considerable seasonal and annual variability in the individual wells sampled, as well as variability among different wells (fig. 8–10). These variations were associated with differences among the wells in the age of the ground water, the depth to water, the depths of the sampled zone below the water table, and the thickness of the aquifer zone sampled. The highest and most variable concentrations (wells 1–3) occurred where depths to the water table were relatively shallow and in wells that sampled water closest to the water table. The lower and less variable concentrations occurred in the deeper wells (wells 4–8) with long screened intervals. These observations are consistent with results from previous studies, indicating that the temporal variability in pesticide concentrations generally tends to diminish with increasing well depth (Barbash and Resek, 1996).

A012132

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Glossary

(Terms in definitions that are defined elsewhere in the Glossary are shown in boldface within the definition. Most definitions are described as they apply to pesticides.)

A

10^{-6} cancer risk concentration (CRC) The concentration of a chemical in drinking water that corresponds to an excess estimated lifetime cancer risk (in addition to cancer risk from other causes) of 1 in 1,000,000.

Acetanilide herbicides A class of pesticides derived from N-acetylaniline and used primarily for weed control in corn, soybeans, and sorghum.

Active ingredient The chemical component of a pesticide product that kills or otherwise controls the target organism(s).

Acute effects Rapid physiological response of an organism (such as death or immobility) resulting from relatively short-term exposure to elevated concentrations of one or more chemicals or other changes in biological, chemical, or physical conditions in the environment.

Adjuvants Chemicals included in a pesticide product to facilitate the application of the product or to enhance the effectiveness of the **active ingredient**. Adjuvants are often referred to as "inert ingredients."

Agricultural management practices Methods used as part of crop cultivation and livestock husbandry (such as irrigation, fertilization, or integrated pest management) to maximize product yields, control soil erosion, maintain soil quality, and (or) minimize any adverse effects on water quality or ecosystem health.

Agricultural stream A stream draining a watershed with more than 50 percent agricultural land (cropland or pasture) and 5 percent or less of urban land.

Ambient water-quality criteria (AWQC) Guidelines issued by USEPA for pollutants designated as toxic under the Clean Water Act and that may provide the basis for state standards. There are two types of these guidelines—those for the protection of human health and those for the protection of aquatic organisms. Aquatic-life criteria may be acute (established for short-term exposure) or chronic (for long-term exposure).

Aquatic-life benchmark A threshold value above which the concentration of a chemical in water or bed sediment may have adverse effects on aquatic organisms. Benchmarks for water are established to address either acute (short-term) or chronic (long-term) exposures.

Aquifer A geologic formation, group of formations, or part of a formation that contains a sufficient amount of saturated permeable material (for example, soil, sand, gravel and (or) rock) to yield significant quantities of water to wells and springs.

B

Baseflow Hydrologic regime in streams, following extended periods of minimal precipitation, during which streamflow is derived primarily from ground-water discharge.

Bed sediment Sediment particles, including eroded soil and organic matter, deposited at the bottom of a stream or other surface-water body.

Benchmark See **water-quality benchmark**.

Benthic Living on or close to the bottom of a stream, lake, or sea.

Bioaccumulative The tendency of a chemical compound to be taken up and retained by organisms from all sources in their environment, such as diet, sediment, soil, or water.

Bioassay The quantitative measurement, under standardized conditions, of the biological effects of a substance on an organism or part of an organism.

C

Carbamate insecticides A class of pesticides consisting of various esters of carbamic acid. Like the **organophosphate insecticides**, they are inhibitors of cholinesterase—the enzyme required for nerve function in the animal body—and are used to kill or control insects in a variety of agricultural and nonagricultural settings.

Chlordane group The set of five compounds whose concentrations are summed to compute the concentration of **total chlordane**, including the *cis* and *trans* **isomers** of chlordane and nonachlor, and the chlordane **degradate**, oxychlordane.

Chronic effects Physiological responses of an organism (such as death, impaired reproduction, or changes in organ function) resulting from long-term exposure to one or more chemicals or other changes in biological, chemical, or physical conditions in the environment.

Common detection level A single concentration threshold, used for assessing the presence or absence of each one of a group of compounds within a sample or set of samples on an equal basis. Use of this threshold avoids biases in detection frequencies caused by varying analytical sensitivities to different compounds—it is also sometimes referred to as a "common assessment level."

Confidence level The probability threshold used to decide whether a particular observation or result of a statistical test was likely to have arisen solely by chance.

Conventional pesticides Compounds that are commonly used to kill or control unwanted organisms in either agricultural or nonagricultural settings. Such chemicals include **herbicides, insecticides, fumigants, fungicides**, and many other types of biocidal compounds, but exclude several other types, such as antifouling agents, disinfectants, and wood preservatives.

Corn Belt The area of the Great Plains and the Midwest where corn and soybeans are the principal crops. It generally

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includes Illinois, Indiana, Iowa, Nebraska, and Ohio, as well as parts of adjoining states.

Crop-group setting A classification of agricultural land that is based on the dominant presence of one, two, or three specific crops (such as "rice," or "corn and soybeans"), as derived from the classification system described by Gilliom and Thelin (1997).

D

DDT group Six compounds derived from the parent pesticides DDT and DDD whose concentrations are summed to compute the concentration of **total DDT**, specifically the *p,p'* and *o,p'* **isomers** of DDT, DDD, and DDE.

Deethylatrazine-to-atrazine ratio The ratio of concentrations of deethylatrazine to atrazine in a particular environmental medium (usually water), used to track the transformation of atrazine to one of its principal **degradates** over time or distance.

Degradate A compound produced from the transformation of a **parent pesticide** or another degradate through either abiotic or biotic processes.

Diffusion The movement of chemicals (in either the gas, liquid, or solid phase) from regions of higher concentration to those of lower concentration.

Domestic well A privately owned well that usually serves one home and supplies water for human consumption and other homeowner uses.

E

EC_{50} In a toxicity test, the "50 percent effect concentration"—that is, the concentration of a chemical at which a specified effect is observed in half of the test organisms within a specified period of time (typically 48 hours).

Endocrine disruptor A chemical that interferes with the **endocrine system** in an organism by mimicking a natural hormone, blocking the effects of a hormone on certain receptors, or causing the overproduction or underproduction of hormones.

Endocrine system A biochemical regulatory system in mammals, birds, fish, and other organisms that is comprised of hormones (which act as chemical messengers), glands that produce hormones, and receptors in various organs and tissues that recognize and respond to the hormones. The system regulates a wide variety of physiological processes in the body, including the development of the brain and nervous system, the growth and function of the reproductive system, metabolic activity, and blood sugar levels.

Environmental medium Any natural solid, liquid, or gas in the environment—such as ground water, stream water, bed sediment, or biological tissues.

Explanatory variable A parameter (for example, chemical use, population, or soil permeability) whose value is used in regression and other statistical models to evaluate and estimate the magnitude of another parameter (the **response variable**).

F

Fish-consumption advisory A recommendation issued by a public agency that people limit or avoid consumption of certain fish species caught from particular water bodies because of contamination of fish with bacterial or **bioaccumulative** pollutants.

Flow path The route or pathway followed by water flowing through the **hydrologic system**. Usually refers to **subsurface** flow.

Fumigant A compound or mixture of compounds that produces a gas, vapor, fumes, or smoke intended to destroy, repel, or control organisms such as insects, bacteria, or rodents.

Fungicides Pesticides that are used to kill unwanted fungi.

G

Glacial till Poorly sorted unconsolidated geologic material deposited by glaciers and generally having low **permeability**, unless fractures or other interconnected openings for flow are present.

Ground-water recharge Water that reaches ground water by infiltration of precipitation or irrigation water through the **unsaturated zone** or by seepage of water from surface-water bodies, such as streams and lakes.

Guideline A threshold value for the maximum acceptable concentration of a pesticide or other contaminant in a given **environmental medium**, specified for the protection of humans, aquatic life, or wildlife. Guidelines are issued for advisory purposes and are not legally enforceable.

H

Half-life The time required for the concentration of a compound in a given **environmental medium** to be reduced to half of its original value by one or more processes, such as degradation or transport into another environmental medium.

Health advisory An estimate of acceptable drinking-water concentrations for a chemical substance, established by USEPA on the basis of health effects information. Although it is not a legally enforceable federal standard, it provides technical guidance to assist Federal, State, and local officials.

Henry's law constant (K_H) A measure of the partitioning of a compound between an aqueous solution and a gas with which it is in contact, quantified as the ratio between the concentrations of the compound in the gas phase and in the aqueous solution at equilibrium.

Herbicides Pesticides that are used to kill unwanted plants.

Human-health benchmark A threshold value above which the concentration of a chemical in water may have adverse effects on humans if the water is used as drinking water without treatment or other measures to lower the concentration.

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Hydraulic conductivity The rate at which a porous medium transmits water.

Hydrogeology The geologic and hydrologic features that control the movement of water, solutes, and small particles through the **subsurface**.

Hydrologic system The assemblage of pathways by which water travels as it circulates beneath, at, and above the Earth's surface through various processes such as precipitation, runoff, evaporation, infiltration, transpiration, and ground-water discharge.

Hydrophilic The tendency of a compound to favor dissolution in, or association with water, rather than organic matter. Often used to refer to compounds with comparatively low K_{oc} values.

Hydrophobic The tendency of a compound to favor **sorption** to, or association with organic matter, rather than dissolution in water. Often used to refer to compounds with comparatively high K_{oc} values.

I

Immobile zones Regions within the **subsurface** through which water and solutes move relatively slowly, if at all. (Contrast with **mobile zones**.)

Inert ingredients See **adjuvants**.

Insecticides Pesticides that are used to kill unwanted insects.

Isomers Compounds with identical chemical composition but with slightly different structures (arrangement of atoms). Examples include *o,p'*- and *p,p'*-DDT; and *cis*- and *trans*-chlordane.

K

K_{oc} See **soil organic carbon-water partition coefficient.**

K_H See **Henry's law constant.**

Kendall's tau test A nonparametric statistical test used to determine whether a particular trend in magnitude is significant at a specified **confidence level**.

L

LC_{50} In a toxicity test, the "50 percent lethal concentration"—that is, the concentration of a chemical at which 50 percent of test organisms die within a specified period of time (typically 48 or 96 hours).

Lifetime Health Advisory (HA-L) The concentration of a chemical in drinking water that is not expected to cause any adverse noncarcinogenic effects in humans over a lifetime of exposure (70 years). This parameter is not a legally enforceable federal standard, but provides technical guidance to assist Federal, State, Tribal, and local officials.

Linear regression A statistical method for analyzing and estimating the magnitude of a **response variable** as a function of one or more **explanatory variables**.

Lipid Any one of a diverse group of **hydrophobic** organic compounds produced and stored by living organisms and that contain long hydrocarbon chains or rings. Examples include fats, oils, waxes, steroids, and carotenoids.

M

Major aquifer A regionally extensive subsurface geologic formation or group of formations that is used, or has the potential to be used, as a significant ground-water resource.

Major aquifer studies NAWQA investigations involving the sampling of 20 to 30 **domestic** and (or) **public-supply wells** that withdraw water from **major aquifers**.

Manufacturing by-products Compounds used for, or generated during, the production of a particular chemical (such as a pesticide **active ingredient**) that may be present in the commercial formulation itself, especially those such as **technical mixtures** that are less highly purified.

Maximum Contaminant Level (MCL) A drinking-water standard that is legally enforceable and that sets the highest permissible concentration of a specific compound in water that is delivered to any user of a public water system. In this report, only values established by the USEPA are used.

Mixed-land-use streams Streams draining watersheds in which no single type of land use (agricultural, urban, or undeveloped) predominates. These include all streams not meeting the specific land-use criteria for **agricultural, urban,** or **undeveloped streams**.

Mixture A combination of two or more compounds detected in the same environmental sample.

Mobile zones Regions within the **subsurface** through which water flows more rapidly than in other locations, often consisting of worm holes, cracks, fractures, and other highly conductive channels. Also referred to as zones of "preferential flow." (Contrast with **immobile zones**.)

Mobility The speed or ease with which a compound moves through the **hydrologic system** relative to the rate of water flow— mobility generally increases with decreasing K_{oc} values.

N

No-effect level In a toxicity study, the highest concentration or dose that was observed to have a negligible impact on the health of the test organisms.

Nonpoint sources Contaminant releases that are diffuse and widely dispersed, such as agricultural runoff or atmospheric deposition.

Nontarget organisms Organisms other than those that a pesticide active ingredient is applied to control or kill.

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O

Observation well A well designed for measuring water levels and testing ground-water quality, and generally not used as a source for drinking water. Also referred to as a "monitoring well."

Organochlorine pesticide compounds A class of synthetic organic chemicals (mostly **insecticides**) with hydrocarbon structures containing one or more chlorine substituents, and that includes **manufacturing by-products** and **degradates**, in addition to **active ingredients**.

Organophosphate insecticides A group of pesticides, consisting of various derivatives of phosphoric, phosphorothioic, or phosphorodithioic acids, in some cases with a nitrogen, fluorine, methyl, or cyano group substituting for one or more of the phosphate oxygens. Like the **carbamate insecticides**, they are inhibitors of cholinesterase—the enzyme required for nerve function in the animal body—and are used to kill or control insects in a variety of agricultural and nonagricultural settings.

P

Parent pesticide The form of an active ingredient as it is released into the environment.

Partitioning The processes by which a compound becomes distributed among different **environmental media**. Such processes include **sorption**, volatilization, dissolution, and biological uptake.

Permeability A measure of the relative ease with which a porous medium can transmit a fluid.

Persistence The tendency of a compound to remain in its original form, rather than undergo **transformation**, in the environment.

Pesticide A chemical applied to crops, rights-of-way, lawns, residences, golf courses, or other settings to kill or control weeds, insects, fungi, nematodes, rodents, or other unwanted organisms.

Pesticide compounds A term used to refer collectively to **parent pesticides**, their **degradates** and, where applicable, their **manufacturing by-products**.

Point source A specific location at which one or more contaminants are known to be released into the **hydrologic system**.

Public-supply well A privately or publicly owned well that provides water for public use to: (1) community water systems, (2) transient non-community water systems, such as campgrounds, or (3) non-transient, non-community systems, such as schools.

R

Rainfall erosivity A parameter in the **Universal Soil Loss Equation** that quantifies the effects of rainfall on soil loss within a particular area, and accounts for both the energy and intensity of rainstorms, averaged over a specified number of years. Also referred to as the "R factor."

Residence time The amount of time that a solute, particle, organism, or other entity spends within a given **environmental medium**.

Response variable The dependent parameter (for example, chemical concentration) whose magnitude is estimated from quantitative relations with other, independent parameters (**explanatory variables**) using statistical relations such as regression models.

Rill irrigation Water management method that employs a series of parallel surface ditches to distribute water to crops.

S

Saturated zone The region in the **subsurface** in which all the interstices or voids are filled with water under a pressure exceeding that of the atmosphere.

Seasonal Kendall test A statistical method that corrects for possible seasonal patterns in a given variable to detect temporal trends in the parameter (or lack thereof) over a period of years.

Seasonal pulse Temporary increase in the concentration of one or more compounds in surface water or ground water that commonly occurs at a particular time of the year—for example, the substantial increases in the concentrations of corn **herbicides** typically observed in streams of the **Corn Belt** in the spring.

Simulation model A mathematical model used to predict the combined effects and (or) consequences of one or more processes of interest by reproducing these effects using mathematical relations and (or) numerical techniques, typically through the use of computer programs.

Soil erodibility A parameter in the **Universal Soil Loss Equation** that quantifies the ease with which a given soil may be carried away by water and which is based on a number of soil characteristics such as soil texture (that is, the percentages of different size fractions such as sand, silt, and clay), organic-matter content, permeability, and structure. Also referred to as the "K factor."

Soil organic carbon-water partition coefficient (K_{oc}) A measure of the partitioning of a compound that is anticipated to occur between soil and water when the two phases are in contact. This parameter is quantified as the ratio between the concentrations of the compound in the soil (normalized to the organic carbon content of the soil) and in the aqueous solution at equilibrium. The K_{oc} provides an indication of the extent of **sorption** of a compound to natural organic matter in the **hydrologic system** and, by extension, an inverse measure of the **mobility** of the compound in water within the **subsurface**.

Sorption The retention, through binding or association, of a solute ion or molecule by a solid.

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Source water A stream, lake, other surface-water body, or aquifer from which water is drawn for human use.

Spatial extrapolation The use of statistical or other models to predict the value of a parameter (for example, the concentration of a chemical compound) in a location where it has not been measured.

Statistical model A model used to represent the effects of one or more processes of interest by quantitative, probabilistic relations (such as regressions) between one or more **explanatory variables** and a particular **response variable.**

Statistical significance The likelihood (commonly expressed as a probability, p) that the result of a statistical test may have occurred solely by chance. Observations associated with p values of 0.05 or less (a "95 percent or greater confidence level") are typically deemed to be "statistically significant," and thus, are unlikely to have occurred solely by chance.

Study Unit A major **hydrologic system** of the United States, geographically defined by surface- or ground-water features, in which NAWQA sampling studies are focused. The NAWQA studies during the first decade of assessments examined 51 Study Units.

Subsurface The region of earth materials beneath the land surface that encompasses the soil, **unsaturated,** and **saturated zones.**

Subsurface tile-drain systems Perforated pipes that are buried in the ground to reduce the water content of poorly drained soils and divert shallow ground water to nearby streams.

Surface runoff The flow of water over the land surface, usually in response to intense rainfall or snowmelt events, irrigation, or rainfall on saturated soils, snow, or impervious surfaces (such as pavement).

T

Target organism An organism that an **active ingredient** of a pesticide is designed to control or kill.

Technical DDT A commercial DDT formulation that commonly contained approximately 80 percent *p,p'*-DDT, approximately 20 percent *o,p'*-DDT, and small amounts of *o,o'*-DDT, *m,p'*-DDT, *p,p'*-DDD, and other **manufacturing by-products.**

Technical mixture A formulation of a commercial chemical product that usually contains minor amounts of **manufacturing by-products** or other compounds in addition to the compound of interest (such as the **active ingredient** in a pesticide product).

Termiticide Pesticides that are used to kill termites, usually in buildings and other structures.

Time-weighted 95th percentile concentration The concentration of a given compound that is exceeded 5 percent of the time, or about 18 days per year (generally not consecutive).

Tolerance level The maximum permissible concentration of a pesticide or pesticide **degradate** allowed in or on foods or animal feed, for the protection of human health. (Also referred to as a "maximum pesticide residue level.")

Total chlordane concentration The sum of the concentrations of multiple compounds derived from commercial chlordane formulations (including components of the original product and **degradates**) that might be present in an environmental sample. For NAWQA bed-sediment and fish-tissue analyses, this consisted of the *cis* and *trans* **isomers** of both chlordane and nonachlor, as well as the chlordane **degradate** oxychlordane. For the chemical analyses of lake sediment cores by Van Metre and Mahler (2005), only *cis*-chlordane, *trans*-chlordane and *trans*-nonachlor were included.

Total DDT concentration The sum of the concentrations of all compounds of interest derived from DDT that might be present in an environmental sample. For NAWQA bed-sediment and fish-tissue analyses, this consisted of the *p,p'* and *o,p'* **isomers** of DDT, DDD, and DDE. For the chemical analyses of lake sediment cores by Van Metre and Mahler (2005), only the *p,p'* isomers of DDT, DDD, and DDE were included.

Total detection frequency The percentage of samples in which any of the analytes of interest are measured at any concentration without correcting to a **common detection level.**

Toxicity The degree to which the presence of a chemical substance at a particular concentration in a given **environmental medium** may be harmful to the health of humans and other organisms that come in contact with that medium.

Toxicity value A quantitative measure of the dose-response relationship observed in a test of the physiological effect of a particular chemical on a specific organism. Examples include LC_{50} and NOAEC values.

Transformation The conversion of one compound to another through either abiotic or biotic processes.

Transformation product See **degradate.**

Triazine herbicides A group of pesticides—all sharing a six-membered aromatic ring consisting of three nitrogen atoms and three carbon atoms in an alternating sequence (a "symmetrical triazine ring")—used primarily for weed control on corn, sorghum, cotton, sugarcane, orchards, fallow land, sod, rights-of-way, lawns, golf courses, and Christmas tree farms.

Tritium unit (TU) A measure of the concentration of tritium (^3H), equal to 1 ^3H atom in 10^{18} atoms of hydrogen (H), or 3.24 picocuries per liter (pCi/L).

U

Undeveloped stream A stream draining a watershed with 25 percent or less of agricultural land and 5 percent or less of urban land.

Unique mixture A combination of two or more specific compounds detected in an environmental sample, regardless of whether other compounds are detected in the same sample.

Universal Soil Loss Equation An empirical equation developed by the U.S. Department of Agriculture to predict the

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average amount of soil lost from a given location per year through wind and water erosion. The equation employs a variety of parameters related to rainfall, soil properties, and topography as **explanatory variables.**

Unsaturated zone The **subsurface** region of earth materials above the **water table** in which the pore spaces may contain a combination of air and water.

Urban stream A stream draining a watershed with more than 5 percent of residential, commercial, transportation, urban recreational areas, and (or) industrial land, and 25 percent or less of agricultural land.

Use intensity The total quantity of a pesticide applied over a specified area, expressed in terms of the amount applied per unit area.

V

Volatilize To move spontaneously from a liquid or dissolved state to a gaseous state.

W

Water table The point below the land surface at which ground water is first encountered and below which the earth is saturated.

Water-quality benchmark A threshold value above which the concentration of a specific chemical in a particular **environmental medium** may have adverse effects on human health, aquatic life, or fish-eating wildlife, and below which there is a low likelihood of such effects (see also **aquatic-life benchmark, human-health benchmark,** and **wildlife benchmark**).

Watershed The land area that drains into a particular stream, river, lake, estuary, or coastal zone.

Wildlife benchmark A threshold value above which the concentration of a chemical in water or fish tissue may have adverse effects on fish-eating wildlife.

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Appendixes 1–4

Appendix 1—Pesticide compounds analyzed in NAWQA samples.

Table A. Pesticide compounds analyzed in NAWQA water samples.

[Pesticide compounds include pesticides, degradates, and manufacturing by-products. Pesticide compounds are grouped by pesticide class. Common synonyms are listed in parentheses in column 1. The cited references are listed by number at the end of Appendix 1. CAS, Chemical Abstracts Service; GCMS, gas chromatography/mass spectrometry; HPLC, high performance liquid chromatography; Parameter code, the number used to identify a pesticide in the U.S. Geological Survey National Water Information System and the U.S. Environmental Protection Agency Data Storage and Retrieval System; µg/L, micrograms per liter.]

Pesticide compound (synonym)	Type of pesticide compound (parent pesticide, if degradate)	CAS number	Parameter code	Analytical method	Long-term method detection level [1] (µg/L)
Amides					
Acetochlor	Herbicide	34256-82-1	49260	GCMS	0.003
Alachlor	Herbicide	15972-60-8	46342	GCMS	0.002
2,6-Diethylaniline	Degradate (Alachlor)	579-66-8	82660	GCMS	0.003
Metolachlor	Herbicide	51218-45-2	39415	GCMS	0.006
Napropamide	Herbicide	15299-99-7	82684	GCMS	0.003
Pronamide (Propyzamide)	Herbicide	23950-58-5	82676	GCMS	0.002
Propachlor	Herbicide	1918-16-7	04024	GCMS	0.005
Propanil	Herbicide	709-98-8	82679	GCMS	0.005
Carbamates					
Aldicarb	Insecticide	116-06-3	49312	HPLC	0.100
Aldicarb sulfone	Degradate (Aldicarb)	1646-88-4	49313	HPLC	0.100
Aldicarb sulfoxide	Degradate (Aldicarb)	1646-87-3	49314	HPLC	0.140
Butylate	Herbicide	2008-41-5	04028	GCMS	0.001
Carbaryl	Insecticide	63-25-2	82680	GCMS	0.021
Carbofuran	Insecticide	1563-66-2	82674	GCMS	0.010
EPTC	Herbicide	759-94-4	82668	GCMS	0.001
3-Hydroxycarbofuran	Degradate (Carbofuran)	16655-82-6	49308	HPLC	0.050
Methiocarb	Insecticide	2032-65-7	38501	HPLC	0.030
Methomyl	Insecticide	16752-77-5	49296	HPLC	0.240
Molinate	Herbicide	2212-67-1	82671	GCMS	0.001
Oxamyl	Insecticide	23135-22-0	38866	HPLC	0.080
Pebulate	Herbicide	1114-71-2	82669	GCMS	0.002
Propham	Herbicide	122-42-9	49236	HPLC	0.110
Propoxur (Baygon)	Insecticide	114-26-1	38538	HPLC	0.060
Thiobencarb	Herbicide	28249-77-6	82681	GCMS	0.002
Triallate	Herbicide	2303-17-5	82678	GCMS	0.001
Chlorobenzoic acid esters					
Dacthal (DCPA) [2]	Herbicide	1861-32-1	82682	GCMS	0.002
Dacthal monoacid	Degradate (Dacthal)	887-54-7	49304	HPLC	0.040
Chlorophenoxy acids					
2,4-D	Herbicide	94-75-7	39732	HPLC	0.080
2,4-DB	Herbicide	94-82-6	38746	HPLC	0.130
Dichlorprop	Herbicide	120-36-5	49302	HPLC	0.060

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Table A. Pesticide compounds analyzed in NAWQA water samples.—Continued

[Pesticide compounds include pesticides, degradates, and manufacturing by-products. Pesticide compounds are grouped by pesticide class. Common synonyms are listed in parentheses in column 1. The cited references are listed by number at the end of Appendix 1. CAS, Chemical Abstracts Service; GCMS, gas chromatography/mass spectrometry; HPLC, high performance liquid chromatography; Parameter code, the number used to identify a pesticide in the U.S. Geological Survey National Water Information System and the U.S. Environmental Protection Agency Data Storage and Retrieval System; µg/L, micrograms per liter.]

Pesticide compound (synonym)	Type of pesticide compound (parent pesticide, if degradate)	CAS number	Parameter code	Analytical method	Long-term method detection level [1] (µg/L)
MCPA	Herbicide	94-74-6	38482	HPLC	0.100
MCPB	Herbicide	94-81-5	38487	HPLC	0.130
2,4,5-T	Herbicide	93-76-5	39742	HPLC	0.040
2,4,5-TP (Silvex)	Herbicide	93-72-1	39762	HPLC	0.030
	Dinitroanilines				
Benfluralin	Herbicide	1861-40-1	82673	GCMS	0.005
Ethalfluralin	Herbicide	55283-68-6	82663	GCMS	0.005
Oryzalin	Herbicide	19044-88-3	49292	HPLC	0.140
Pendimethalin	Herbicide	40487-42-1	82683	GCMS	0.011
Trifluralin	Herbicide	1582-09-8	82661	GCMS	0.005
	Miscellaneous				
Bentazon	Herbicide	25057-89-0	38711	HPLC	0.030
Norflurazon	Herbicide	27314-13-2	49293	HPLC	0.021
	Miscellaneous acids				
Acifluorfen	Herbicide	50594-66-6	49315	HPLC	0.040
Chloramben methyl ester	Herbicide	7286-84-2	61188	HPLC	0.110
Clopyralid	Herbicide	1702-17-6	49305	HPLC	0.210
Dicamba	Herbicide	1918-00-9	38442	HPLC	0.050
Picloram	Herbicide	1918-02-1	49291	HPLC	0.040
	Nitrophenols				
Dinoseb	Herbicide	88-85-7	49301	HPLC	0.040
DNOC	Herbicide	534-52-1	49299	HPLC	0.130
	Organochlorines				
Chlorothalonil	Fungicide	1897-45-6	49306	HPLC	0.070
p,p'-DDE	Degradate (*p,p'*-DDT)	72-55-9	34653	GCMS	0.001
Dichlobenil	Herbicide	1194-65-6	49303	HPLC	0.050
Dieldrin	Insecticide, Degradate (Aldrin)	60-57-1	39381	GCMS	0.002
alpha-HCH	Degradate (*gamma*-HCH), By-product in technical lindane [3]	319-84-6	34253	GCMS	0.002
gamma-HCH (Lindane)	Insecticide	58-89-9	39341	GCMS	0.002
Triclopyr	Herbicide	55335-06-3	49235	HPLC	0.040
	Organophosphates				
Azinphos-methyl (Guthion)	Insecticide	86-50-0	82686	GCMS	0.020
Chlorpyrifos	Insecticide	2921-88-2	38933	GCMS	0.003
Diazinon	Insecticide	333-41-5	39572	GCMS	0.003

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Table A. Pesticide compounds analyzed in NAWQA water samples.—Continued

[Pesticide compounds include pesticides, degradates, and manufacturing by-products. Pesticide compounds are grouped by pesticide class. Common synonyms are listed in parentheses in column 1. The cited references are listed by number at the end of Appendix 1. CAS, Chemical Abstracts Service; GCMS, gas chromatography/mass spectrometry; HPLC, high performance liquid chromatography; Parameter code, the number used to identify a pesticide in the U.S. Geological Survey National Water Information System and the U.S. Environmental Protection Agency Data Storage and Retrieval System; µg/L, micrograms per liter.]

Pesticide compound (synonym)	Type of pesticide compound (parent pesticide, if degradate)	CAS number	Parameter code	Analytical method	Long-term method detection level [1] (µg/L)
Disulfoton	Insecticide	298-04-4	82677	GCMS	0.011
Ethoprop (Ethoprophos)	Insecticide	13194-48-4	82672	GCMS	0.002
Fonofos	Insecticide	944-22-9	04095	GCMS	0.001
Malathion	Insecticide	121-75-5	39532	GCMS	0.014
Parathion (Ethyl parathion)	Insecticide	56-38-2	39542	GCMS	0.005
Parathion-methyl (Methyl parathion)	Insecticide	298-00-0	82667	GCMS	0.003
Phorate	Insecticide	298-02-2	82664	GCMS	0.006
Terbufos	Insecticide	13071-79-9	82675	GCMS	0.009
		Phenols			
Bromoxynil	Herbicide	1689-84-5	49311	HPLC	0.030
		Pyrethroids			
cis-Permethrin [2]	Insecticide	54774-45-7	82687	GCMS	0.003
		Sulfite esters			
Propargite	Acaricide	2312-35-8	82685	GCMS	0.011
		Triazines			
Atrazine	Herbicide	1912-24-9	39632	GCMS	0.004
Cyanazine	Herbicide	21725-46-2	04041	GCMS	0.009
Deethylatrazine	Degradate (Atrazine)	6190-65-4	04040	GCMS	0.003
Metribuzin	Herbicide	21087-64-9	82630	GCMS	0.003
Prometon	Herbicide	1610-18-0	04037	GCMS	0.007
Simazine	Herbicide	122-34-9	04035	GCMS	0.006
		Uracils			
Bromacil	Herbicide	314-40-9	04029	HPLC	0.040
Terbacil	Herbicide	5902-51-2	82665	GCMS	0.017
		Ureas			
Diuron	Herbicide	330-54-1	49300	HPLC	0.060
Fenuron	Herbicide	101-42-8	49297	HPLC	0.030
Fluometuron	Herbicide	2164-17-2	38811	HPLC	0.030
Linuron	Herbicide	330-55-2	82666	GCMS	0.018
Neburon	Herbicide	555-37-3	49294	HPLC	0.030
Tebuthiuron	Herbicide	34014-18-1	82670	GCMS	0.008

[1] The long-term method detection level (reference 1) is calculated annually. The value reported in the table is the maximum long-term method detection level for the period 1992–2001.

[2] This pesticide also can be considered an organochlorine pesticide because it is an organic pesticide with multiple chlorine substituents.

[3] Prior to 1977, *alpha*-HCH was a manufacturing by-product in technical lindane, which is a mixture of several isomers of hexachlorocyclohexane (reference 2).

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Table B. Pesticide compounds analyzed in NAWQA bed-sediment or whole-fish samples.

[Pesticide compounds include pesticides, degradates, and manufacturing by-products. Pesticide compounds are grouped by pesticide class. Common synonyms are listed in parentheses in column 1. The cited references are listed by number at the end of Appendix 1. CAS, Chemical Abstracts Service; Parameter code, the number used to identify a pesticide in the U.S. Geological Survey National Water Information System and the U.S. Environmental Protection Agency Data Storage and Retrieval System; µg/kg dw, micrograms per kilogram dry weight; µg/kg ww, micrograms per kilogram wet weight; —, not analyzed.]

Pesticide compound (synonym)	Type of pesticide compound (parent pesticide, if degradate)	CAS number	Bed sediment		Whole fish	
			Parameter code	Reporting level (µg/kg dw)	Parameter code	Reporting level (µg/kg ww)
		Chlorobenzoic acid esters				
Dacthal (DCPA) [1]	Herbicide	1861-32-1	49324	5	49378	5
		Organochlorines				
Aldrin	Insecticide, Component of total dieldrin [2]	309-00-2	49319	1	49353	5
cis-Chlordane	Insecticide, Component of total chlordane [3]	5103-71-9	49320	1	49380	5
trans-Chlordane	Insecticide, Component of total chlordane [3]	5103-74-2	49321	1	49379	5
Chloroneb	Insecticide	2675-77-6	49322	5	—	—
o,p'-DDD	Degradate (*o,p'*-DDT), Component of total DDT [4]	53-19-0	49325	1	49374	5
p,p'-DDD (*p,p'*-TDE)	Insecticide, Degradate (*p,p'*-DDT), Component of total DDT [4]	72-45-8	49326	1	49375	5
o,p'-DDE	Degradate (*o,p'*-DDT), Component of total DDT [4]	3424-82-6	49327	1	49373	5
p,p'-DDE	Degradate (*p,p'*-DDT), Component of total DDT [4]	72-55-9	49328	1	49372	5
o,p'-DDT	By-product in technical DDT, Component of total DDT [4]	789-02-6	49329	2	49377	5
p,p'-DDT	Insecticide, Component of total DDT [4]	50-29-3	49330	2	49376	5
Dieldrin	Insecticide, Degradate (Aldrin), Component of total dieldrin [2]	60-57-1	49331	1	49371	5
Endosulfan I (*alpha*-Endosulfan)	Insecticide	959-98-8	49332	1	—	—
Endrin	Insecticide	72-20-8	49335	1	49370	5
alpha-HCH	Degradate (*gamma*-HCH), By-product in technical lindane, Component of total HCH [5]	319-84-6	49338	1	49366	5
beta-HCH	By-product in technical lindane, Component of total HCH [5]	319-85-7	49339	1	49365	5
gamma-HCH (Lindane)	Insecticide, Component of total HCH [5]	58-89-9	49345	1	49363	5
delta-HCH	Degradate (*gamma*-HCH), By-product in technical lindane, Component of total HCH [5]	319-86-8	—	—	49364	5
Heptachlor	Insecticide, Component of total heptachlor [6]	76-44-8	49341	1	49369	5
Heptachlor epoxide	Degradate (Heptachlor), Component of total heptachlor [6]	1024-57-3	49342	1	49368	5
Hexachlorobenzene	Insecticide	118-74-1	49343	1	49367	5
Isodrin	Insecticide	465-73-6	49344	1	—	—
o,p'-Methoxychlor	Insecticide, Component of total methoxychlor [7]	30667-99-3	49347	5	49362	5
p,p'-Methoxychlor	Insecticide, Component of total methoxychlor [7]	72-43-5	49346	5	49361	5
Mirex	Insecticide	2385-85-5	49348	1	49360	5
cis-Nonachlor	By-product in technical chlordane, Component of total chlordane [3]	5103-73-1	49316	1	49359	5

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Table B. Pesticide compounds analyzed in NAWQA bed-sediment or whole-fish samples.—Continued

[Pesticide compounds include pesticides, degradates, and manufacturing by-products. Pesticide compounds are grouped by pesticide class. Common synonyms are listed in parentheses in column 1. The cited references are listed by number at the end of Appendix 1. CAS, Chemical Abstracts Service; Parameter code, the number used to identify a pesticide in the U.S. Geological Survey National Water Information System and the U.S. Environmental Protection Agency Data Storage and Retrieval System; µg/kg dw, micrograms per kilogram dry weight; µg/kg ww, micrograms per kilogram wet weight; —, not analyzed.]

Pesticide compound (synonym)	Type of pesticide compound (parent pesticide, if degradate)	CAS number	Bed sediment		Whole fish	
			Parameter code	Reporting level (µg/kg dw)	Parameter code	Reporting level (µg/kg ww)
trans-Nonachlor	By-product in technical chlordane, Component of total chlordane [3]	39765-80-5	49317	1	49358	5
Oxychlordane	Degradate (Chlordane), Component of total chlordane [3]	27304-13-8	49318	1	49357	5
Pentachloroanisole	Degradate (Pentachlorophenol)	1825-21-4	49460	1	49356	5
Toxaphene	Insecticide, Technical mixture	8001-35-2	49351	200	49355	200
	Pyrethroids					
cis-Permethrin [1]	Insecticide, Component of total permethrin [8]	52774-45-7	49349	5	—	—
trans-Permethrin [1]	Insecticide, Component of total permethrin [8]	51877-74-8	49350	5	—	—

[1] This pesticide also can be considered an organochlorine pesticide because it is an organic pesticide with multiple chlorine substituents.

[2] The pesticide group "total dieldrin" refers to the summed concentrations of aldrin and dieldrin.

[3] The pesticide group "total chlordane" refers to the summed concentrations of *cis*-chlordane, *trans*-chlordane, *cis*-nonachlor, *trans*-nonachlor, and oxychlordane. Chlordane was applied as a technical-grade mixture of over 140 compounds, including nonachlor isomers and other manufacturing by-products.

[4] The pesticide group "total DDT" refers to the summed concentrations of *o,p'*-DDT, *p,p'*-DDT, *o,p'*-DDD, *p,p'*-DDD, *o,p'*-DDE, and *p,p'*-DDE. Technical DDT contained *p,p'*-DDT (the active ingredient) and *o,p'*-DDT (a manufacturing by-product).

[5] The pesticide group "total HCH" refers to the summed concentrations of *alpha*-HCH, *beta*-HCH, *gamma*-HCH, and *delta*-HCH. Technical lindane is a mixture of several isomers of hexachlorocyclohexane; *gamma*-HCH is the active ingredient, and the other isomers are manufacturing by-products. In 1977, USEPA cancelled inclusion of *alpha*- and *beta*-HCH in technical-grade lindane (reference 2).

[6] The pesticide group "total heptachlor" refers to the summed concentrations of heptachlor and heptachlor epoxide.

[7] The pesticide group "total methoxychlor" refers to the summed concentrations of *o,p'*-methoxychlor and *p,p'*-methoxychlor.

[8] The pesticide group "total permethrin" refers to the summed concentrations of *cis*-permethrin and *trans*-permethrin.

References—Appendix 1

1. Oblinger Childress, C.J., Foreman, W.T., Conner, B.F., and Maloney, T.J., 1999, New reporting procedures based on long-term method detection levels and some considerations of interpretations of water-quality data provided by the U.S. Geological Survey National Water Quality Laboratory: U.S. Geological Survey Open-File Report 99-193, 19 p.

2. U.S. Environmental Protection Agency, 1992, National study of chemical residues in fish: U.S. Environmental Protection Agency, Office of Science and Technology, EPA-823-R-92-008b, v. 2, variously paged.

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Appendix 2—Properties affecting transport and fate.

Table A. Properties affecting the transport and fate of selected pesticide compounds.

[Pesticide compounds selected are those detected most frequently in NAWQA samples (see figs. 4–2 and 4–4), as well as several that were detected infrequently, despite extensive use. All values measured at (or estimated for) 25°C, except for those shown in italics. Unless noted otherwise, (1) values for octanol-water partition coefficient (K_{ow}, dimensionless), soil organic carbon-water partition coefficient (K_{oc}), water solubility (S_w) and Henry's law constant (K_H) are from Mackay and others (1997); (2) transformation half-lives in soil and water were measured in the laboratory (rather than in the field) at neutral pH in the dark, and obtained from the U.S. Department of Agriculture (2005); and (3) all are recommended values selected by the compilation authors when more than one value was available from the literature. Compounds are listed in the same order as in figures 4–2 and 4–4. Numbers of significant figures are identical to those given in original sources. mg/L, milligrams per liter; mL/g, milliliters per gram; NA, data not available from any of the references consulted; Pa•m³/mol, pascal-cubic meters per mole; >, greater than.]

Pesticide compound (synonym)	log K_{ow}	log K_{oc} (K_{oc} in mL/g)	S_w (mg/L)	log K_H (K_H in Pa•m³/mol)	Half-life for transformation (days)	
					In aerobic soil	In water
Agricultural herbicides and degradates detected most frequently in water						
Atrazine	2.75	2.00	30	-3.54	146	[1]742
Deethylatrazine	[1,2]1.3	[1,2]1.90	[1]2,700	[1,2]-4.12	[1,2]170	NA
Metolachlor	3.13	2.26	430	-2.63	26	[1,2]410
Cyanazine	2.22	2.3	171	-6.52	[2]17	[2]>200
Alachlor	2.8	2.23	240	-2.7	[1,2]20.4	[1,2]640
Acetochlor	[1]3.0	[1,2]2.38	[1,3]*223*	[1,3]*-2.15*	[1,2,3]*14*	[1]2,300
Metribuzin	[1,3]*1.60*	1.72	[1,3]*1,000*	[1,2]-5.31	172	[2]>200
Bentazon	[1,2]2.80	[1,2]1.54	[1,3]*500*	[1,2,3]*-3.7*	[1,2]35	[1,2,3]*>200*
EPTC	3.2	2.3	370	0.00988	[1,3]*7*	[2]>200
Trifluralin	5.34	4.14	[2]0.5	1.00	169	[2]>32
Molinate	3.21	1.92	970	-0.839	[1,3]*21*	[2]>200
Norflurazon[1]	2.45	2.55	34	-4.46	130	[2]>200
Urban herbicides detected most frequently in water						
Simazine	2.18	2.11	5	-3.46	[2]91	[1,2]>32
Prometon	2.99	2.54	750	-4.05	932	[2]>200
Tebuthiuron	[1,2]1.79	[1]2.1	[1,2]2,400	[1]-4.88	[1]1,050	[2]>2,700
2,4-D	2.81	[1]1.68	890	-3.61	[1,2]2.3	[1,2]732
Diuron	2.78	2.6	40	-3.17	372	>500
Dacthal (DCPA)	[1]4.28	[1]3.75	[1]0.5	[1]-0.66	[1]16	[2]>200
Bromacil	2.11	1.86	815	-4.89	275	[2]>30
Insecticides detected most frequently in water						
Diazinon	3.3	2.76	60	-1.39	39	140
Chlorpyrifos	4.92	3.78	0.73	0.0374	30.5	29
Carbofuran	2.32	2.02	351	-4.30	11	[2]289
Carbaryl	2.36	2.36	120	-4.35	17	11
Malathion	2.8	3.26	145	-2.64	<1	[2]6.3
Dieldrin	5.20	4.08	0.17	0.0492	NA	3,830
Organochlorine pesticide compounds detected most frequently in bed sediment and fish tissue						
p,p'-DDE	5.7	5.0	0.04	0.900	NA	[1,2,3]*>44,000*
p,p'-DDD	5.5	5.0	0.05	-0.194	NA	[2]10,000
p,p'-DDT	6.19	5.4	0.0055	0.37	NA	[1,2,3]*5,000*

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Table A. Properties affecting the transport and fate of selected pesticide compounds.—Continued

[Pesticide compounds selected are those detected most frequently in NAWQA samples (see figs. 4–2 and 4–4), as well as several that were detected infrequently, despite extensive use. All values measured at (or estimated for) 25°C, except for those shown in italics. Unless noted otherwise, (1) values for octanol-water partition coefficient (K_{ow}, dimensionless), soil organic carbon-water partition coefficient (K_{oc}), water solubility (S_w) and Henry's law constant (K_H) are from Mackay and others (1997); (2) transformation half-lives in soil and water were measured in the laboratory (rather than in the field) at neutral pH in the dark, and obtained from the U.S. Department of Agriculture (2005); and (3) all are recommended values selected by the compilation authors when more than one value was available from the literature. Compounds are listed in the same order as in figures 4–2 and 4–4. Numbers of significant figures are identical to those given in original sources. mg/L, milligrams per liter; mL/g, milliliters per gram; NA, data not available from any of the references consulted; Pa•m³/mol, pascal-cubic meters per mole; >, greater than.]

Pesticide compound (synonym)	log K_{ow}	log K_{oc} (K_{oc} in mL/g)	S_w (mg/L)	log K_H (K_H in Pa•m³/mol)	Half-life for transformation (days)	
					In aerobic soil	In water
o,p'-DDE	5.8	[1,2]5.58	0.1	0.405	NA	NA
o,p'-DDD	6.0	[1,2]5.36	[2]0.10	[1]-2.7	NA	[2]NA
o,p'-DDT	[2]NA	[2]NA	0.026	-0.460	NA	NA
cis-Chlordane	6.0	5.5	0.056	-0.466	NA	[1]>7.2×10⁷
trans-Chlordane	6.0	5.5	0.056	-0.582	NA	[1,2]>10,000
Nonachlor[1]	5.66	4.86	0.06	-1.69	NA	NA
Oxychlordane[1]	2.6	2.48	200	-1.52	NA	NA
Dieldrin	5.20	4.08	0.17	0.0492	NA	3,830
Heptachlor epoxide	5.0	4.0	0.35	[1]0.51	NA	NA
Pentachloroanisole [1]	5.66	4.62	0.2	2.91	NA	NA
Hexachlorobenzene	[1]5.31	[1]4.7	[1]0.0062	[1,2]1.69	NA	[1,2]>26,000
Heavily used pesticides not detected frequently in water						
Chlorothalonil	2.64	3.2	0.6	1.77	NA	[2]>200
Dicamba	2.21	[1]1.11	4500	-3.66	[1,2]28	[2]>200
Parathion-methyl (Methyl parathion)	3.0	3.7	25	-1.68	[1,2]3.3	41
Pendimethalin	[1]5.2	[1]4.13	[1]0.275	[1]0.0899	1300	[2]>200
Terbufos	4.48	2.70	5	0.39	5	1.9

[1]Value(s) obtained from sources other than Mackay and others (1997) for K_{ow}, K_{oc}, S_w, and K_H; or U.S. Department of Agriculture (2005) for transformation half-lives. See *http://ca.water.usgs.gov/pnsp/pubs/circ1291/* for data sources.

[2]See *http://ca.water.usgs.gov/pnsp/pubs/circ1291/* for details related to computation or selection of parameter value.

[3]See *http://ca.water.usgs.gov/pnsp/pubs/circ1291/* for temperature of measurement.

References—Appendix 2

Mackay, D., Shiu, W-Y., and Ma, K-C, 1997, Illustrated handbook of physical-chemical properties and environmental fate for organic chemicals, Volume V. Pesticide Chemicals: New York, NY, Lewis Publishers, 812 p.

U.S. Department of Agriculture, 2005, Agricultural Research Service (ARS), Pesticide Properties Database, accessed August 22, 2005, at *http://www.ars.usda.gov/Services/docs.htm?docid=6433*.

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Appendix 3— Water-quality benchmarks for pesticide compounds that exceeded one or more benchmarks in NAWQA samples.

Table A. Water-quality benchmarks for pesticide compounds that exceeded one or more benchmarks in NAWQA water samples.

[For pesticide compounds in water, benchmarks are for protection of human health and aquatic life. This table includes only those pesticide compounds that exceeded one or more benchmarks in NAWQA water samples; for these compounds, all benchmark values that were compared with concentrations in water are listed here. The complete set of benchmarks used for all pesticide compounds analyzed by NAWQA is available at *http://ca.water.usgs.gov/pnsp/pubs/circ1291/*. Common synonyms are listed in parentheses in column 1. OPP references are listed by number at the end of Appendix 3. Environmental concentration, the measured or calculated concentration statistic that is appropriate for comparison with the benchmark; CRC(10^{-6}), 10^{-6} cancer risk concentration; EC_{50}, 50 percent effect concentration; EFED, Environmental Fate and Effects Division; USEPA, U.S. Environmental Protection Agency; HA-L, lifetime health advisory; IRED, Interim Reregistration Eligibility Decision; IRIS, Integrated Risk Information System database; LC_{50}, 50 percent lethal concentration; LOC, level of concern; MCL, maximum contaminant level; NOAEC, no-observed-adverse-effects concentration; OPP, Office of Pesticide Programs; RED, Reregistration Eligibility Decision; µg/L, microgram sper liter; >, greater than; <, less than; —, no benchmark available.]

Pesticide compound (synonym)	Human-health benchmarks (µg/L)		Aquatic-life benchmarks (µg/L)									
	Derived from USEPA drinking-water standards and guidelines (Office of Water)		Derived from USEPA ambient water-quality criteria for aquatic life (Office of Water)		Derived from USEPA Reregistration Eligibility Decisions and ecological risk assessments (Office of Pesticide Programs)							
	Value [1]	Type	Acute [2]	Chronic [2]	Acute fish [3]	Chronic fish [4]	Acute invertebrates [5]	Chronic invertebrates [6]	Acute nonvascular plants [7]	Acute vascular plants [8]	Aquatic community effects [9]	OPP references
Environmental concentration (µg/L):	Time-weighted annual mean		Each individual sample	4-day moving average	Each individual sample	60-day moving average	Each individual sample	21-day moving average	Each individual sample	Each individual sample	60-day moving average	
Amides												
Alachlor	2	MCL	—	—	900	187	1,600	110	1.64	—	—	(3)
Carbamates												
Carbaryl	700	HA-L	—	—	[10] 125	[10] 210	2.55	1.5	1,100	—	—	(4, 5)
Carbofuran	40	MCL	—	—	44	5.7	1,115	0.75	—	—	—	(6)
Methomyl	200	HA-L	—	—	265	57	4.4	[11] 0.4	—	—	—	(7)
Molinate	—	—	—	—	105	[12] 210	170	[12] 340	220	3,300	—	(8)
Thiobencarb	—	—	—	—	280	—	50	1.0	17	770	—	(9)
Nitrophenols												
Dinoseb	7	MCL	—	—	—	—	—	—	—	—	—	—
Organochlorines												
p,p'-DDE	[13] 0.1	CRC(10^{-6})	[14] 1.1	[14] 0.001	—	—	—	—	—	—	—	—
Dieldrin	0.002	CRC(10^{-6})	0.24	0.056	—	—	—	—	—	—	—	—
gamma-HCH (Lindane)	0.2	MCL	0.95	—	0.85	[12] 1.7	0.5	[12] 1	—	—	—	(11)

Table A. Water-quality benchmarks for pesticide compounds that exceeded one or more benchmarks in NAWQA water samples.—Continued

[For pesticide compounds in water, benchmarks are for protection of human health and aquatic life. This table includes only those pesticide compounds that exceeded one or more benchmarks in NAWQA water samples; for these compounds, all benchmark values that were compared with concentrations in water are listed here. The complete set of benchmarks used for all pesticide compounds analyzed by NAWQA is available at *http://ca.water.usgs.gov/pnsp/pubs/circ1291/*. Common synonyms are listed in parentheses in column 1. OPP references are listed by number at the end of Appendix 3. Environmental concentration, the measured or calculated concentration statistic that is appropriate for comparison with the benchmark; CRC(10^{-6}), 10^{-6} cancer risk concentration; EC_{50}, 50 percent effect concentration; EFED, Environmental Fate and Effects Division; USEPA, U.S. Environmental Protection Agency; HA-L, lifetime health advisory; IRED, Interim Reregistration Eligibility Decision; IRIS, Integrated Risk Information System database; LC_{50}, 50 percent lethal concentration; LOC, level of concern; MCL, maximum contaminant level; NOAEC, no-observed-adverse-effects concentration; OPP, Office of Pesticide Programs; RED, Reregistration Eligibility Decision; µg/L, microgram sper liter; >, greater than; <, less than; —, no benchmark available.]

Pesticide compound (synonym)	Human-health benchmarks (µg/L)		Aquatic-life benchmarks (µg/L)									
	Derived from USEPA drinking-water standards and guidelines (Office of Water)		Derived from USEPA ambient water-quality criteria for aquatic life (Office of Water)		Derived from USEPA Reregistration Eligibility Decisions and ecological risk assessments (Office of Pesticide Programs)							
	Value [1]	Type	Acute [2]	Chronic [2]	Acute fish [3]	Chronic fish [4]	Acute invertebrates [5]	Chronic invertebrates [6]	Acute nonvascular plants [7]	Acute vascular plants [8]	Aquatic community effects [9]	OPP references
Environmental concentration (µg/L):	Time-weighted annual mean		Each individual sample	4-day moving average	Each individual sample	60-day moving average	Each individual sample	21-day moving average	Each individual sample	Each individual sample	60-day moving average	
Organophosphates												
Azinphos-methyl (Guthion)	—	—	—	0.01	0.18	[12] 0.36	0.08	[12] 0.16	—	—	—	(12)
Chlorpyrifos	20	HA-L	0.083	0.041	0.9	0.57	0.05	0.04	140	—	—	(13, 14)
Diazinon	0.6	HA-L	—	—	45	[15] 0.55	[10] 0.1	[10] 0.17	3,700	—	—	(15, 16)
Disulfoton	0.3	HA-L	—	—	19.5	[12] 39	1.95	0.037	—	—	—	(17)
Malathion	100	HA-L	—	0.1	2	[12] 4	0.25	0.06	—	—	—	(18)
Parathion (Ethyl parathion)	—	—	0.065	0.013	9	[16] 0.19	0.02	0.002	—	—	—	(19)
Parathion-methyl (Methyl parathion)	2	HA-L	—	—	500	[15] 80	0.07	0.02	5,300	—	—	(20)
Phorate	—	—	—	—	0.5	[12] 1	0.30	0.21	1,300	—	—	(21, 22)
Terbufos	0.9	HA-L	—	—	0.385	[12] 0.77	0.1	0.030	—	—	—	(23)
Sulfite esters												
Propargite	—	—	—	—	[10] 15.5	[10] 16	37	9	19.4	75,000	—	(24)
Triazines												
Atrazine	3	MCL	—	—	2,650	62	360	62	32	18	17.5	(25, 26)
Cyanazine	1	HA-L	—	—	—	—	—	—	—	—	—	—
Ureas												
Diuron	10	HA-L	—	—	355	26	80	[12] 160	2.4	—	—	(27)

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[1] From reference 1, unless noted otherwise.

[2] From reference 2.

[3] Benchmark = Toxicity value x LOC. For acute fish, the toxicity value is generally the lowest 96-hour LC_{50} in a standardized test (usually with rainbow trout, fathead minnow, or bluegill), and the LOC is 0.5.

[4] Benchmark = Toxicity value x LOC. For chronic fish, the toxicity value is usually the lowest NOEAC from a life-cycle or early life-stage test (usually with rainbow trout or fathead minnow), and the LOC is 1.

[5] Benchmark = Toxicity value x LOC. For acute invertebrate, the toxicity value is usually the lowest 48- or 96-hour EC_{50} or LC_{50} in a standardized test (usually with midge, scud, or daphnids), and the LOC is 0.5.

[6] Benchmark = Toxicity value x LOC. For chronic invertebrates, the toxicity value is usually the lowest NOAEC from a life-cycle test with invertebrates (usually with midge, scud, or daphnids), and the LOC is 1.

[7] Benchmark = Toxicity value x LOC. For acute nonvascular plants, the toxicity value is usually a short-term (less than 10 days) EC_{50} (usually with green algae or diatoms), and the LOC is 1.

[8] Benchmark = Toxicity value x LOC. For acute vascular plants, the toxicity value is usually a short-term (less than 10 days) EC_{50} (usually with duckweed) and the LOC is 1.

[9] Exceedance of this benchmark concentration, as an average for any 60-day period, could cause community-level effects on aquatic plants (based on changes in plant community diversity as predicted by the Comprehensive Aquatic Systems Model), and indirect effects on fish and aquatic invertebrates from disturbance of the aquatic plant community (from reference 26).

[10] Although the underlying acute toxicity value is greater than the chronic toxicity value, the acute benchmark is lower than the chronic benchmark because acute and chronic toxicity values were multiplied by LOC values of 0.5 and 1, respectively.

[11] Because the underlying toxicity value is a "greater-than" value (such as >265,000), this benchmark may overestimate toxicity.

[12] The chronic benchmark is based on the acute toxicity value (which was lower than the lowest available chronic toxicity value) and, therefore, may underestimate chronic toxicity.

[13] From reference 10.

[14] Benchmark applies to total DDT, so comparison with measured *p,p'*-DDE concentration may underestimate potential effects. To account for potential contamination of some stream-water samples by *p,p'*-DDE, which may have resulted from sample collection and analysis procedures, exceedance of the chronic aquatic-life criterion was determined after subtracting 0.002 ug/L from the measured concentration of *p,p'*-DDE. The expected overall effect of this compensation is to underestimate the true frequency of exceedance of the 0.001 ug/L chronic aquatic-life criterion for *p,p'*-DDE (Details are provided at *http://ca.water.usgs.gov/pnsp/pubs/circ1291/*.)

[15] Because the underlying toxicity value is a "less-than" value (such as <1,500), this benchmark may underestimate toxicity.

[16] This benchmark has greater uncertainty than usual because of methods used or conditions in the underlying toxicity study.

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Table B. Water-quality benchmarks for pesticide compounds that exceeded one or more benchmarks in NAWQA bed sediment or whole-fish samples.

[For pesticide compounds in bed sediment and whole-fish tissue, benchmarks are for protection of aquatic life and fish-eating wildlife, respectively. This table includes only those pesticide compounds that exceeded one or more benchmarks in NAWQA sediment or fish samples; for these compounds, all benchmark values that were compared with concentrations in sediment or fish are listed here. The complete set of benchmarks used for all pesticide compounds analyzed by NAWQA is available at *http://ca.water.usgs.gov/pnsp/pubs/circ1291/*. Common synomyms are listed in parentheses in column 1. The cited references are listed by number at the end of Appendix 3. $Benchmark_{High}$, highest value in the range of wildlife benchmarks available for a given pesticide compound or group; $Benchmark_{Low}$, lowest value in the range of wildlife benchmarks available for a given pesticide or group; C_f, concentration in food; Eisler-PC, proposed criterion from Contaminant Hazard Review series by R. Eisler and colleagues; ESB, equilibrium partitioning sediment benchmark; FFC, fish flesh criterion; NOAEL-ECF, no-observed-adverse-effects level equivalent concentration in food; TEC, threshold effect concentration; TRG, tissue residue guideline; USEPA, U.S. Environmental Protection Agency; µg/g, micrograms per gram; µg/kg dw, micrograms per kilogram dry weight; µg/kg ww, micrograms per kilogram wet weight; —, no benchmark available.]

Pesticide compound (synonym)	Bed-sediment benchmarks for protection of benthic aquatic organisms		Whole-fish benchmarks for protection of fish-eating wildlife			
	Consensus-based threshold effect concentration (TEC) (µg/kg dw) [1]	USEPA equilibrium partitioning sediment benchmark (ESB) (µg/g of sediment organic carbon) [1]	$Benchmark_{Low}$ value (µg/kg ww) [2]	Type of $Benchmark_{Low}$	$Benchmark_{High}$ value (µg/kg ww) [2]	Type of $Benchmark_{High}$
			Organochlorines			
Total Chlordane [3]	3.24	—	300	Eisler-PC	4,200	NOAEL-ECF
o,p'-DDD + *p,p'*-DDD [4]	4.88	—	see [5]	—	see [5]	—
o,p'-DDE + *p,p'*-DDE [4]	3.16	—	see [5]	—	see [5]	—
o,p'-DDT + *p,p'*-DDT [4]	4.16	—	see [5]	—	see [5]	—
Total DDT [5]	5.28	—	6	NOAEL-ECF	200	New York FFC
Dieldrin	1.90	12	81	NOAEL-ECF	[6] 120	New York FFC
Endosulfan I (*alpha*-Endosulfan	—	0.29	—	—	—	—
Endrin	2.22	5.4	20	NOAEL-ECF	25	New York FFC
gamma-HCH (Lindane)	2.37	0.37	3,950	NOAEL-ECF	3,950	NOAEL-ECF
Heptachlor epoxide	2.47	—	see [7]	—	see [7]	—
Total Heptachlor [7]	—	—	200	New York FFC	529	NOAEL-ECF
Total Methoxychlor [8]	—	1.9	16,300	NOAEL-ECF	16,300	NOAEL-ECF
Toxaphene	—	10	6.3	Canadian TRG	32,500	NOAEL-ECF

[1] TECs are from reference 28. ESBs are from references 29–31.

[2] $Benchmark_{Low}$ and $Benchmark_{High}$ refer to the range of benchmark values from the following four sources: Oak Ridge NOAEL-equivalent concentrations in food (the lowest C_f value for piscivorous wildlife species from reference 32); New York fish flesh criteria—noncancer (reference 33); Canadian tissue residue guidelines (references 34–35); proposed criteria from the U.S. Fish and Wildlife Service's report series, Contaminant Hazard Reviews (references 36–37).

[3] Sum of the concentrations of *cis*- and *trans*-chlordane, *cis*- and *trans*-nonachlor, and oxychlordane.

[4] Benchmark applies to the sum of these two compounds.

[5] Sum of the concentrations of *o,p'* and *p,p'* isomers of DDD, DDE, and DDT.

[6] The benchmark is for total dieldrin (sum of the concentrations of aldrin plus dieldrin). However, this benchmark is considered applicable to dieldrin concentration data because only one fish sample contained any aldrin (10 µg/kg), and in that sample both aldrin and dieldrin (43 µg/kg) were well below all benchmarks.

[7] Sum of the concentrations of heptachlor and heptachlor epoxide.

[8] Sum of the concentrations of *o,p'* and *p,p'* isomers of methoxychlor.

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Water: Human-Health Benchmarks

1. Pesticide compounds without human-health benchmarks:

The following pesticide compounds measured by NAWQA in stream water and ground water had no human-health benchmarks (names in parentheses are synonyms):

Acetochlor
Azinphos-methyl (Guthion)
Benfluralin
Bromoxynil
Chloramben methyl ester
Clopyralid
Dacthal mono-acid
2,4-DB
Deethylatrazine
Dichlobenil
Dichlorprop
2,6-Diethylaniline
DNOC
EPTC
Ethalfluralin
Ethoprop (Ethoprophos)
Fenuron
3-Hydroxycarbofuran
Linuron
MCPB
Methiocarb
Molinate
Napropamide
Neburon
Norflurazon
Oryzalin
Parathion (Ethyl parathion)
Pebulate
Pendimethalin
cis-Permethrin
Phorate
Propanil
Propargite
Thiobencarb
Triallate
Triclopyr

2. Pesticide compounds with human-health benchmarks, but no exceedances:

The following pesticide compounds measured in water had human-health benchmarks available, but these benchmarks were never exceeded (names in parentheses are synonyms):

Acifluorfen
Alachlor
Aldicarb
Aldicarb sulfone
Aldicarb sulfoxide
Bentazon
Bromacil
Butylate
Carbaryl
Carbofuran
Chlorothalonil
Chlorpyrifos
2,4-D
Dacthal (DCPA)
p,p'-DDE
Dicamba
Disulfoton
Diuron
Fluometuron
Fonofos
alpha-HCH
Malathion
MCPA
Methomyl
Metolachlor
Metribuzin
Oxamyl
Parathion-methyl (Methyl parathion)
Picloram
Prometon
Pronamide (Propyzamide)
Propachlor
Propham
Propoxur (Baygon)
Simazine
2,4,5-T
Tebuthiuron
Terbacil
Terbufos
2,4,5-TP (Silvex)
Trifluralin

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Water: Aquatic-Life Benchmarks

1. Pesticide compounds without aquatic-life benchmarks:

The following pesticide compounds measured by NAWQA in stream water had no aquatic-life benchmarks (names in parentheses are synonyms):

Acetochlor
Chloramben methyl ester
Clopyralid
Cyanazine
Dacthal mono-acid
Deethylatrazine
Dicamba
Dichlorprop
2,6-Diethylaniline
Dinoseb
DNOC
Fenuron
Fonofos
alpha-HCH
3-Hydroxycarbofuran
MCPB
Neburon
Prometon
Propham
2,4,5-T
2,4,5-TP (Silvex)

2. Pesticide compounds with aquatic-life benchmarks, but no exceedances:

The following pesticide compounds measured in stream water had aquatic-life benchmarks available, but these benchmarks were never exceeded (names in parentheses are synonyms):

Acifluorfen
Aldicarb
Aldicarb sulfone
Aldicarb sulfoxide
Benfluralin
Bentazon
Bromacil
Bromoxynil
Butylate
Chlorothalonil
2,4-D
Dacthal (DCPA)
2,4-DB
Dichlobenil
EPTC
Ethalfluralin
Ethoprop (Ethoprophos)
Fluometuron
gamma-HCH (Lindane)
Linuron
MCPA
Methiocarb
Metolachlor
Metribuzin
Napropamide
Norflurazon
Oryzalin
Oxamyl
Pebulate
Pendimethalin
cis-Permethrin
Picloram
Pronamide (Propyzamide)
Propachlor
Propanil
Propoxur (Baygon)
Simazine
Tebuthiuron
Terbacil
Triallate
Trifluralin
Triclopyr

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Bed Sediment: Aquatic-Life Benchmarks

1. Pesticide compounds without aquatic-life benchmarks:

The following pesticide compounds measured by NAWQA in bed sediment had no aquatic-life benchmarks:

Aldrin
Chloroneb
Dacthal (DCPA)
alpha-HCH
beta-HCH
Heptachlor
Hexachlorobenzene
Isodrin
Mirex
Pentachloroanisole
cis-Permethrin
trans-Permethrin

Note: Several additional compounds measured, such as *cis*-chlordane and *p,p'*-DDE, did not have benchmarks themselves, but were part of pesticide groups (total chlordane and total DDT, respectively) that did have sediment benchmarks.

2. Pesticide compounds with aquatic-life benchmarks, but no exceedances:

All pesticide compounds or groups with benchmarks in sediment exceeded those benchmarks in one or more samples.

Whole Fish Tissue: Wildlife Benchmarks

1. Pesticide compounds without wildlife benchmarks:

The following pesticide compounds measured by NAWQA in whole fish had no benchmarks for fish-eating wildlife:

Dacthal (DCPA)
Pentachloroanisole

Note: Several additional compounds measured, such as *cis*-chlordane and *p,p'*-DDE, did not have benchmarks themselves, but were part of pesticide groups (total chlordane and total DDT, respectively) that did have wildlife benchmarks.

2. Pesticide compounds with wildlife benchmarks, but no exceedances:

The following pesticide compounds or groups measured in whole fish had wildlife benchmarks available, but these benchmarks were never exceeded (names in parentheses are synonyms):

beta-HCH
gamma-HCH (Lindane)
Total HCH
Heptachlor
Hexachlorobenzene
Total Methoxychlor
Mirex

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Appendix 4—List of abbreviations, acronyms, and units of measurement

Note: Clarification or additional information is provided in parentheses.

ATSDR	Agency for Toxic Substances and Disease Registry
AWQC-AL	ambient water-quality criterion for the protection of aquatic life (USEPA)
CAS	Chemical Abstract Service
CCME	Canadian Council of Ministers of the Environment
CERCLA	Comprehensive Environmental Recovery, Compensation, and Liability Act
CWA	Clean Water Act
DDD	1,1-dichloro-2,2-bis(chlorophenyl)ethane (DDT degradate)
DDE	1,1-dichloro-2,2-bis(chlorophenyl)ethylene (DDT degradate)
DDT	1,1,1-trichloro-2,2-bis(chlorophenyl)ethane
ESA	ethanesulfonic acid
ESB	equilibrium partitioning sediment benchmark (USEPA)
FFC	fish flesh criterion for protection of fish-eating wildlife, noncancer values (NYSDEC)
FFDCA	Federal Food, Drug, and Cosmetic Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FQPA	Food Quality Protection Act
ft	foot (feet)
g	gram
GCMS	gas chromatography with mass spectrometric detection
HA-L	lifetime health advisory (USEPA)
HPLC	high performance liquid chromatography
IARC	International Agency for Research on Cancer
kg	kilogram
K_H	Henry's law constant
K_{oc}	soil organic carbon-water partition coefficient
L	liter
lb	pound
LOAEC	lowest-observed-adverse-effects concentration
LOC	level of concern (USEPA)
MCL	Maximum Contaminant Level (USEPA)
mg	milligram
mi	mile
mL	milliliter
mm	millimeter
NAWQA	National Water-Quality Assessment Program (USGS)
NCBP	National Contaminant Biomonitoring Program (U.S. Fish and Wildlife Service)
NLCD	National Land Cover Data
NOAEC	no-observed-adverse-effects concentration
NOAEL	no-observed-adverse-effects level
NPDES	National Pollutant Discharge Elimination System (USEPA)

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Appendix 4—List of abbreviations, acronyms, and units of measurement

Note: Clarification or additional information is provided in parentheses.

NYSDEC	New York State Department of Environmental Conservation
OPP	Office of Pesticide Programs (USEPA)
OW	Office of Water (USEPA)
ppb	parts per billion
PTI	pesticide toxicity index
SDWA	Safe Drinking Water Act
TEC	threshold effect concentration
TRG	tissue residue guideline (Canadian)
TU	tritium unit
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WET	whole effluent toxicity (USEPA)
yr	year
µg	microgram

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