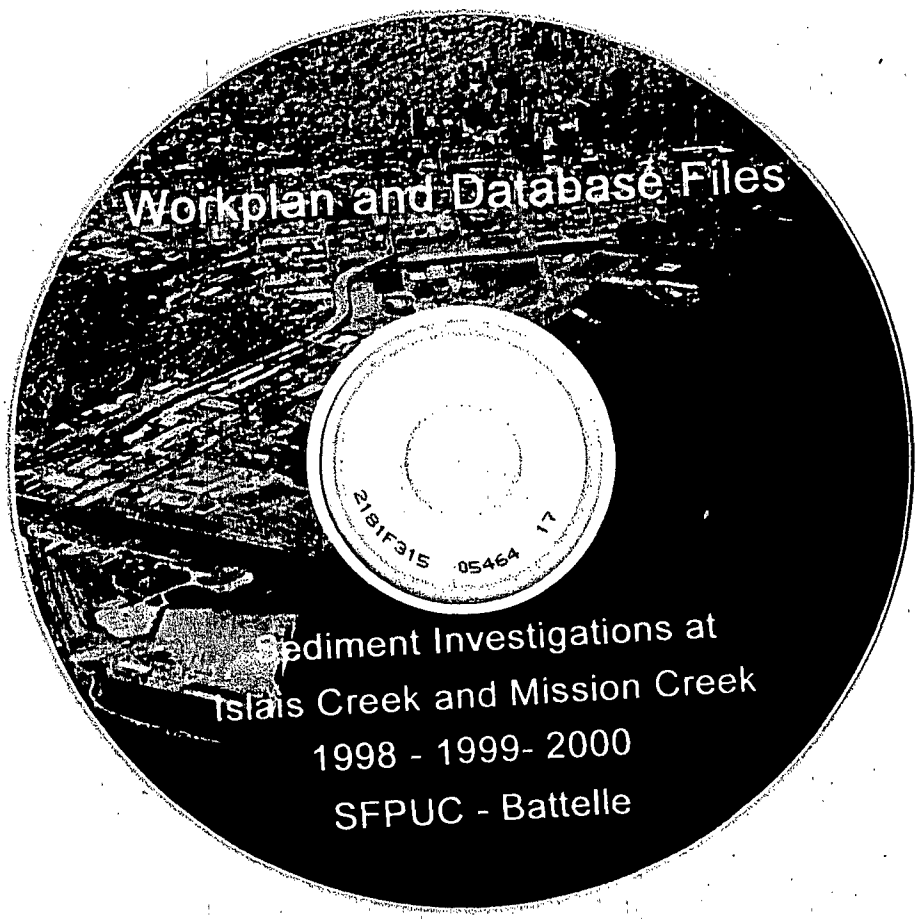
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Sediment Investigations at
Islais Creek and Mission Creek
1998 - 1999- 2000
SFPUC - Battelle

DRAFT FINAL REPORT

SEDIMENT INVESTIGATIONS AT ISLAIS CREEK AND MISSION CREEK

1998 – 1999 – 2000

Prepared for:
CITY AND COUNTY OF SAN FRANCISCO
PUBLIC UTILITIES COMMISSION, SPARC

Submitted to:
CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

Prepared by:
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PREFACE

In early 1998, the City and County of San Francisco, Public Utilities Commission (SFPUC) began intensive investigations into the sediment conditions at Islais and Mission Creeks. These investigations, which were conducted over the course of three years, required the combined efforts of San Francisco Bay RWQCB staff, program managers and scientists from the City and County of San Francisco, and scientists and technicians from several environmental consulting firms. Although the project team largely remained intact over the course of these investigations, many of the team members have changed firms and/or affiliations. Ms. Leslie Lundgren consistently served as Program Manager for SFPUC and facilitated interactions between the RWQCB and the City and County of San Francisco. She was the primary contact for the three RWQCB staff Project Managers that oversaw the investigations: Mr. David Leland from 1998-1999; Mr. Brad Job from 1999-2001; and Mr. Steve Moore from 2001 through 2002. Ms. Cynda Maxon functioned as the Scientific Project Manager, while with Arthur D. Little (ADL) from 1998 to 2001, and with Battelle Memorial Institute (Battelle) from 2001 through 2002. Field sampling was overseen by Ms. Arleen Navarett of SFPUC with support from Olivia Chen Consultants and SCA Environmental. Organic chemicals were analyzed at the former ADL Environmental Laboratory in Cambridge, MA. Inorganic analyses were performed at the SFPUC Water Quality Bureau Laboratory. Acute toxicity testing was performed by the SFPUC Water Quality Bureau Environmental and Field Services Division, and Pacific EcoRisk Laboratory (in 1998 only). Bioaccumulation testing was performed by EVS Environmental Consultants, located in Vancouver, B.C.

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ACRONYMS AND ABBREVIATIONS

Abbreviation	Definition
%	percent
µg	microgram
$\mu g \cdot g^{-1}$	micrograms per gram (same as ppm)
$\mu g \cdot L^{-1}$	micrograms per Liter (same as ppb)
<	less than
>	greater than
µm	micron
‰	parts per thousand
AAF	atomic absorption flame
AAGF	atomic absorption graphite furnace
AAH	atomic absorption hydride
AAS	atomic absorption spectrometry
ADL	Arthur D. Little, Inc.
Al	aluminum
ANOVA	analysis of variance
ARAR	applicable or relevant and appropriate requirement
As	arsenic
ASTM	American Society of Testing Methodology
AVS	acid volatile sulfides
Ba	barium
Battelle	Battelle Memorial Institute
BPTCP	Bay Protection and Toxic Cleanup Plan
BSAF	biota-sediment accumulation factor
C	centigrade
Cd	cadmium
CERCLA	comprehensive environmental response, compensation and liability act
cm	centimeters
COC	chemical of concern
COPC	chemical of potential concern
CPI	carbon preference index
Cr	chromium
CSO	City-operated combined sewer outfall
CTD	conductivity, temperature and depth
Cu	copper
CV	coefficient of variation
CVAA	cold vapor atomic absorption
CVAAS	cold vapor atomic absorption spectrophotometry
DDT	dichlorodiphenyltrichloroethane
DGPS	Differential Global Positioning System

DHS	Department of Health Services
DMMO	Dredge Materials Management Organization
EBS	Environmental Baseline Study
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
ERL	effects range-low
ERM	effects range-median
FAAS	flame atomic absorption spectrophotometry
FDA	United States Food and Drug Administration
Fe	iron
FED	functional equivalent document
g	gram
GC	gas chromatograph
GC/FID	gas chromatography/flame ionization detection
GC/MS	gas chromatography/mass spectrometry
GPS	Global Positioning System
H2S	hydrogen sulfide
H_2SO_4.	sulfuric acid
HCl	hydrochloric acid
HF-HNO3-HclO4	hydrofluoric-nitric-perchloric acid
Hg	mercury
HMW	high molecular weight
HNO_3	nitric acid
ICP	inductively coupled plasma spectrometry
ICP/MS	inductively-coupled plasma/mass spectrometry (ICP)
$kg \cdot m^{-3}$	kilogram per cubic meter
kg	kilogram
km	kilometer
L	liter
LAB	linear alkylbenzene
LMW	low molecular weight
m	meter
m^2	square meter
MDL	method detection limit
mg	milligram
$mg \cdot kg^{-1}$	milligrams per kilogram
MGD	million gallons per day
MGP	manufactured gas plant
mL	milliliter
mm	millimeter
N/P	napthalenes to phenanthrenes ratio
NAS	National Academy of Science
$ng \cdot g^{-1}$	nanograms per gram (same as ppb)
NH_3	ammonia

NIST	National Institute of Standards and Technology
nm	nanometer
NWAS	Northwest Aquatic Sciences
OC	organic carbon
OCC	Olivia Chen Consultants
OEHHA	Office of Environmental Health Hazard Assessment
p	probability
PAH	polycyclic aromatic hydrocarbons
PER	Pacific EcoRisk
Pb	lead
PCA	principal component analysis
PCB	polychlorinated biphenyl
ppb	parts per billion (same as $ng \cdot g^{-1}$)
ppm	parts per million (same as $\mu g \cdot g^{-1}$)
PRMP	pilot regional monitoring program
r	correlation coefficient
r^2	correlation coefficient squared
RBI	relative benthic index
RI/FS	remedial investigation and feasibility study
RMP	regional monitoring program
RPD	relative percent difference
RSD	relative standard deviation
RTU	relative turbidity units
RWQCB	San Francisco Bay Regional Water Quality Control Board
SAP	Sampling and Analysis Plan
SCA	SCA Environmental
SEWPCP	South East Water Pollution Control Plant
SFPUC	San Francisco Public Utilities Commission
SHC	saturated hydrocarbons
SIM	selected ion monitoring
SOP	standard operating procedure
SRM	standard reference material
SWRCB	State Water Resources Control Board
SWTP	San Francisco wastewater treatment plant
TIE	toxicity identification evaluation
TOC	total organic carbon
TPAH	total polycyclic aromatic hydrocarbons
TPH	total petroleum hydrocarbons
TRV	toxicity reference value
UCM	unresolved complex mixture
UPL	upper predictive limit
ZGFAAS	Zeeman graphite furnace atomic absorption spectrophotometry
Zn	zinc

EXECUTIVE SUMMARY

Sediment investigations at Islais and Mission Creeks focus primarily on elevated chemical concentrations combined with toxicity to benthic invertebrates. These indicators of sediment quality formed the primary drivers for the Regional Board's classification of these creeks as "confirmed toxic hot spots" under the statewide Bay Protection and Toxic Cleanup Program (BPTCP). Following the hot spot designations, the RWQCB issued a Water Code Section 13267 letter requiring the City and County of San Francisco to conduct further investigations in the subject creeks. In response, the City and County of San Francisco formulated an ambitious program, producing the most current and comprehensive data sets ever assembled for these two creeks. Over 100 sediment samples were collected from a total of 59 stations from the creeks in three consecutive yearly surveys. In addition, up to six Regional Monitoring Program in-bay reference stations were co-sampled. Two of the investigations were conducted during wet weather in October 1998 and April 2000. A single dry weather investigation was conducted in October 1999. Toxicity and chemistry tests were performed on surface sediments to document the horizontal extent of impacts; and subsurface cores were analyzed to estimate the vertical extent of contamination. Standard 28-day laboratory tests using clams were conducted in April 2000 to evaluate the potential bioaccumulation of chemicals from creek sediments. These tests were designed to address elevated concentrations of mercury, PCBs and selected chlorinated pesticides in creek sediments that are known to bioaccumulation in marine food webs.

The SFPUC investigations used field and laboratory methods that were consistent with those used in the BPTCP, except for minor modifications to the 10-day acute toxicity test. The test species (*Eohaustorius estuarius*) is vulnerable to elevated levels of ammonia and/or hydrogen sulfide, which are viewed as confounding factors in standard toxicity tests. The SFPUC followed EPA protocol, which required reduction of ammonia and sulfides to levels that would not interfere with toxicity test results. In addition, resident predators in test sediments were removed prior to testing, and the test species was properly acclimated (for salinity changes) prior to testing. Any of these factors could have contributed to the extremely high mortality observed in the BPTCP toxicity testing of these creeks, independent of coincident chemical concentrations. This premise is at least partly supported by the fact that chemical concentrations were fairly consistent across BPTCP and SFPUC investigations; however, sediments with the highest chemical concentrations consistently posted the highest survival of amphipods in the SFPUC studies. The only other deviations from the BPTCP approach made by SFPUC were to methods of data analysis. These included use of statistical comparisons between creek and reference sediments to substantiate elevated chemical concentrations in sediments. It was presumed that the in-bay reference sites used in the BPTCP and revisited in the SFPUC investigations represent sediment background conditions that are appropriate to gauge environmental impact in the creeks. This approach differs from that used in the BPTCP, which relied on a comparison of creek sediment concentrations to a calculated effects-range-median (ERM) quotient, where any sediment sample with an ERM quotient greater than 0.5 was considered impacted. The statistical approach used by SFPUC was conservative for nearly all chemicals tested, as there were a greater number of sediment samples that were statistically elevated than those that exceeded the ERM quotient.

Chemical Distribution Patterns

Chemical concentrations in the two creeks varied considerably as a function of location, sediment type and TOC concentration. Most notably, nearly all contaminant concentrations increased with depth and decreased with distance from the end of each creek, returning to in-bay reference concentrations in the eastern portion of each creek (e.g., east of the 3rd and 4th Street bridges). These consistent trends strongly suggest that contaminant inputs to the creeks have decreased over time and that buried contaminants are in place, with little probability of resuspension to the water column.

Most chemical concentrations were positively correlated with sediment TOC; however, with few exceptions similar relationships were not observed with grain size. In addition, many metals were positively correlated with either aluminum or iron, which are major constituents of sediment minerals. Sediment concentrations of chlorinated pesticides, polychlorinated biphenyls (PCB) and polycyclic aromatic hydrocarbons (PAH), which are nonionic organic compounds, increased with increasing TOC, as expected, due to their relative insolubility in water and high affinity for particulate matter.

Toxic Hot Spot Evaluation

Islais Creek. Only two locations at the west end of Islais Creek met the BPTCP definition of a toxic hot spot using data from the three SFPUC surveys (1998, 1999 & 2000). These results refute previous BPTCP assertions that the entire creek is toxic, in that impacts are confined to a small, localized area (<1 acre) west of the 3rd Street Bridge. The BPTCP toxic hot spot listing relied on data collected from a total of three stations from which only a single location was sampled twice for the same parameters (in 1994 and 1997). SFPUC findings are based on a total of 18 stations, six of which were sampled in three consecutive surveys. These two stations, located west of the 3rd Street Bridge, had toxicity results ranging from 43-70% survival, which while statistically significant, were greatly improved over the 0% survival measured in these sediments in the BPTCP. Sediments from these two stations displayed consistently elevated concentrations of lead, PAH, PCBs, and Chlordane. However, sediments with the highest chemical concentrations, located directly under Interstate 280 at the west end of the creek, consistently posted the highest survivals in the 10-day amphipod test. Bioaccumulation results for tissues exposed to creek end sediments may challenge any presumptions that associated chemicals are not bioavailable, as chlorinated compounds were significantly elevated in creek tissues compared to tissues exposed to in-bay reference sediments. However, sediment-tissue bioaccumulation factors were less than unity (one) for all samples, indicating that these chemicals may not biomagnify through the local food web. Bioaccumulation of mercury in creek tissues was at or below concentrations measured in reference tissues for all stations except one. The limited area of impact at the creek end (< 1 acre), coupled with strong evidence that contaminant concentrations are decreasing and have minimal biomagnification potential, make Islais Creek an ideal candidate for natural recovery.

Mission Creek. None of the 13 Mission Creek stations sampled qualified as toxic hot spots. These results were driven by the high, uniform survival in the 10-day amphipod test, which are in stark contrast to the BPTCP results for these sediments. The BPTCP identified the entire area of Mission Creek (18 acres) as a toxic hot spot based on the confirmatory sampling of a single station sampled in 1995 and 1997 at the west end of the creek. Subsequent sampling by SFPUC in 1998, 1999 and 2000 of eight

creek-end stations and initial testing in 1998 of five stations east of the 4th Street Bridge failed to identify a single toxic hot spot. Stations east of 4th Street were sampled only once, as results showed that these sediments were representative of in-bay reference sediments and did not warrant further studies. SFPUC results refute previous BPTCP assertions that the entire creek is toxic, in that sediment toxicity was at or below that measured at in-bay reference stations at all 22 samples tested during the three surveys. Similar to Islais Creek, tissues exposed to west end Mission Creek sediments displayed statistically elevated concentrations of chlorinated compounds compared to reference tissues. However, biota-sediment accumulation factors were far less than one, again indicating a low biomagnification potential for these contaminants in the local food web.

1 S

1.0 INTRODUCTION

This report presents the results, conclusions, and recommendations of two sediment investigations conducted in San Francisco Bay at Islais and Mission Creeks on behalf of the City and County of San Francisco, Public Utilities Commission (SFPUC). Two of the investigations were conducted during wet weather in October 1998 and April 2000. A single dry weather investigation was conducted in October 1999. This report also evaluates the relevant regulatory framework and data utilized by the San Francisco Bay Regional Water Quality Control Board (RWQCB) in the Bay Protection and Toxic Cleanup Plan (BPTCP) in the designation of Islais and Mission Creeks as toxic hot spots.

Creek conditions were examined relative to clean in-bay reference sites to evaluate the spatial extent of sediment chemical contamination and toxicity. Sediment contaminant type and distribution were examined for each creek in order to estimate relative contributions from City-operated combined sewer overflows (CSOs) and other possible sources. In addition, this information may be used to evaluate possible remedial or preventative measures. The scope of the investigations followed the Sampling and Analysis Plan (SAP) first submitted to the RWQCB in October 1998 (ADL 1998), and revised for the October 1999 and May 2000 investigations (ADL 1999). The SAPs were responsive to the RWQCB's Section 13267 letter of June 1998 and subsequent letters issued in August and September 1998 that further defined the requirements for collection and analysis of sediment data in the two subject creeks. A third site, Yosemite Creek, was also addressed in the RWQCB August and September 1998 letters, and investigated concurrently with Islais and Mission Creeks. Results for the Yosemite Creek studies will be issued in a separate report. The investigations were performed by Arthur D. Little, Inc. (ADL) and SFPUC, with field support from Olivia Chen Consultants (OCC) and SCA Environmental (SCA). This report was prepared by Battelle Memorial Institute (Battelle).

1.1 PURPOSE OF REPORT

The primary objectives of this report are to determine the current environmental status of each of the two creeks, and to confirm or refute the toxic hot spot designations of Islais and Mission Creeks. These designations were based on state legislation, passed in 1989, which provided modifications to Division 7, Chapter 5.6 of the California Water Code, and are described as the Bay Protection and Toxic Cleanup Program (BPTCP).

Toxic hot spot designation by the RWQCB was primarily based upon significant recurrent toxicity to test organisms from sediments collected (and tested) in Fall 1994 and Spring 1997 by the RWQCB in both Islais and Mission Creeks. The designations were supported by elevated chemical concentrations in creek sediment and indications of an impacted benthic invertebrate community in 1997.

The RWQCB issued a Water Code Section 13267 letter in June 1998, requiring SFPUC to define sediment contamination in Mission and Islais Creeks and determine the extent to which combined sewer overflows at both creeks and the Quint Street outfall at Islais are presently or historically responsible (RWQCB 1998). In addition, information regarding the vertical extent of contamination was required to determine the extent of impact and for use in considering remedial options.

The comprehensive sampling program initiated by SFPUC was responsive to both RWQCB requests concerning the two creeks. Toxicity and chemistry tests were conducted on surface sediments to document the horizontal extent of impacts; and subsurface cores were analyzed to estimate the vertical extent of contamination. Bioaccumulation of selected chemicals of potential concern (COPCs) was examined in May 2000 only, using clam tissue exposed to creek sediments in standard 28-day laboratory tests. The analytical results provide an appropriate basis for interaction with the RWQCB to achieve final site designation and to develop plans for future prevention and control strategies, if warranted.

Specific objectives of these investigations were:

1. to confirm or refute the RWQCB's findings, indicating that Mission and Islais Creeks are toxic and contaminated;
2. to define the vertical extent of contamination in the two creeks;
3. to define the horizontal extent of contamination and toxicity under both wet and dry weather conditions in the two creeks;
4. if possible, to determine sources of contamination to the receiving creek beds; and,
5. to provide recommendations regarding remediation or preventative actions appropriate for each creek.

1.2 REPORT ORGANIZATION

The main body of this report consists of ten sections described below. Appendices A and B present laboratory data and graphics, organized by creek and study year. Detailed descriptions of laboratory, data analysis and quality control methods used in support of these investigations are presented in separate documents (ADL 1998 & 1999) that are included on the CD-ROM (*Sediment Investigations at Islais Creek and Mission Creek*), accompanying this report.

Section 1 - Introduction presents the purpose and objectives of the study, citing regulatory requirements and background. An overview of methods used in the BPTCP to evaluate sediment chemical and biological data in the designation of toxic hot spots is provided. Methods used by the RWQCB are contrasted with those used in other regulatory programs to examine alternative interpretations of sediment data.

Section 2 – Site History presents the location, geological setting, potential contaminant sources, and sediment chemical and biological results from previous investigations for each of the two creeks. Historical data used in the hot spot designations of Islais and Mission Creeks are reviewed.

Section 3 – Decision Rules, Study Design and Methods presents decision rules that are applied in Section 9, to determine the extent of environmental impact at each creek. These rules were agreed upon by SFPUC and RWQCB staff, and are used to determine whether the subject creeks warrant additional action. An overview of the study design applied to each creek along with sampling inventories and corresponding minor modifications made between sampling events are presented in Section 3.2. Brief

discussions of field, laboratory and analytical procedures are provided in Section 3.3. Detailed methods are presented in the project SAPs are included on the CD-ROM.

Section 4 – Physical Characteristics of Sediment presents results for grain size and total organic carbon in creek and reference area sediments. Effects of sediment physical characteristics on chemical and biological parameters are emphasized.

Section 5 – Sediment Toxicity presents results for standard 10-day acute laboratory tests, using the amphipod *Eohaustorius estuarius*. Results for creek and reference areas are described by presenting central tendencies, range and variation. Comparisons of survival between creek and reference areas also are presented for each of the two creeks. October 1998 and 1999, and May 2000 data are compared to estimate temporal variation for each creek.

Section 6 – Sediment Chemistry presents results for organic and metal contaminants measured in each of the two creeks, defining vertical and horizontal patterns of distribution. Results are described by presenting central tendencies, range and variation. Results for statistical comparisons between creek and reference area surface sediments also are presented, and are used to identify contaminants of potential concern (COPC) for each creek. October 1998 and 1999, and May 2000 data are compared to estimate temporal variation for each creek.

Section 7 – Bioaccumulation in Clams presents results for selected chemicals of concern measured in organisms exposed to sediments in standard 28-day laboratory tests. Results are described by presenting central tendencies, range and variation. Lipid-normalized chemical concentrations in tissue for each creek station are compared to tissue results from clams exposed to in-bay reference stations.

Section 8 – Source Identification of Selected COPCs. This section discusses potential contaminant sources for selected COPCs at each creek. Chemicals of potential concern identified in Section 6 that may have multiple sources are discussed, including metals, polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs). Knowledge of site use combined with forensic chemistry methods, including source ratio and principal components analysis (PCA), are used to identify likely contaminant sources for each creek.

Section 9 – Application of Decision Rules and Recommendations are presented in this section. The current status of each creek is determined by applying chemistry and toxicity results to the decision matrix presented in Section 3. Recommendations for no further action, additional analyses, remedial action or preventative measures are presented following the results from the applied decision rules. Arguments to delist all of Mission Creek and most of Islais Creek as confirmed toxic hot spots are presented, since these sediments no longer meet RWQCB criteria.

Cited literature is listed in *Section 10.*

1.3 REGULATORY BACKGROUND

In 1989, the California State Legislature established a Bay Protection and Toxic Cleanup Program (BPTCP). Under BPTCP legislative authority, four goals were established: 1) protection of present and future beneficial uses of California's bays and estuaries; 2) identification and characterization of contaminated areas; 3) development of plans for cleanup of contaminated sites, or other remedial or mitigation action; and 4) development of control strategies for toxic pollutants to prevent creation of new areas of contamination.

The BPTCP designated contaminated areas as "toxic hot spots," following Section 13391.5 of the Water Code, as areas in which hazardous substances have accumulated in water or sediment to levels which 1) may pose a substantial present or potential hazard to aquatic life, wildlife, fisheries, or human health; 2) may adversely affect beneficial uses of bays, estuaries, or ocean waters as defined the water quality control plans; or 3) exceed adopted water quality or sediment quality objectives. Additional details of BPTCP toxic hot spot definition are provided by SWRCB (1998).

The definition of a toxic hot spot was broadly defined in the Water Code. The legislation, therein, granted the State Water Resources Control Board (SWRCB) and RWQCB the final authority for designation of toxic hot spots in their areas of jurisdiction, providing a means for refined definitions to address specific contamination issues within the context of local background conditions. A "potential toxic hot spot" is a site where information exists indicating possible impairment but without sufficient information to be classified as a "candidate toxic hot spot" (Hunt et al. 1998a).

As set forth in the Draft Functional Equivalent Document (FED) Appendix A, Volume I (SWRCB 2000), and summarized by Hunt et al. (1998a), a site is considered a candidate toxic hot spot if any of the following conditions are met.

1. The site exceeds water or sediment quality objectives or water quality standards of the RWQCB or the U.S Environmental Protection Agency (EPA).
2. The water or sediment exhibits recurrent toxicity associated with toxic pollutants that is significantly different from the toxicity observed at reference sites. The toxicity tests must also be approved by the SWRCB and RWQCB, and toxic pollutants should be present in concentrations known to cause or contribute to the toxic response.
3. Tissue pollutant levels of organisms collected from the site exceed acceptable levels established by the U.S. Food and Drug Administration (FDA) for the protection of human health, or National Academy of Science (NAS) standards for protection of human health and wildlife. If the state Office of Environmental Health Hazard Assessment (OEHHA) or Department of Health Services (DHS) has issued a health advisory against consumption of edible resident non-migratory organisms on a site or water body, the site is a candidate toxic hot spot if the contaminant of concern is associated with sediment or water at the site.
4. Impaired environmental conditions associated with toxic pollutants, as measured by reduction in growth, reduction in reproductive capacity, abnormal development, or histopathological (tissue) abnormalities in organisms.

5. Significant degradation in biological populations and/or communities associated with the presence of elevated levels of toxic pollutants.

Once a candidate toxic hot spot was designated and approved by the SWRCB and RWQCB, it was subsequently listed in the statewide cleanup plan as a "known toxic hotspot," including requirements for pollution prevention, control and remediation.

These definitions include a degree of subjectivity that provides a means of interpretation and site definition within the framework of local conditions. For example, there are no regulatory standards for sediment quality in the state of California (Condition 1), and interpretation of sediment toxicity results in the case of San Francisco Bay is complicated by the presence of a residual level of toxicity in virtually all bay sediments representing background conditions. Condition 2 raises the issue of chemical concentrations "known to cause, or contribute to, toxic responses." Marine and estuarine sediments present a complex physical and chemical mixture of compounds and elements, potentially including toxic contaminants of anthropogenic origin. The biological effects of contaminants are significantly influenced by their equilibria dynamics between adsorbed and soluble states, as determined by physical and chemical conditions within the matrix of sediment particles and pore-water. Factors such as organic carbon content, grain size, reduction-oxidation potential, pH, and the presence of compounds associated with organic degradation (e.g., ammonia, hydrogen sulfide), all play a role in contaminant bioavailability and biological response, including acute or chronic toxicity, and need to be considered in the determination of impact. Because the basic physical-chemical nature of sediment varies between localities, irrespective of introduced contaminants, considerable variability has been observed in toxicity tests with respect to individual contaminant concentrations (Long & Morgan 1990; Long et al. 1995, 1998); and chemical concentrations "known to cause toxicity" cannot accurately be predicted. However, predictability of response generally increases as a function of the number of contaminants present that exceed estimated concentration thresholds (Long et al. 1998, MacDonald et al. 2000).

Significant degradation of biological communities (Condition 5) has its definitive precepts in the well-documented changes in benthic communities associated with point source discharges of contaminants, particularly where organic matter is introduced. Reduced biological diversity and the presence of high numbers of opportunistic "pollution indicator" species characterize these areas in relatively stable offshore marine habitats. Shallow estuarine sites that are subject to wider ranging vicissitudes of salinity and temperature and food availability tend to have higher levels of variability in diversity and individual species abundance under natural conditions, and effects of biological contaminants are less discernible in the face of elevated natural variability. High levels of variability in San Francisco Bay benthic communities and difficulties in the interpretation of pollution effects are recognized by both regional regulators and benthic ecologists (Hunt et al. 1998a; Nichols 1986; Thompson et al. 1997).

1.3.1 Toxic Hot Spot Identification in San Francisco Bay

In the San Francisco Bay region, the phases of BPTCP toxic hot spot identification included: 1) a review of existing reports on water and sediment quality; 2) surveys of sites in a Pilot Regional Monitoring Program (PRMP), which included a method validation study along a pollution gradient; 3) a reference site study that established toxicological and statistical methods for identifying polluted sites in

comparison with reference conditions in the bay; 4) a toxicity screening study of sites throughout the region, selected on the basis of previous information and PRMP results; and 5) confirmation (follow-up) studies of sites that exhibited toxicity and/or elevated chemistry during screening (Hunt et al. 1998a).

The monitoring and screening approach to identifying sediment toxic hot spots included toxicity testing, chemical analysis for trace metals and organic compounds, and benthic community analysis. This approach, known as the sediment quality triad (Chapman et al. 1997), was modified in that benthic community structure was not included for all confirmation studies due to inherent difficulties in the interpretation of benthic data for parts of San Francisco Bay (see Methods, Hunt et al. 1998a). The primary screening tool was sediment toxicity testing, augmented by chemical and biological analyses, with definition of a candidate toxic hot spot contingent upon evidence of recurrent toxicity by confirmation testing at a subsequent date. Most sites in the bay, including Islais and Mission Creeks, were initially monitored in 1994, with follow-up confirmation in 1997.

In emphasizing this "weight-of-evidence" approach, the BPTCP upon Condition 2, defined toxic hot spot sites as those displaying recurrent sediment toxicity or impaired benthic community, supported by synoptic chemical concentrations present at levels known to be associated with toxicity.

1.3.1.1 Toxicity Criteria

A primary BPTCP criterion for candidate and final toxic hot spot designation is recurrent toxicity, i.e., "when at least two samples collected at different times from a station or site are determined to be significantly toxic by any of the BPTCP toxicity test protocols." BPTCP criteria for evaluation of toxicity data in San Francisco Bay adopted an approach of statistical comparison with background bay reference sites. Sediment samples were considered toxic "if there was at least a 95% probability that the sample was as toxic or more toxic than would be expected from the worst 10% of reference samples" (Hunt et al. 1998a). This approach, which acknowledges the presence of background residual toxicity in the bay, developed reference envelope tolerance limits for sediment toxicity (Table 1-1). For example, within this framework, any toxicity test result in which amphipod (Eohaustorius) survival exceeded 69.5% of control survival would not indicate significant toxicity. Control sediments from an unimpacted habitat are collected with the test organisms (e.g., amphipods). Animals tested in these control sediments must display at least 90% amphipod survival for a successful test.

Table 1-1. Reference tolerance limits for San Francisco Bay sediment toxicity tests (from Hunt et al. 1998a).

Protocol	Tolerance Limit as percent (%) of Control
Amphipod (*Eohaustorius*) Survival	69.5
Sea Urchin Larval Development in porewater	94.3
Sea Urchin Larval Development at sediment water interface	86.7

The reference site standards shown in Table 1-1 indicate moderate toxicity of background sediments to the amphipod test organism and relatively little effect upon sea urchin larval development.

Five BPTCP reference sites sampled in 1994 and 1995 were utilized for establishing background conditions for the amphipod test. San Francisco Bay BPTCP reference sites and test results are

described by Hunt et al. (1998b). In addition, test results from three regional monitoring program (RMP) sites were included as part of the regional background database for the 10-day amphipod test (Dr. John Hunt, UC Santa Cruz, personal communication, 5/99). Toxicity test procedures for the RMP are described in the 1994 Annual Report (SFEI 1995).

Although conservative, this approach is reasonable to assess relative toxicity in San Francisco Bay. However, due to the transient nature of toxicity test results the approach is significantly improved if test (i.e., the site under investigation) sediment toxicity data are compared to reference toxicity data collected and analyzed within the same time frame (similar to sediment control data). This is because temporal variations in reference sediment toxicity may occur if bay-wide conditions or test organisms are stressed. Under changing conditions it is important to quantify the background or residual toxicity of uncontaminated reference sites for comparison and subsequent determination of toxic hot spots.

Confounding Factors. Factors other than anthropogenic contaminants can control or contribute to toxicity expressed in a sediment bioassay. These factors obscure or interfere with the relationship between chemicals of concern and the observed toxic effect and are commonly referred to as "confounding factors". Confounding factors known to influence benthic infauna toxicity, include porewater quality, temperature, salinity, sensitivity and health of test organisms, and sediment physical characteristics. Some of the most prominent confounding factors are non-persistent chemicals such as ammonia, hydrogen sulfide, or salinity, and persistent sediment features such as total organic carbon (quantity and quality), grain size, sediment grain angularity, and water content and cohesiveness of sediment. Sensitivity of tested populations to these factors cannot be overstated, especially when evaluating studies across seasons. Laboratory quality control measures are intended to reduce effects from confounding factors; however, they are often difficult to measure and impossible to control. Not controlling or accounting for confounding factors during testing can produce effects that are not related to the chemicals of concern, leading to misinterpretation of sediment quality.

Four specific types of possible confounding factors were identified from the analysis of BPTCP toxicity test data: elevated levels of ammonia (NH_3) and hydrogen sulfide (H_2S), low dissolved oxygen concentrations and increased test organism sensitivity due to acclimation and holding time. Ammonia and hydrogen sulfide were "quantified to assist in the interpretation of biological analyses" in the BPTCP studies, but no attempt was made to control test concentrations. These chemicals, most often attributed to the bacterial degradation of organic compounds, occur naturally in marine and estuarine sediments. Sediments associated with quiescent, low energy environments, like those found in the upper ends of Islais and Mission Creeks, are often found to contain toxic levels of ammonia and hydrogen sulfide in the complete absence of other contaminants. Depressed dissolved oxygen concentrations are generally associated with organically enriched (high TOC) sediments and high levels of bacterial/biological activity. The San Francisco Dredge Materials Management Organization (DMMO) acknowledges the importance of these confounding factors and their influence on toxicity test results and in concordance with EPA Region IX, reccomends a modification to standard static amphipod toxicity testing protocols. This important, often necessary, modification permits the sequential replacement of water overlying the tested sediments prior to the introduction of test organisms. During this procedure, overlying water is removed (approximately 80%), tested for ammonia and hydrogen sulfide, and replaced with clear fresh seawater adjusted to specified test conditions (e.g., temperature, salinity). If ammonia and hydrogen

sulfide levels are found to exceed threshold limits for a specific test organism, sediments can be equilibrated for approximately four hours followed by water replacement. This sequence is repeated until ammonia and hydrogen sulfide levels are below threshold limits. Admittedly, the replacement of overlying water also has the potential of removing chemicals of concern, but this removal is considered inconsequential since *in situ* sediments are in a continuous state of water replacement. Overlying water replacements were not performed during BPTCP amphipod testing, thus high levels of ammonia and hydrogen sulfide, and low dissolved oxygen levels could have contributed to observed toxic responses.

Recent investigations (Battelle 1999) have shown a negative relationship between toxic response and acclimation/holding time for *Eohaustorius estuarius*. Amphipods that were rapidly acclimated to test salinity conditions (rate greater than 5 parts per thousand [‰] per day) and held for less than 48-hours post acclimation had higher toxicity and inter-replicate variation than amphipods more slowly acclimated and held 48-hours or more prior to testing. Longer combined acclimation/holding times (up to 11 days) seemed to produce healthier, less stressed test organisms. *Eohaustorius estuarius* used in the BPTCP studies were collected in the very low salinity waters (~2 ‰) of Yaquina Bay, Oregon and acclimated to a salinity of 20 ‰. Once acclimated, the amphipods were held for an additional 48 hours prior to test initiation. If the salinity acclimation rate used in the BPTCP studies (rate was not defined) was greater than 5 ‰ per day, organism response (toxicity) could have been confounded by this additional stress.

High levels of hydrogen sulfide, high ammonia, low dissolved oxygen levels and possible short acclimation periods, all known factors that confound the interpretation of toxicity test results, combine and bring into question the conclusions drawn by the BPTCP for Islais and Mission Creeks.

1.3.1.2 Chemical Criteria

The BPTCP adopted chemical guidelines based upon a summary evaluation of 89 studies detailing synoptically collected chemistry and toxicity data from North American coastal estuarine and marine sediments. Results of these studies, which assessed data from more than 1000 samples tested nationwide, were published by Long et al. (1995), providing chemical concentration guidelines that have been embraced as an interpretive tool by regulatory agencies. The guidelines are presented as effects range-low (ERL) and effects range-median (ERM) concentrations for individual and summary (e.g., total PCBs) compounds. Generally, adverse effects were noted in less than 10% of studies in which chemical concentrations were below the ERL guideline. The ERM represents concentrations at the middle of the observed effect range, above which significant toxic effects were observed in more than half of the tests. ERM chemical concentration guidelines from Long et al. (1995) are presented in Appendix C. The BPTCP adopted these guidelines for interpretation of San Francisco conditions, with the exception of a higher DDT criterion, which was derived from local studies in San Francisco Bay (RWQCB 1994) and normalized to organic carbon content following a method from Schwartz et al. (1994).

In recognition of compounded and synergistic effects from sediment co-occurrence of multiple contaminants, Long et al. (1998) presented the additional concept of an ERM quotient for interpretation of sediment toxicity test results. For any suite of sediment chemicals with potential contaminant effects, individual concentrations are divided by the ERM value, producing a corresponding ERM quotient.

These quotients are then totaled and divided by the number of compounds analyzed to give a mean ERM quotient. Relative to controls, Long et al. (1998) found that 71% of amphipod tests indicated a highly toxic response when mean ERM quotients exceeded 1.0, and a 32% incidence within the mean ERM quotient range of 0.11 to 1.0, also noting that the probability of significant toxicity generally increased with increasing numbers of chemicals that exceeded their ERMs. The BPTCP adopted a more conservative guideline of 0.5 for the mean ERM quotient, where exceedance of this value was used as an indication of "contributing chemical contamination."

As a caveat to the wide ranging toxicity results observed nationwide in contaminated sediments, Long et al. (1998) states that sediment quality guidelines were prepared as "...informal (non-regulatory) benchmarks to aid in the interpretation of sediment chemistry data." It was emphasized that sediment quality ERL and ERM guidelines are non-existent for many of the chemicals measured in test sediments, and toxicity test results may be complicated by the presence of high concentrations of ammonia and hydrogen sulfide that can co-vary with anthropogenic substances and contribute to observed toxicity. These compounds are organic breakdown products, occurring both naturally and from anthropogenic activities that result in organic loading of sediments (e.g., domestic sewage discharges).

BPTCP procedures for identification of toxic hot spots have adopted this caveat, utilizing chemistry data only in a supportive context to accompany candidate toxic hot spot designations that are primarily based upon observed recurrent biological impact (i.e., toxicity or impaired benthic community). BPTCP site designations in San Francisco Bay have emphasized the number of chemical concentrations that exceed ERM guidelines, the factor by which they are exceeded, and the ERM quotients. The mean ERM quotient utilized by the San Francisco BPTCP was calculated using ERM quotients of 16 individual and summary chemicals, including nine metals and seven organic compound categories (Fairey et al. 1996). Individual compounds, for each of the following two group categories are summarized in Appendix C.

1. Metals: antimony, arsenic, cadmium, chromium, copper, lead, mercury, silver and zinc.
2. Organic compounds: total DDT, total Chlordane, Dieldrin, Endrin, total PCBs, low molecular weight polycyclic aromatic hydrocarbons (LMW PAH) and high molecular weight PAH (HMW PAH).

BPTCP standards for San Francisco Bay (Hunt et al. 1998a) designated sites as having elevated sediment chemical concentrations if any of the following conditions were present:

1. the mean ERM quotient exceeded 0.5,
2. six or more chemicals were present at concentrations exceeding ERM values, and
3. one or more chemicals were present at concentrations that are known to show a likely association with biological effects, based upon existing literature or best professional judgement.

Application of ERM Quotients. The source of ERM values used to calculate each one of the 16 ERM quotients was cited from Long et al. (1995) by the BPTCP. ERM values for chlorinated pesticides used by the BPTCP were actually taken from Long and Morgan (1990). These guidelines were considered inappropriate and subsequently dropped from Long's 1995 listing, except for DDT, which had a different ERM in 1995. The compounds were dropped because of insufficient data, which produced extremely low

confidence in corresponding ERM values, especially for total Chlordane (E. Long, email communication).

Additionally, several individual ERM quotients were calculated incorrectly in the BPTCP, thereby overestimating the level of chemical contamination at potential toxic hot spot sites, including the creeks. Low and high molecular weight PAH concentrations were calculated using 12 compounds each instead of seven and six, respectively, as dictated by Long et al. (1995). BPTCP ERM quotients for low and high molecular weight PAH were both overestimated by an approximate factor of two (since compounds in each group nearly always co-occur). This error caused the BPTCP to incorrectly conclude that PAHs were responsible for "contributing chemical contamination" to observed toxicity using their own definition.

ERM standards are based on data collected nationwide and, therefore, do not necessarily provide the best estimates of threshold concentrations "known to cause toxicity" in San Francisco Bay sediments. For example, nickel has significantly higher background concentrations in San Francisco Bay than its corresponding ERM value; however, it is rarely associated with toxicity as recognized by the BPTCP and others. This condition exists for other substances and warrants determination of ERM values specific to sediments in San Francisco Bay or a different approach altogether to designate sites as chemically elevated (e.g., reference envelope approach).

Organic carbon and sediment quality guidelines. The ERM is an effects-based guideline for sediment dry-weight chemical concentrations, which does not account for common factors known to influence contaminant bioavailability and toxicity. Therefore, many sediments with contaminant concentrations much higher than the ERM(s) show no toxic effect when tested. Grain size characteristics, total organic carbon (TOC) content and acid-volatile sulfide (AVS) concentration are known to have a significant influence on sediment contaminant concentrations and associated toxicity (Di Toro 1990, 1991; Lamberson et al. 1992). Sediment contaminants are frequently associated with low-energy (depositional) environments (such as the two creeks) where fine-grained particles accumulate and organic carbon content is often enriched. These environments also are potential repositories for contaminants transported from distant sources via aerial fallout and/or bay hydrodynamics. ERMs, which are based on an average concentration of 1.2% TOC, do not address contaminant bioavailability of these sediments, which include the TOC-enriched sediments often encountered along the San Francisco Bay waterfront.

Since sediment pore-water provides the main route of toxic exposure for many organisms (USEPA 1999), the equilibrium partitioning between the soluble porewater-phase and the relatively unavailable phases associated with organic carbon are critical factors. For nonionic organic compounds (e.g., chlorinated pesticides, PAH, PCB) that have a strong binding affinity for organic carbon, higher TOC portends a reduced level of bioavailability. This equilibrium partitioning approach was first adopted by the EPA in 1996 (EPA 1996 draft), dropped, and then revised in 1999 (EPA 1999) to normalize nonionic organic chemical sediment concentrations to organic carbon content. Application of these guidelines to individual PAH compounds would triple the threshold criteria for sediments with an average TOC concentration of 3%, such as those located in the west end of Islais and Mission Creeks. Total DDT was the only BPTCP "chemical" with a sediment quality criterion based on TOC concentration (i.e., 100 µg total DDT per gram organic carbon [100 $\mu g \cdot g^{-1}$ OC]) from Schwartz et al. (1994). Use of this criterion

substantially reduces the effective concentration of DDT in sediments with high TOC, such as the creeks. For example, a sediment dry weight concentration of 100 $ng \cdot g^{-1}$ DDT corresponds to an organic carbon normalized concentration of 100 $ng \cdot g^{-1}$ OC DDT for a sample containing 1% TOC. However, the same sediment sample containing 2% TOC (similar to those in the west end of Islais and Mission Creeks) would halve the carbon normalized concentration of DDT (i.e., 50 $ng \cdot g^{-1}$ OC DDT).

In summary, if the BPTCP continues to use ERM quotients to determine the extent of chemical contamination in support of toxic hot spot designation, the analytes used in the quotients must be consistent with those on which they are based (i.e., Long et al. 1995). In addition, they should be internally consistent as well as consistent with national criteria (e.g., USEPA 1993). Consistency as well as scientific defensibility calls for use of criteria based on organic carbon content for all nonionic organic compounds, such as that used for total DDT, especially if these data are used in support of biological impacts, as they are in the BPTCP. Total organic carbon normalized criteria for nonionic chemicals of concern for the subject creeks is discussed further in Section 4.

Recalculation of ERM Quotients. Based on the above discussion, ERM quotients were recalculated for SFPUC 1997 data to assess the current status of chemical contamination of Islais Creek. This was done to confirm or refute BPTCP findings indicating that the subject site is a toxic hot spot, while correcting for errors in the original BPTCP determination. Based on guidelines provided in Long et al. (1995) (except Dieldrin and Endrin, which were based on Long and Morgan [1990] and total DDT based on Schwartz et al. [1994]) and the BPTCP proposed list of contaminants, the mean ERM quotient was recalculated as follows:

Mean ERM quotient = (ArsenicQ + CadmiumQ + ChromiumQ + CopperQ + LeadQ + MercuryQ + SilverQ + ZincQ + Total DDTQ + DieldrinQ + EndrinQ + LMW PAHQ +

HMW PAHQ) /13 (total number of chemical quotients)

where:

LMW PAHQ = (Acenaphthene + Acenaphthylene + Anthracene + Fluorene + C1 Napthalenes (includes all structural isomers) + Naphthalene + Phenanthrene)/3160

HMW PAHQ = (Benz(a)anthracene + Benz(a)pyrene + Chrysene + Dibenzo(a,h)anthracene + Fluoranthene + Pyrene)/9600

3160 = ERM for LMW PAH & 9600=ERM for HMW PAH from Long et al. (1995)

All other quotients are the same as those used in the BPTCP.

The following quotients were not used in the recalculated mean ERM quotient for reasons previously discussed or noted: total Chlordane, antimony (not measured in this study) and total PCB. The recalculated mean ERM quotient is based on a total of 13 compounds compared to the mean BPTCP ERM quotient, which is based on 16 compounds. PCBs and Chlordane, which are generally not toxic to sediment biota, were retained as chemicals of concern in this study and evaluated for their tissue bioaccumulation potential (see Section 7).

1.3.1.3 Benthic Community and Other Guidelines

BPTCP benthic community guidelines were based upon a Relative Benthic Index (RBI), first developed for the San Diego Bay BPTCP report (Fairey et al. 1996), and modified for use in San Francisco Bay. The index involves a number of calculations that compare site conditions to the range of conditions in the bay. The relative abundance of known pollution-tolerant and pollution-intolerant species from the bay are factored into the calculation, as are total community abundance and the abundance and diversity of molluscs and crustaceans, representing major taxonomic groups that are relatively sensitive to pollution (described in Hunt et al. 1998a). The standardization of site conditions to the range of conditions in the bay gives an RBI ranging from 0.00 (most impacted) to 1.00 (least impacted). The BPTCP adopted an RBI value of 0.3 or lower to indicate a degraded benthic community in San Francisco Bay.

Other BPTCP environmental criteria for hot spot designation include standards for tissue bioaccumulation of contaminants (Condition 3) and impairment of biological function as evidenced by altered growth, reproduction or histopathological abnormality (Condition 4). These two conditions were not factors in the toxic hot spot designation of Islais and Mission Creeks (see RWQCB 1998).

Use of benthic community criteria are probably not appropriate for environments such as Islais and Mission Creeks, which may have impaired communities due to physical factors independent of contaminant concentrations. These physical factors include diminished water circulation (low-energy), episodic inputs of fresh water from road runoff and CSOs, and high deposition of detrital material contributing in part to anoxic conditions (e.g., low levels of dissolved oxygen).

Notes

2

2.0 SITE HISTORY

Site descriptions and environmental histories for Islais and Mission Creeks are provided in this section. Existing data from the Bay Protection and Toxic Cleanup Program (BPTCP) along with results from other relevant studies are presented as a precursor to SFPUC's investigations. Site history and setting are reviewed to identify potential contaminant sources at each creek. Site location and the major drainage basin within San Francisco Bay are shown for each creek in Figures 2-1 and 2-2, respectively.

2.1 ISLAIS CREEK

The Islais Creek channel extends approximately one mile in length, running east-west on the San Francisco waterfront, near the foot of Potrero Hill and Caesar Chavez Street (Figure 2-1). The creek has been maintained in its present configuration for more than 100 years. The creek watershed that extended further to the west was land filled prior to the turn of the century. The present Islais Creek drainage basin is pictured in Figure 2-2. The creek channel is presently divided into a western and eastern segment by a narrow 30-m wide constriction underneath the 3rd Street Bridge (Figure 3-1, Section 3). The western channel, representing about one-third of the creek length, ranges from 75-90 m in width. The eastern segment expands to widths of 120-150 m. Channel depths range from approximately 2-11 m. Representative BPTCP sampling of three stations in 1994 and 1997 recorded depths ranging from 2-3 m.

A general description of Islais Creek provided by the RWQCB (1998) portrays the creek banks as being lined with concrete riprap, interspersed with small isolated patches of vegetation. Old pier pilings are common along the south shore of the western segment and much of the eastern segment lies underneath pier structures. These creosote-soaked wooden pilings may provide continuing sources of polycyclic aromatic hydrocarbons (PAH) to creek sediments. Areas adjacent to the creek are characterized by light industrial and urban development, including a sand and gravel facility, grain terminal, oil and grease rendering facility, warehouse and container cargo terminal along shore areas of the eastern segment, and auto wreckers, scrap metal recyclers and warehouses along the western segment. Freeway Interstate 280 passes directly over the upper end of the creek (Figure 3-1, Section 3). These surrounding activities may be pollutant sources to the creek from runoff and deposition from air emissions. The RWQCB considered them minor sources compared to contributions from combined sewer overflows (CSOs) and the Quint Street wastewater outfall (RWQCB 1998).

2.1.1 CSOs and the Quint Street Outfall

Five CSO discharges, including the main CSO Weir, enter into Islais Creek. Combined sewer overflow pairs are located on opposite sides of the creek at 3rd Street at the western (upper) end near Shelby and Marin Streets. A main CSO weir, constructed in 1997, is located on the north shore and extends from Indiana Street to about a block west of 3rd Street. Discharges consist of domestic and industrial wastewater and stormwater runoff. They enter into the western segment of Islais Creek during periods of wet-weather flow when the Southeast Water Pollutions Control Plant (SEWPCP) exceeds its treatment capacity. The SEWPCP discharges secondarily treated sewage into the bay, approximately 250 m offshore of Pier 80 at a depth of 12.5 m (40 feet), extending offshore about 70 m upcoast of the Islais Creek entrance into the bay (Figure 3-1, Section 3).

Table 2-1. Islais Creek sediment toxicity and chemistry results from 1994 and 1997 BPTCP studies.

Station No./ID	Site Description	Date Sampled	Percent Fines[1]	Percent TOC[2]	Amphipod[3] % Survival	Urchin[4] Porewater % devel.	Urchin[5] SWI % devel.	ERM Quotient	Chemicals Exceeding ERM
20011/1411	Islais Creek	9/94	87.7	4.32	57[6]	0[6,7]	0[6,7]	na	na
20011/1735	Islais Creek	4/97	38.7	3.99	0[6]	8[6,7]	8[6,7]	1.18	Chlordane[8], Dieldrin PCBs[8], LMW PAH
21303/1736	Islais Creek mid-gradient	4/97	100	2.68	81	na	45[6]	0.60	Mercury, Chlordane, ppDDE, PCBs
21304/1737	Islais Creek end-gradient	4/97	100	2.99	49	na	76[6]	0.62	Mercury, Nickel Chlordane, PCBs

[1]fines = % (dry weight) of sediments smaller than 63 microns.
[2]TOC = total organic carbon, % sediment dry weight.
[3]Amphipod test organism = *Eohaustorius estuarius*
[4]Mean percent normal development of sea urchin larvae (*Strongylocentrotus purpuratus)* in 100% sediment porewater.
[5]Mean percent normal development of sea urchin larvae (*Strongylocentrotus purpuratus)* at the sediment water interface (SWI).
[6]Hydrogen sulfide concentrations exceeded known threshold toxicity levels reported by Knezovich et al.(1996) for amphipod (0.114 mg/L) and urchin development (0.0076 mg/L); lowest observed effects concentrations (LOEC).
[7]Unionized ammonia concentrations exceeded known threshold toxicity level reported by Knezovich et al. (1996) for amphipod (0.8 mg/L), lowest observed effects concentration (LOEC).
[8]more than 5 times guideline ERM value.

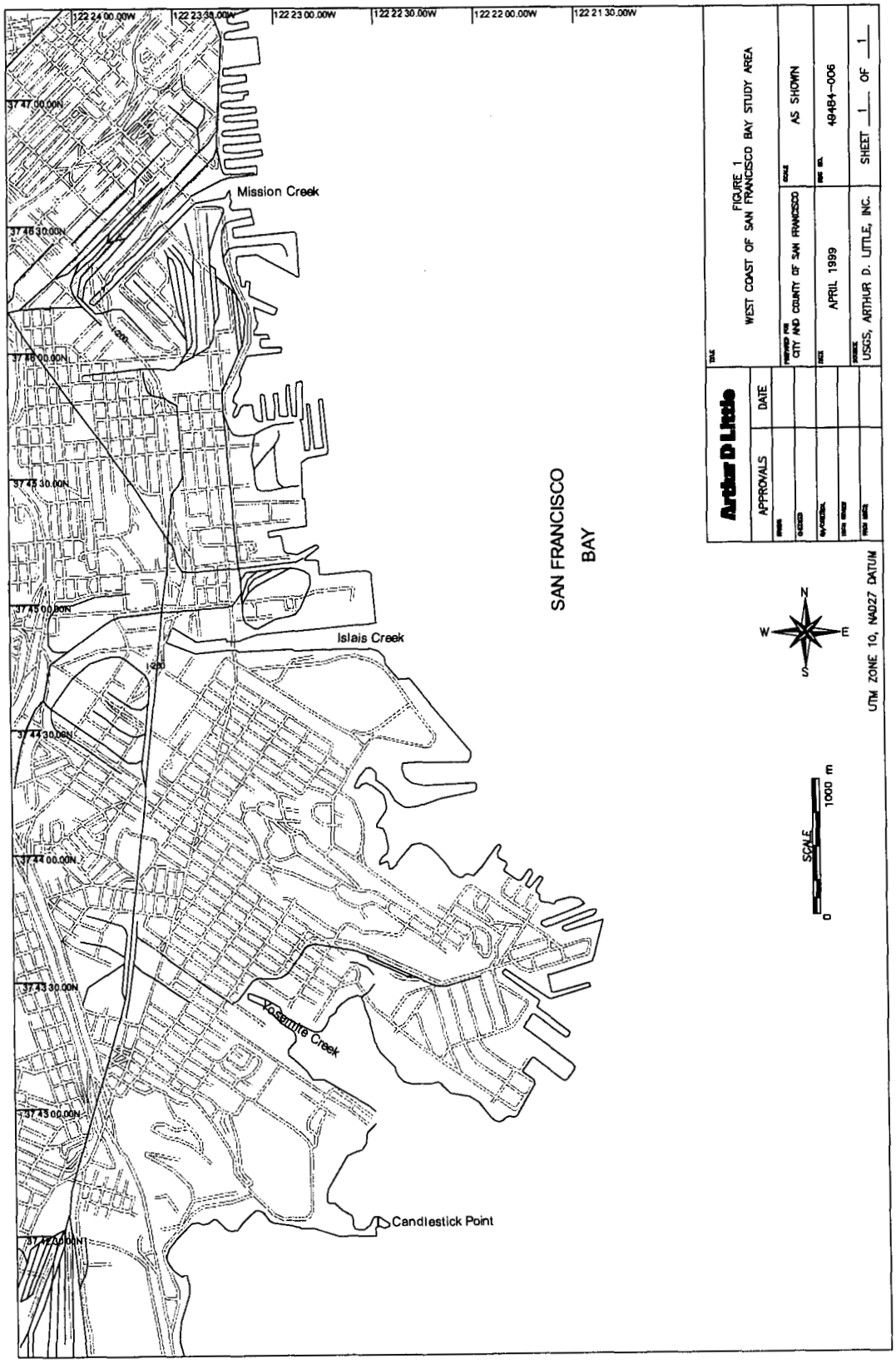

Figure 2-1. San Francisco Bay study area.

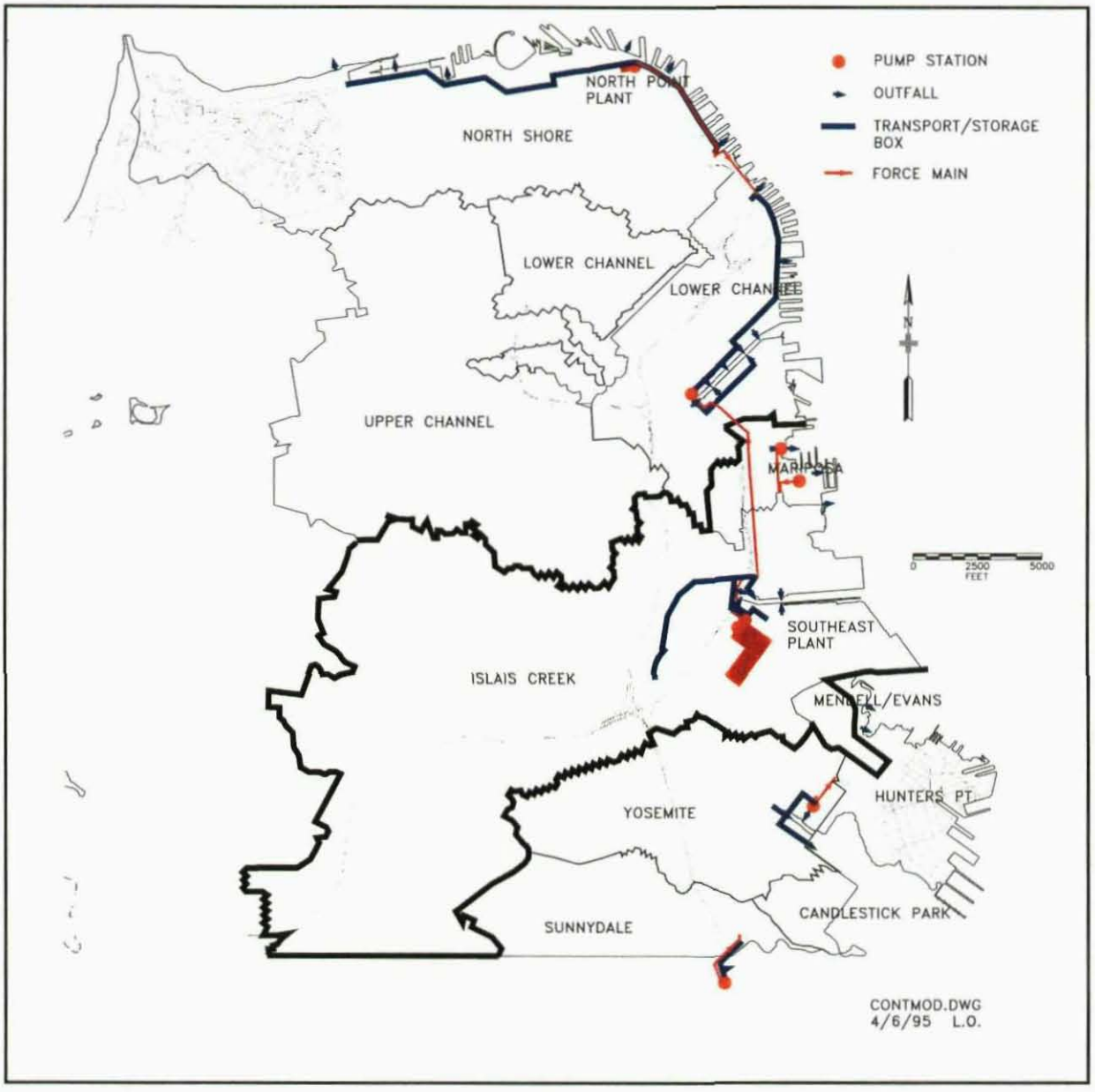

Figure 2-2. Major drainage basin for Islais and Mission Creeks.

2.2 MISSION CREEK

Mission Creek extends 1.2 km from its upper end, entering into the bay on the eastern San Francisco waterfront (Figure 2-1). The creek has been maintained in its present configuration for more than 100 years. Landfill of the watershed that extended further to the west took place prior to the turn of the century. The present Mission Creek drainage basin is pictured in Figure 2-2. Most creek sections are 10-60 m wide, with narrowing at the two bridges at 3rd and 4th Streets. Interstate 280 passes over the creek between 6th and 7th Streets.

A description of the present creek environment and surroundings provided by the Regional Board (RWQCB 1998), characterized the creek as follows: "...Concrete riprap and isolated vegetation line the creek banks." Houseboats with year-round residents are docked at the Mission Creek Harbor located between 5th and 6th Streets on the south shore. Light industrial and urban development surrounds the creek. Demolition debris is evident along the north shore at 2nd Street in China Basin. New retail development is planned for this area. On the south shore there are warehouse facilities, a sand-and-gravel operation near the creek mouth and a golf driving range near 6th Street.

During wet-weather storm periods, seven CSOs potentially discharge sanitary sewage water, industrial wastewater and storm water runoff into the creek. Discharge points range from 3rd Street to the upper end near 7th Street (Figure 3-2, Section 3). Two CSO pairs are located at 4th and 6th Streets, discharging at opposite shorelines. The remaining three CSOs at 3rd, 5th and 7th Streets discharge from the northern shoreline. The upper end CSO near 7th Street, often referred to as the Division Street overflow structure, is the major source of discharge, accounting for approximately 95% of the stormwater overflow entering the creek (RWQCB 1998). The construction of storage facilities in 1983 made it possible to treat storm water overflow to primary standards, removing significant amounts of wastewater settleable and floatable solids. These sewer storage boxes have acted to restrict ground water flow into the creek channel. These collection facilities are perpendicular to the groundwater flow direction, extending to a depth of nearly 6 m (20 feet) below ground surface along the length of the creek, collecting combined sewer and runoff overflows and acting as a barrier to groundwater seepage.

There are several historical sources of chemicals into soil and groundwater surrounding Mission Creek channel (Figure 2-3). ENVIRON (1998) tested soils and groundwater from a 238-acre area adjacent to the south shoreline of the creek. Groundwater was reported at 1.2-3 m below surface with seepage flow directed toward the creek channel. Tidal fluctuations influenced water levels in groundwater wells, indicating exchange with surrounding marine waters. Soils were found to contain trace levels of a few pesticides, volatile organic compounds, PAHs and other various organic chemicals, metals, asbestos and petroleum hydrocarbons. Sources include landfills from the early 1900s, spills and leaks from underground storage tanks, and releases from numerous industrial operations, including bulk oil storage, pipelines and transfer facilities. These all represent potential sources of contamination to the creek environment through seepage and runoff.

2.2.1 Historical Data

A 1979 study conducted by CH2MHill (1979) indicated elevated chemical concentrations and degraded benthic community conditions from sediments collected 20 m upstream of 6th Street. ERM guideline concentrations for copper, lead, mercury and nickel were exceeded and the RBI was zero, indicating a complete absence of benthic infaunal organisms.

Historical data were cited by the BPTCP as supportive of the 1998 candidate toxic hot spot designation. However, BPTCP 1994 screening and confirmation studies in 1995 and 1997 relied on data from only two locations to form the sole evidentiary basis for Mission Creek candidate toxic hot spot designation, as discussed below.

2.2.2 Mission Creek Toxic Hot Spot Designation

The upper end of Mission Creek in the vicinity of 6th Street was designated as a candidate toxic hot spot by RWQCB (1998) due to impacts upon aquatic life resulting from contaminated sediment, meeting the criteria prescribed in Condition 2 of the California Water Code candidate toxic hot spot definition (SWRCB 1998).

BPTCP data showed recurrent toxicity in both amphipod and sea urchin development tests at Station 21030 from the study in May 1995 and follow-up in April 1997 (Table 2-2). Amphipod survival was 5% and 19% for the two studies, respectively. Sea urchin development was completely unsuccessful in May 1995 porewater tests (0%) and 11% in the 1997 follow-up sediment-water interface exposure. Test sediments from Station 21030 had high levels of hydrogen sulfide and unionized ammonia that may have contributed to the toxic response since they exceeded toxicity threshold levels for these organisms reported by Knezovich et al. (1996) and EPA (1995). However, the BPTCP conducted a Toxicity Identification Evaluation (TIE) following the initial sampling and found significant toxicity remaining after hydrogen sulfide and ammonia were removed, concluding that residual toxicity had to be due to other chemicals present. The source of the remaining toxicity was not identified (S.R. Hansen & Associates 1996).

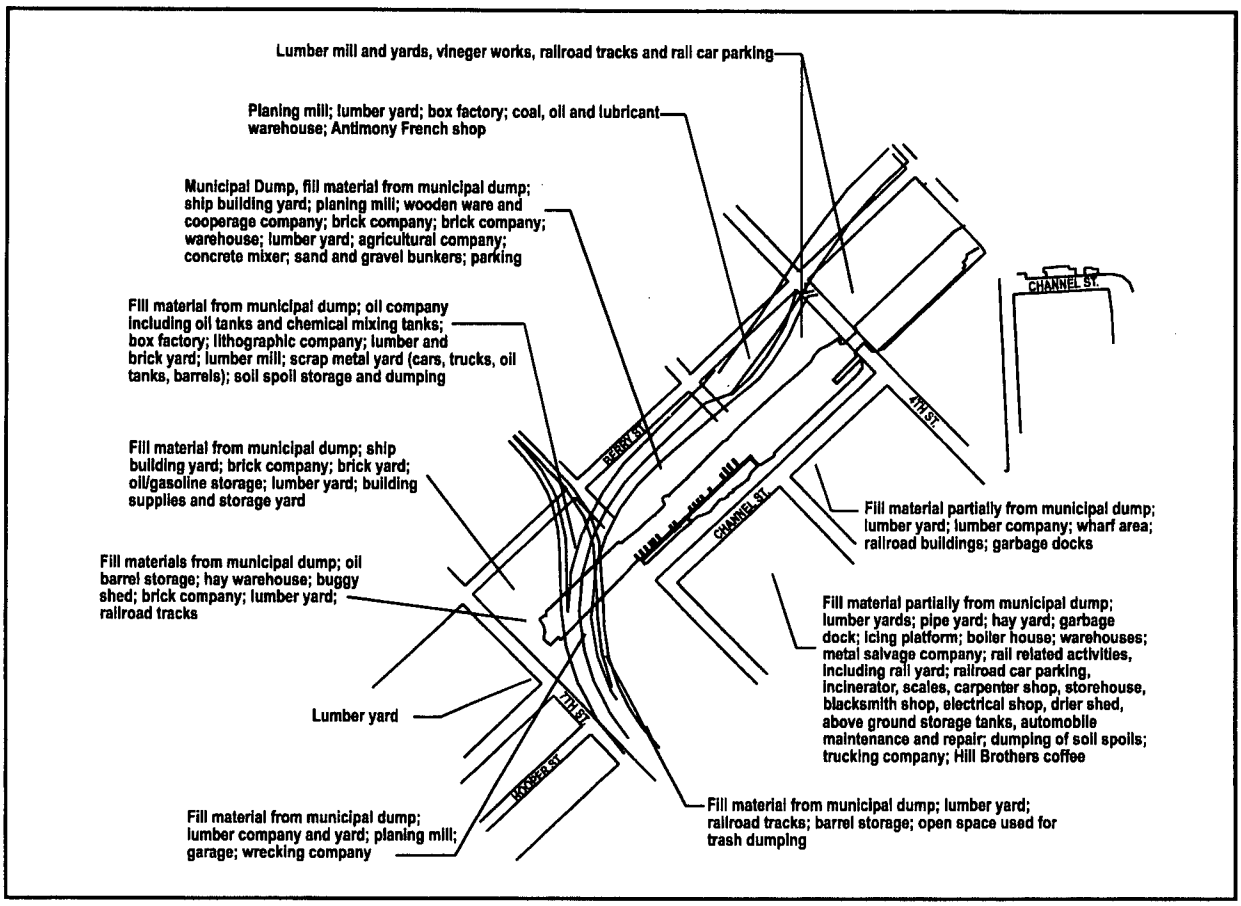

Figure 2-3. Industrial use at Mission Creek.

Table 2-2. Mission Creek BPTCP sediment toxicity and chemistry results.

Station No./ID	Site Description	Date Sampled	Percent Fines[1]	Percent TOC[2]	Amphipod[3] % Survival	Urchin[4] Porewater % devel.	Urchin[5] SWI % devel.	ERM Quotient	Chemicals Exceeding ERM
21030/1507	Mission Creek Site 1 (upper end)	5-2-95	7.22	1.02	5[6]	0[6,7]		0.51	Chromium, Lead, Nickel, Chlordane
21030/1732	Mission Creek Site 1 (upper end)	4-1-97	26.44	2.78	19		11[6]	3.93	Chromium, Copper, Lead[8], Mercury[9], Silver, Zinc, Chlordane[9], dieldrin, PCBs, phenanthrene, lmwPAHs, hmwPAHs
21031/1508	Mission Creek Site 2 (Creek Mouth)	5-1-95	97.72	1.44	83	57[6,7]		0.22	Nickel
21301/1733	Mission Creek Mid-Gradient	4-1-97	100.00	2.71	58		98	1.00	Chlordane[8], PCBs, hmwPAHs
21302/1734	Mission Creek End-Gradient (Near Mouth)	4-1-97	100.00	1.52	80		94	0.28	none

[1]fines = % (dry weight) of sediments smaller than 63 microns.
[2]TOC = total organic carbon, % sediment dry weight.
[3]Amphipod test organism = Eohaustorius estuarius.
[4]Mean percent normal development of sea urchin larvae (Strongylocentrotus purpuratus) in 100% sediment porewater.
[5]Mean percent normal development of sea urchin larvae (Strongylocentrotus purpuratus) at the sediment water interface (SWI).
[6]Hydrogen sulfide concentrations exceeded known threshold toxicity levels reported by Knezovich et al.(1996) for amphipod (0.114 mg/L) and urchin development (0.0076 mg/L); lowest observed effects concentrations (LOEC).
[7]Unionized ammonia concentrations exceeded known threshold toxicity level reported by Knezovich et al. (1996) for amphipod (0.8 mg/L), lowest observed effects concentration (LOEC), and urchin development (0.07 mg/L) no observed effects concentration (NOEC).
[8]more than 5 times guideline ERM value.
[9]more than 10 times guideline ERM value.

In support of the candidate toxic hot spot designation, BPTCP sediment chemical analyses indicated chemical concentration levels well in excess of ERM guidelines, as indicated in Table 2-2.

The toxicity from BPTCP Station 21030 (Site 1, near 6th Street) was associated with a mean ERM quotient of 0.51 in May 1995 and 3.93 in the follow-up survey. These values exceed the adopted Regional BPTCP threshold standard of 0.5. Organic compounds noted as exceeding ERM thresholds were Chlordane, PCBs, Dieldrin, phenanthrene and both low and high molecular weight PAHs (Table 2-2). Chlordane exceeded the ERM guidelines by more than a factor of ten. Significantly elevated metal concentrations were noted for chromium, lead, mercury, silver and zinc. Mercury exceeded the ERM guideline by more than a factor of 10. The BPTCP benthic community analysis for Station 21030 (upper-end, 6th Street) was zero in the 1997 sampling, associated with a mean ERM quotient of 3.93 (Table 2-2). This was cited as supportive evidence for the hot spot designation (RWQCB 1998).

An ERM quotient of 1.00 was evident in the 1997 confirmation phase from the mid-gradient site (BPTCP Station 21301, near 4th Street). Chlordane, PCBs and low molecular weight PAHs exceeded ERM guidelines. Chlordane exceeded the guideline by a factor of greater than five (Table 2-2). The

trace metal nickel also exceeded the ERM guideline, but as previously discussed, it was excluded from regulatory concern.

The evidence of contaminated sediments in Mission Creek prompted the RWQCB to define a preliminary assessment of actions required to remedy or restore the toxic hot spot to an unpolluted condition. Corrective actions included: 1) a requirement for a site investigation to delineate the horizontal and vertical extent of contamination along the creek, and relationship to CSOs; 2) preparation of a feasibility study for remedial action based upon site investigation findings; 3) implementation of remediation options from the feasibility study; and 4) follow-up monitoring to establish that the site has been cleaned up and remains clean.

Notes

3

3.0 DECISION RULES, STUDY DESIGN AND METHODS

This section presents the decision rules and study design used to achieve program objectives described in Section 1.1. Decision rules were established for the interpretation of sediment chemistry, toxicity and tissue bioaccumulation data collected at each creek. The decision rules were presented in the Sampling and Analysis Plan (SAP) (ADL 1999) submitted to the RWQCB in November 1999. These rules were established since sediment quality criteria are not promulgated for chemicals of potential concern in San Francisco Bay.

The study design describes environmental analyses and corresponding sampling locations used to determine the spatial extent of environmental impact to sediments that have received and continue to receive combined effluent and stormwater discharges from City-operated CSOs (study objectives 3 & 4, Section 1.1). The analytical chemistry program featured ultra-trace measurements of organic and inorganic compounds consistent with methods and analyte lists used in the San Francisco Bay Regional Monitoring Program (RMP) and the Bay Protection and Toxic Cleanup Program (BPTCP). Modifications in BPTCP toxicity test protocols were made to improve data quality and minimize potentially confounding factors following EPA recommendations. Detailed method descriptions of field activities, laboratory and data analyses, including quality control procedures and criteria, are presented in the Sampling and Analysis Plans are included on the CD-ROM accompanying this report.

3.1 DECISION RULES

The question of whether creek sediments are impacted and pose a threat to the ecology of San Francisco Bay relative to reference sediments is answered based on an evaluation of surface sediment chemistry, toxicity and bioaccumulation data. This weight-of-evidence approach extends the toxicity reference envelope, used in the BPTCP, to chemistry and bioaccumulation data. Test results are applied to the decision matrix shown in Table 3-1, which presents specific actions in response to results for each of the three data types, ranging from consideration for remedial or preventative action to no further action at the creeks. Significant impacts that are measured two or more times at any one station are used to confirm findings, following the BPTCP approach for confirmation of toxic hot spots. This approach differs from that used in the BPTCP, in that significant chemical impacts are defined statistically, rather than by exceeding a guideline value (such as an ERM). This approach proved to be more conservative, in that there were no samples that exceeded the ERM value that were not statistically elevated compared to reference concentrations (see Section 6). Bioaccumulation in clam tissue, which was measured in the April 2000 survey only, also is evaluated by comparing chemical tissue concentrations between creek and reference stations. Additionally, biota-sediment accumulation factors (BSAFs) are examined to identify creek sediments with the greatest bioaccumulation potential. This is a reasonable approach, since sediments are assumed to be the primary source of bioaccumulated contaminants.

In brief, chemistry and toxicity results from 1999 and 2000 surveys are compared on a station-by-station basis to an upper 95th-predictive limit calculated using corresponding reference data. Since only one reference station was sampled in 1998, data are evaluated following the approach used in the BPTCP (see Section 1.3), where any creek station with an ERM summary quotient greater than 0.5 and less than 69.5%

(of control) amphipod survival, is considered potentially impacted. Only those stations that are significantly toxic and contaminated in two or more surveys are considered impacted and in need of further action.

Descriptions of data analysis and statistics used to support decisions are presented in the Sampling and Analysis Plan for the study (ADL 1999). Table 3-1 is an abbreviated decision matrix, which presents the most probable data outcomes. Unlikely outcomes that are not shown, such as significant bioaccumulation in the absence of elevated sediment chemistry, are addressed as they occur in Sections 5 through 7.

Table 3-1. Decision rules used to assess environmental impact at each creek.

Chemistry	Toxicity	Bioaccumulation[1]	Action
+	+	-	Consideration for remedial or preventative action; possible studies to determine ecological risk
+	-	-	No remedial action; continued monitoring
+	-	+	Possible studies to determine potential food web effects (ecological risk)
-	+	-	Possible studies to determine cause of toxicity
-	-	-	No further action
+	+	+	Candidate for remedial or preventative action

[1]=performed in April 2000 only; Pluses (+) denote significantly higher values in creek sediments compared to reference sediments for any single test for 2 or more years; Minuses (-) denote no significant differences between creek and reference sediments for 2 or more years.

3.2 STUDY DESIGN

Sediment sampling locations were chosen to measure the vertical and horizontal distribution of sediment chemical contaminants throughout each creek, and toxicity in corresponding surface samples. Locations that provided the basis for the toxic hot spot designation of the western segments of Islais and Mission Creeks (RWQCB 1998) were re-sampled in this program. Station transects in each creek extended perpendicular to shore in the vicinities of active and historical CSOs and storm drain locations (see Figures 3-1 and 3-2). Ecological impact was assessed by comparing creek results for each station to a threshold limit calculated using reference station results for the same survey.

Surface sediment chemistry and toxicity were measured in October 1998, October 1999, and April 2000 at each creek and at selected in-bay reference locations (Figures 3-1 through 3-3). Bioaccumulation tests using the clam, *Macoma nasuta* were conducted in April 2000 only. Tissues were analyzed for COPCs (identified in Section 6) known to biomagnify in the marine food web.

Subsurface sediment cores were collected in October 1998 to a nominal depth of 4 feet below the sediment surface and analyzed for bulk chemistry in 1-ft intervals. Sediments in all surveys were analyzed for 20 trace level polychlorinated biphenyl congeners (PCBs), 17 chlorinated pesticides, 41 polynuclear aromatic hydrocarbons (PAHs) - including alkylated homologs and 12 metals. April 2000 tissue samples were analyzed for mercury, PCBs and chlorinated pesticides. Total and resolved saturated hydrocarbons (SHC), linear alkylbenzenes (LABs) and PCB Aroclors also were measured in the October 1998 survey. Aroclors were measured for comparison with historical data. Saturated hydrocarbons were measured to help determine potential petroleum-related sources of co-occurring PAH. Linear alkylbenzenes were measured as

indicators of sewage-related contamination. These chemical tracers were used as ancillary data to identify potential sources of coexisting contaminants, and were not treated as potential COPCs. In addition, sediment grain size and total organic carbon (TOC) were measured to support interpretation of chemistry and toxicity data.

Acute toxicity was measured in surface sediments using the amphipod crustacean *Eohaustorius estuarius* exposed for 10-days in all three sampling events; however, not all stations sampled in 1998 for chemistry were tested for toxicity (Tables 3-3, 3-4, 3-6 and 3-7). In 1998 field samples were split and sent to SFPUC Oceanside Laboratory and Pacific EcoRisk (PER) for testing. This additional quality control measure was taken because the SFPUC laboratory had not previously conducted the 10-day amphipod test. There were no statistical differences between laboratory mean values reported for any of the 19 samples tested (5 replicates per sample, $p<0.05$). Only SFPUC results are reported for 1998, as the primary purpose of the duplicate analysis was to have backup data (from PER) in the event that SFPUC results did not pass quality control requirements. SFPUC conducted all toxicity tests in the 1999 and 2000 surveys. Conventional sediment parameters were assessed in each test to determine whether observed toxicity was attributable to natural products of organic degradation, such as ammonia and dissolved sulfides. Modifications to the BPTCP toxicity protocol consisted of 1) exchanges of overlying water both before and during (one per day) the test to reduce ammonia, and 2) press sieving of sediments prior to test initiation to remove potential resident predators.

Parameters measured and corresponding laboratories used throughout the program are presented in Table 3-2. Individual analytes and detection limits for each test are presented in Appendices A and B. Detailed method descriptions are presented in corresponding Work Plans or SAPs.

Surface sediment sampling inventories for each creek, detailing number of stations sampled and tests performed, are presented in Tables 3-3 and 3-4. Corresponding reference station information is shown in Table 3-7. Reference station location coordinates are shown in Table 3-6. Location coordinates for all samples collected are included in the project database (provided in Excel on the report CD-ROM). Subsurface core descriptions are presented in Table 3-8 for all three creeks. A description of the sampling design used to collect surface sediment in each creek follows.

Table 3-2. Summary of analytical methods and laboratories used in each survey.

Parameter	Year Studied[1]	Laboratory	Analytical Method
	Sediment Chemistry		
PAHs	1998-2000	ADL	EPA SW-846 8270 modified using SIM
PCB congeners & Pesticides[2]	1998-2000	ADL	EPA SW-846 8082 modified
Saturated Hydrocarbons (SHC)	1998	ADL	EPA SW-846 8015 modified
LAB	1998	ADL	EPA SW-846 8270 modified using SIM
Metals	1998-2000	SFPUC	EPA SW-846 6010 and 7000 series
Total Organic Carbon (TOC)	1998-2000	SFPUC	EPA SW-846 Method 9060
Grain Size	1998-2000	SFPUC	Plumb et al. 1981
	Bioassays		
10-day solid phase amphipod	1998-2000	SFPUC/PER	ASTM E1367-92 modified using EPA/USACE 1999 (PN 99-3)
28-day clam bioaccumulation	2000	EVS	EPA/USACE 1991
	Bioaccumulation in Clam Tissue		
PCB congeners & Pesticides	2000	ADL	EPA SW-846 8082 modified
Mercury	2000	SFPUC/ Battelle	EPA SW-846 7460

[1]1998-2000 = October 1998, October 1999 & April 2000; [2]Aroclors also measured in 1998

3.2.1 Islais Creek – Surface Sediments

Eighteen stations in Islais Creek were sampled in 1998 and six were re-sampled in 1999 and 2000. Stations were sampled in six (1998) and three (1999 & 2000) cross-creek transects, extending from the west-end to the creek mouth (Figure 3-1). Stations located east of the 3rd Street Bridge (i.e., transects 4-6), were found to be unimpacted in 1998 and were not re-sampled in the following surveys. Stations sampled in 1999 and 2000 included all 1998 stations that had less than 68.5% survival in toxicity tests, as well as all stations with ERM quotients greater than 0.5. Sampling parameters are shown for each station for each of the three surveys in Table 3-3.

Table 3-3. Sampling inventory for surface sediments collected at Islais Creek.

Station	Metals	PAH	PCBs & Pesticides[a]	LAB, SHC & Aroclors	Grain Size/TOC	Toxicity
			October 1998			
1C	1	1	1	1	1	
1N	1	1	1	1	1	1
1S	1	1	1	1	1	
2C	1	1	1	1	1	
2N	1	1	1	1	1	1
2S	1	1	1	1	1	
3C	1	1	1	1	1	
3N	3	3	3	3	3	
3S	1	1	1	1	1	1
4C	3	3	3	3	3	
4N	1	1	1	1	1	
4S	1	1	1	1	1	1
5C	1	1	1	1	1	1
5N	1	1	1	1	1	
5S	1	1	1	1	1	
6C	1	1	1	1	1	1
6N	1	1	1	1	1	
6S	1	1	1	1	1	
Total samples in 1998	22	22	22	22	22	6
Total stations in 1998	18	18	18	18	18	6
			Samples Collected October 1999 and April 2000[1]			
1N	1	1	1		1	1
1S	1	1	1		1	1
2N	1	1	1		1	1
2S	1	1	1		1	1
3N	1	1	1		1	1
3S	1	1	1		1	1
Total samples each year	6	6	6	0	6	6
Total stations each year	6	6	6	0	6	6

[1]PCBs, pesticides and mercury were also measured in clam tissue at each station in April 2000

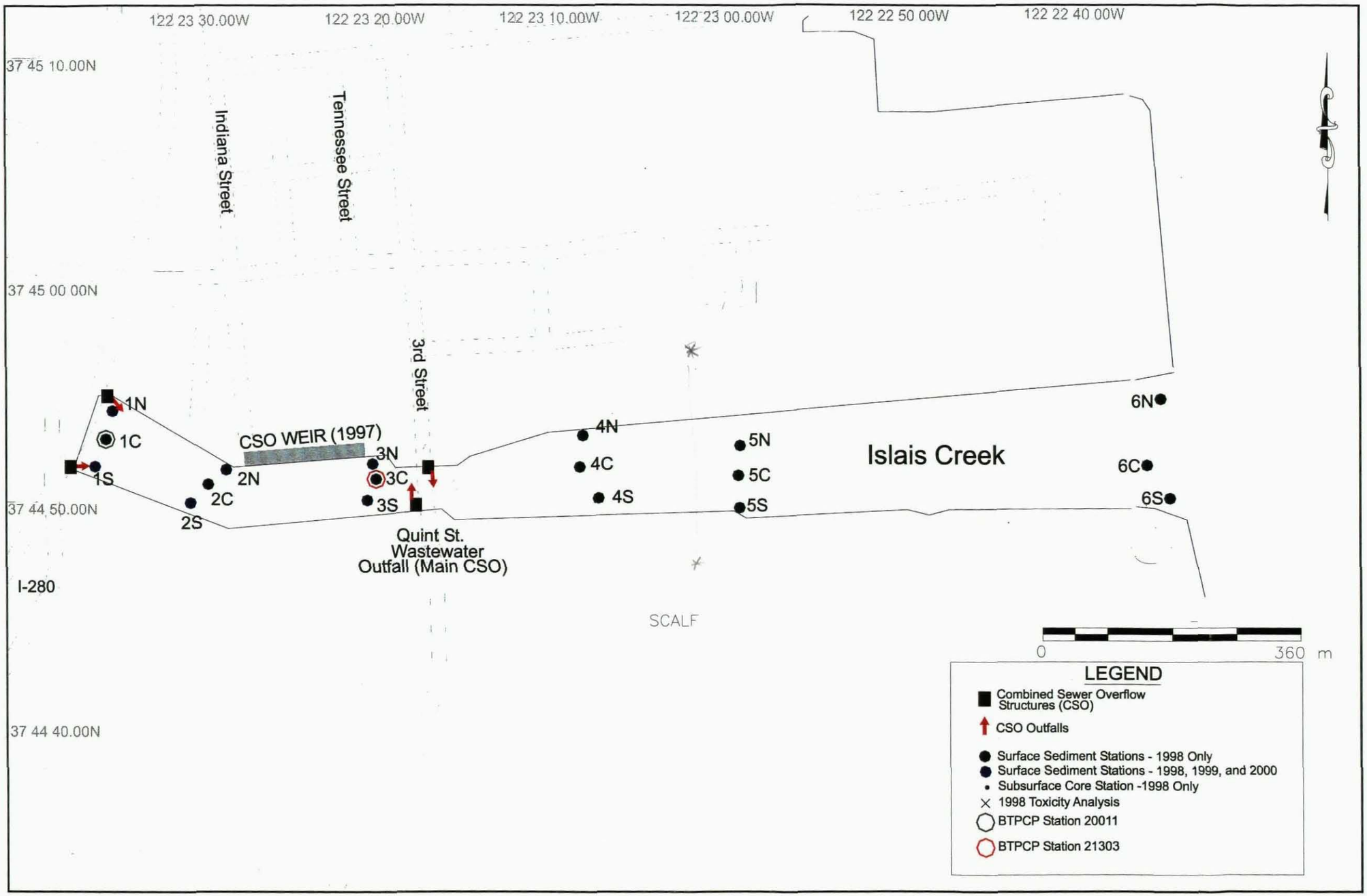

Figure 3-1. Islais Creek Sampling Stations.

3.2.2 Mission Creek

Thirteen stations in Mission Creek were sampled in 1998 and eight were re-sampled in 1999 and 2000 (Figure 3-2). Six stations each from the cross-creek transects, extending from the west end to the creek mouth, were sampled for toxicity. The eight stations re-sampled in 1999 and 2000 extended from the main discharge CSO to the 4th Street intersection. Re-sampled stations included all 1998 stations that had ERM quotients greater than 0.5. There were no 1998 sediments with significant toxicity (i.e., < 69.5% control survival). Sampling parameters are shown for each station for each of the three surveys in Table 3-4.

Table 3-4. Sampling inventory for surface sediments collected at Mission Creek.

Station	Metals	PAH	PCBs & Pesticides	LAB, SHC & Aroclors	Grain Size/TOC	Toxicity
			October 1998			
1N	1	1	1	1	1	1
1S	1	1	1	1	1	
2N	1	1	1	1	1	
2S	1	1	1	1	1	1
3N	1	1	1	1	1	1
3S	1	1	1	1	1	
4N	3	3	3	3	3	
4S	1	1	1	1	1	1
5N	1	1	1	1	1	1
5S	1	1	1	1	1	
6C	1	1	1	1	1	
6N	1	1	1	1	1	1
6S	1	1	1	1	1	
Total Samples	15	15	15	15	15	
Total Stations	13	13	13	13	13	6
			October 1999 and April 2000[1]			
1N	1	1	1		1	1
1S	1	1	1		1	1
2N	1	1	1		1	1
2S	1 (5)[2]	1	1 (5)[2]		1	1
3N	1	1	1		1	1
3S	1	1	1		1	1
4N	1	1	1		1	1
4S	1	1	1		1	1
Total Samples	8 (12)	8	8 (12)	0	8	8
Total Stations	8	8	8	0	8	8

[1]=PCBs, pesticides and mercury were also measured in clam tissue at each station in April 2000 only; [2]=Tissue laboratory replicates used in April 2000 only

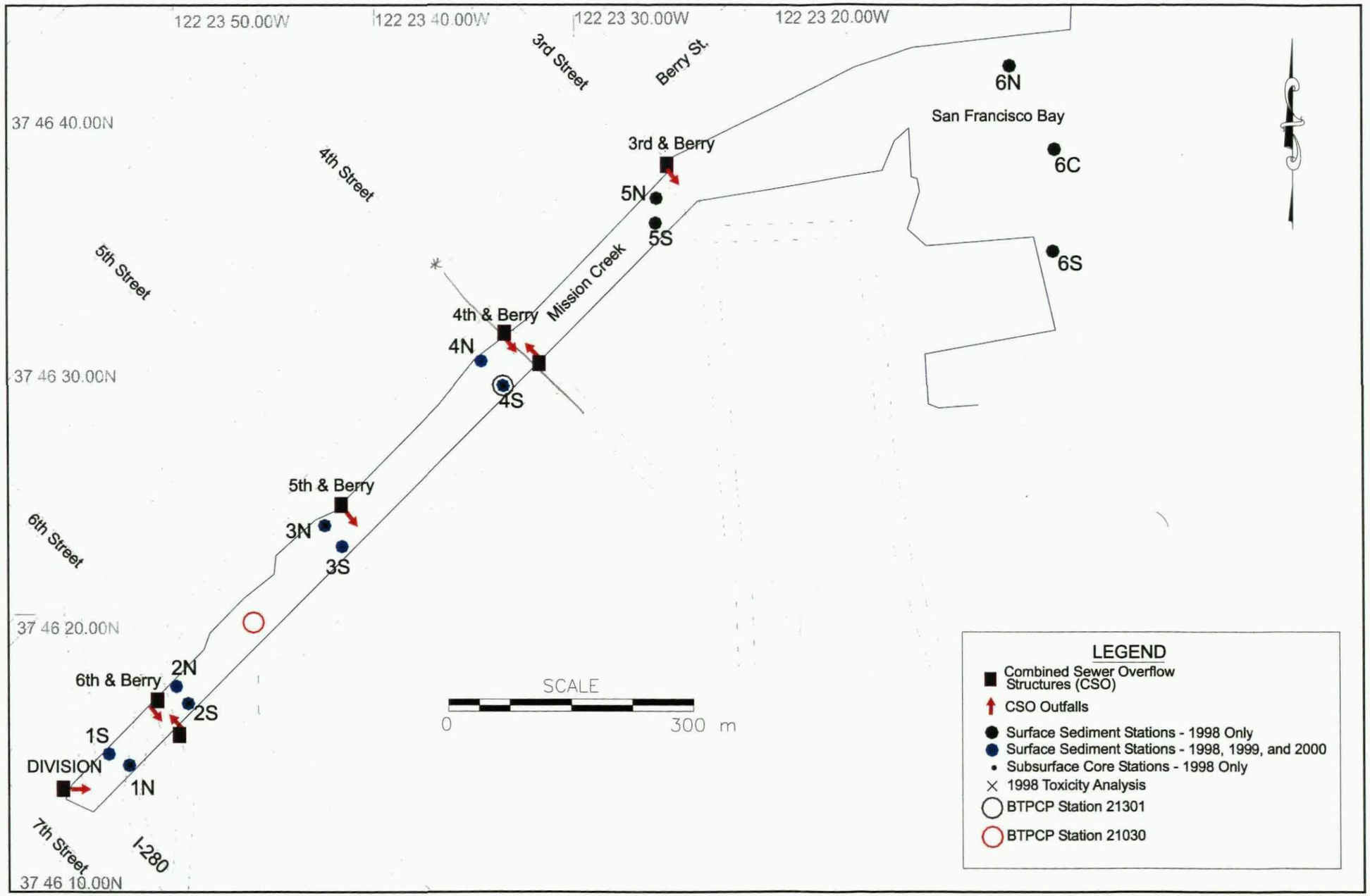

Figure 3-2. Mission Creek Sampling Stations.

3.2.4 Reference Area

A total of six reference stations were sampled throughout the program, although not all stations were sampled each year (see Tables 3-6 & 3-7). These locations, shown in Figure 3-4, extending from the south to north end of San Francisco Bay, consisted primarily of fine-grained sediments (i.e., >80%) with moderate organic carbon content (ca. 1%). Five of the sites were sampled previously in the Regional Monitoring Program (RMP) and/or BPTCP, and used to define the toxicity reference envelope (Hunt et al. 1998a). In the 1999 SFPUC survey, an additional reference station at Tomales Bay, located approximately 20 kilometers northwest of San Francisco Bay was included. This site was evaluated in the BPTCP but not used in the development of toxicity tolerance limits. It was sampled as a potential "fine-grained" reference site that had consistently produced high amphipod survival and low chemical concentrations in numerous dredge material disposal studies. It was not re-sampled in 2000, as the other in-bay reference stations adequately addressed "fine-grained" conditions.

The 1998 SFPUC survey, in contrast to following years, used only one reference station, Paradise Cove. A single reference location was considered adequate to address the initial study objective, which was to "confirm or refute BPTCP findings." Use of BPTCP toxic hot spot criteria eliminated the need for statistical comparisons between creek and in-bay reference sediments. Reference sites were expanded in 1999 and 2000 to provide background data sufficient to calculate corresponding reference envelopes relevant to each survey. This was considered necessary after reduced survival was observed in toxicity tests performed at Paradise Cove in 1998, in the absence of elevated chemical contaminants.

Although unimpacted, the in-bay reference stations are not well matched with the environmental conditions of the creeks under investigation, due to differences in grain size/mineralogy, total organic carbon, hydrodynamics and other conditions (e.g., temperature, depth, salinity). Any of these factors can affect the parameters of interest, potentially confounding interpretation of results. These stations were used because of their established history within the BPTCP and RMP, and the lack of other suitable reference locations that may have better represented creek conditions. Since creek and reference sediments are not well-matched, chemistry results are normalized to minimize effects that may be due to physical characteristics. This is a common approach that is used to correct disparities between test and reference areas that are independent of contaminant inputs. Chemical results were normalized using total organic carbon, since it is known to have a significant influence on sediment contaminant concentrations and associated toxicity (Di Toro 1991; Schwartz et al. 1984).

Table 3-5. Reference Area surface sediment sampling locations.

Location	BPTCP Station ID	Latitude (N)[1]	Longitude (W)[1]	Location Description
Paradise Cove	20005	37° 53' 57.00"	122° 27' 51.60"	Central San Francisco Bay
Tubbs Island	20006	38° 06' 52.20"	122° 25' 09.60"	San Pablo Bay
Island #1	20007	37° 06' 43.20"	122° 19' 42.60"	San Pablo Bay
North Site	20013	37° 34' 13.80"	122° 08' 58.50"	South San Francisco Bay
South Site	20014	37° 32' 10.80"	122° 07' 09.60"	South San Francisco Bay
Marconi Cove	20009	38° 08' 21.60"	122° 52' 27.60"	Tomales Bay

[1]Station coordinates shown in NAD 83 datum

Table 3-6. Sample inventory for surface sediments collected at Reference Area.

Station	Metals	PAH	PCBs & Pesticides	LAB, SHC & Aroclors	Grain Size/TOC	Toxicity
			October 1998			
Paradise	1	1	1	1	1	1
Total Stations	1	1	1	1	1	1
			October 1999			
Island#1	1	1	1		1	1
Marconi Cove	1	1	1		1	1
North Site	1	1	1		1	1
Paradise	1	1	1		1	1
South Site	1	1	1		1	1
Tubbs Island	1	1	1		1	1
Total Stations	6	6	6	0	6	6
			April 2000[1]			
Island#1	1	1	1		1	1
North Site	1	1	1		1	1
Paradise	1	1	1		1	1
South Site	1	1	1		1	1
Tubbs Island	1	1	1		1	1
Total Stations	5	5	5	0	5	5

[1] PCBs, pesticides and mercury were measured in clam tissue in April 2000

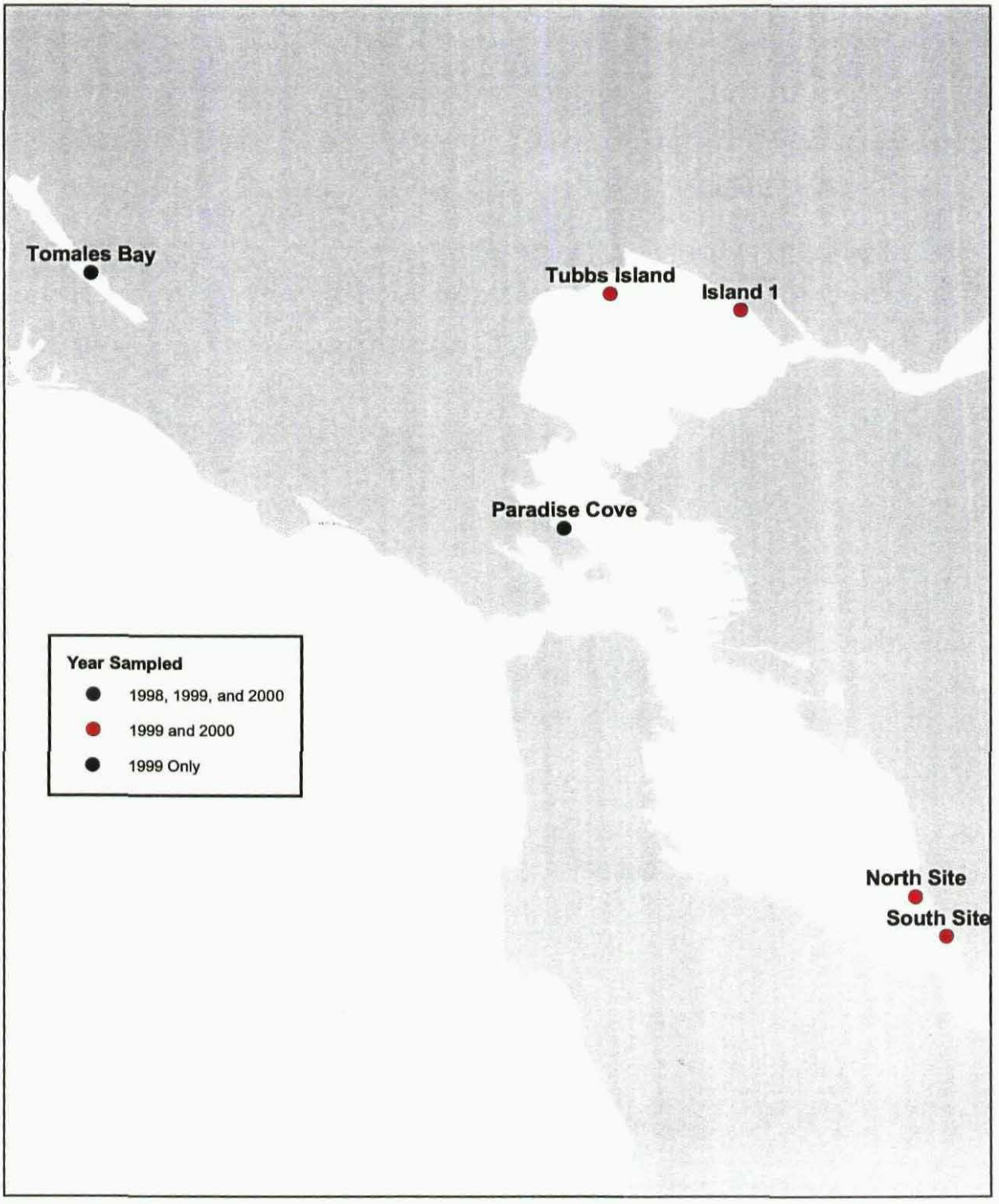

Figure 3-3. San Francisco Bay reference sites.

3.2.5 Subsurface Sediments

Five to six subsurface cores were collected in October 1998 from each creek that penetrated a maximum depth of 4 feet. The top two 1-ft core intervals (i.e., 0-1 and 1-2 ft) were analyzed for bulk chemistry, grain size and total organic carbon. The remaining core intervals (i.e., 2-3 ft and 3-4 ft) were stored frozen until they were analyzed in 1999 for bulk chemistry only. Core locations, which corresponded with surface sediment stations, are shown for each creek in Figures 3-1 through 3-3. Cores were not collected at any of the in-bay reference stations. Subsurface data were collected to determine whether significant vertical contaminant gradients exist in each creek. Gradients are tested using linear regression models for each chemical of concern (see Section 6). Statistically significant results ($p<0.01$) are used to verify that buried sediments are "in-place", and contaminants are not being resuspended or re-released into the bay.

3.2.5 Summary of statistical comparisons between creek and reference stations

Individual comparisons are made for each station within each creek and year sampled using a group tolerance limit, to produce a "reference envelop" for each parameter evaluated. Since this method requires group replicates, only reference data collected in 1999 and 2000 were used. For the 1998 survey, toxicity and chemistry data were compared to the established BPTCP reference envelop toxicity criterion and corresponding ERMs, respectively.

The probit method ($\gamma=0.85$; $\alpha=0.05$ for one-sided test) used in the BPTCP (see Hunt et al. 1998a) was used to calculate the toxicity tolerance limit. A 95th percent one-sided predictive limit ($\alpha=0.05$ for one-sided test) was calculated for chemical parameters measured in reference surface sediments. The predictive interval is a modification of the confidence interval and is used when comparing individual results to grouped data (see Steel and Torrie 1960). Nonparametric tolerance interval bounds were used (Hahn and Meeker 1991) for chemical data that failed test assumptions for the predicative limit (e.g., non-normally distributed data). A lower tolerance limit was calculated for reference survival (to identify stations more toxic than reference); and an upper predictive limit was calculated for reference chemistry (to identify stations more contaminated than reference).

Table 3-7. Sample inventory for subsurface sediments collected in October 1998.

Creek/Station	Core Intervals[1]	Analyses[2]	Comments
		Islais Creek	
1C	1, 2, 3, 4	Grain size, PCB, pesticides, PAH, metals, TOC	
2N	1, 2, 3, 4.	Grain size, PCB, pesticides, PAH, metals, TOC	
3S	1, 2, 3, 4	Grain size, PCB, pesticides, PAH, metals, TOC	
4S	1, 2	Grain size, PCB, pesticides, PAH, metals, TOC	2-3 & 3-4 ft cores collected but not analyzed
5C	1, 2	Grain size, PCB, pesticides, PAH, metals, TOC	"
6C	1, 2	Grain size, PCB, pesticides, PAH, metals, TOC	"
		Mission Creek	
1N	1, 2, 3	Grain size, PCB, pesticides, PAH, metals, TOC	3-4 ft core not collected due to refusal
2S	1, 2, 3, 4	Grain size, PCB, pesticides, PAH, metals, TOC	
3N	1, 2, 3, 4	Grain size, PCB, pesticides, PAH, metals, TOC	
4S	1, 2, 3, 4	Grain size, PCB, pesticides, PAH, metals, TOC	
5N	1, 2	Grain size, PCB, pesticides, PAH, metals, TOC	2-3 & 3-4 ft cores collected but not analyzed
6N	1, 2	Grain size, PCB, pesticides, PAH, metals, TOC	"

[1]=core interval 1=1-2 ft, 2=2-3 ft, 3=3-4 ft, 4=4-5 ft; [2]=Grain size & TOC - measured in 1-2 & 2-3 ft intervals only

3.3 METHODS SUMMARY

Abbreviated field and analytical methods follow. Detailed method descriptions for sample collection, handling, laboratory, data analysis and quality control are presented in the Sampling and Analysis/Quality Assurance Plans for each survey are contained in the CD-ROM accompanying this report.

3.3.1 Field Methods

Surface sediments were collected with a 0.05-m^2 Ponar grab sampler, constructed of stainless steel and coated with Halar to reduce cross-contamination. A sufficient number of grabs (4-5) were collected at each station to ensure adequate sediment for testing. Surface sediment was subsampled from the top 5 cm of each grab and homogenized in a Halar-coated bucket. Subsurface sediments were sampled using a gravity corer with a butyrate liner. The liners were capped and sediments were sub-sectioned into 1-ft intervals and homogenized in SFPUC's Oceanside Laboratory prior to subsampling. Organic chemistry samples were placed in borosilicate glass jars; metal samples were placed in polycarbonate jars and TOC and grain size samples were stored in plastic bags. All samples were stored on ice and transferred within 48 hours from the vessel to SFPUC's Oceanside Laboratory for subsequent shipment or analysis.

3.3.2 Laboratory Methods

All samples were analyzed using standard analytical methods referenced in individual laboratory standard operating procedures (SOPs). Quality control samples for laboratory and field samples were analyzed. Laboratory quality control samples consisted of calibration standards, matrix spikes, duplicate

samples, standard reference materials, surrogates, and laboratory blanks where appropriate. Table 3-8 lists chemistry, toxicity and physical tests, and analytical laboratories for the program.

Table 3-8. Summary of sediment analytical methods and laboratories.

Parameter	Laboratory	Analytical Method
Chemistry		
Polynuclear Aromatic Hydrocarbons (PAH)	ADL	EPA SW-846 8270 modified using SIM
Polychlorinated Biphenyl Congeners (PCBs) & Chlorinated Pesticides	ADL	EPA SW-846 8082 modified for congener analysis
Metals	SFPUC	EPA SW-846 6010 and 7000 series
Total Organic Carbon (TOC)	SFPUC	EPA SW-846 Method 9060
Grain Size	SFPUC	Plumb et al. 1981
Toxicity		
10-day solid phase amphipod	SFPUC[1]	ASTM E1367-92 modified using EPA/USACE 1999 (PN 99-3)

[1]=Pacific EcoRisk Laboratory also analyzed samples in 1998 survey

3.3.2.1 Physical Laboratory Methods

Sediment grain size was analyzed using a sieve and pipette method by SFPUC, which produced results for four grain size classes (gravel, sand, silt and clay). Results reported for 1998 samples only, included mean diameter, percent sediment contribution for each of 16 size classes, Phi sorting coefficient, skewness and kurtosis. Percent gravel, sand, silt and clay only were reported for 1999 and 2000 data. Total organic carbon (TOC) was analyzed by SFPUC using EPA Method SW-846 9060, combustion followed by infrared detection of carbon dioxide, and reported as a percentage of total sediment dry weight.

3.3.2.2 Chemical Laboratory Methods

Sediment hydrocarbon analyses consisting of polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyl (PCB) congeners, and chlorinated pesticides were analyzed by ADL's Environmental Laboratory. Additionally, saturated hydrocarbons (SHC) and linear alkylbenzenes were analyzed for source identification purposes in the 1998 survey only. A total of 41 PAH compounds were measured using gas chromatography with mass spectrometer selected ion monitoring (SIM). PCBs were measured as 22 congeners in all surveys and additionally as Aroclors in 1998 only. Dry weight detection limits for organic analytes were all in the sub-part-per-billion range, ranging from 0.01 $ng \cdot g^{-1}$ for pesticides and PCBs to 0.1 $ng \cdot g^{-1}$ for PAHs.

Table 3-9 shows detection limits and corresponding methods for the 12 heavy or trace metals measured throughout the investigation. Sediment metals were analyzed by SFPUC using nitric acid and hydrochloric acid digestion followed by inductively coupled plasma spectroscopy (ICP), or atomic

absorption with either a flame or graphite furnace detector, except mercury, which was analyzed using atomic absorption following cold vapor extraction.

Table 3-9. Methods and detection limits for metals ($\mu g \cdot g^{-1}$ dry weight).

Metal	Minimum Detection Limit	Analytical Method*
Aluminum (Al)	0.2/0.01	ICP/AAGF
Arsenic (As)	0.5	ICP
Cadmium (Cd)	1.0/0.025	ICP/AAH
Chromium (Cr)	0.1/0.01	ICP/AAGF
Copper (Cu)	0.2	ICP
Iron (Fe)	0.2	ICP
Mercury (Hg)	0.3	ICP
Nickel (Ni)	0.0005	CVAA
Lead (Pb)	0.2	ICP
Selenium (Se)	1.0/0.07	ICP/AAGF
Silver (Ag)	0.025	AAH
Zinc (Zn)	0.1	ICP

AAH = Atomic absorption hydride; ICP= Inductively coupled plasma emission spectroscopy; AAGF= Atomic absorption with graphite furnace; CVAA = Cold vapor atomic absorption

3.3.2.3 Toxicity Laboratory Methods

The acute 10-day amphipod test was performed by SFPUC following ASTM E1367-92 modified following EPA/USACE guidelines in Public Notice 99-3 to remove potential confounding toxicity from elevated levels of ammonia and/or hydrogen sulfide. All test sediments were press-sieved (through 0.5 mm mesh stainless steel screens) and picked to remove possible amphipod predators and native amphipods prior to test initiation. Eighty percent (80%) of overlying water was exchanged and allowed to equilibrate for 24-hours for all sediment samples with ammonia porewater values greater than 20 $mg \cdot L^{-1}$ prior to test initiation. Dissolved oxygen, pH, salinity and temperature were measured and recorded daily. After 10-days of exposure, amphipods were carefully removed by wet-sieving, counted, placed on clean sediment and permitted to rebury. Percent survival and percent reburial were reported for each of the five laboratory replicates run for each sample. The test was considered valid if after ten days of exposure the average control survival was ≥90% and each control replicate had at least 80% survival.

3.3.2.4 Bioaccumulation Laboratory Methods

A 28-day clam bioaccumulation test was undertaken to evaluate the potential for chemical uptake and subsequent food chain transfer. Bioaccumulation of certain organic chemicals and metals is known to occur across trophic levels. The test animal, *Macoma nasuta* is widely distributed and native to San Francisco Bay, commonly used in dredged sediment studies, known to actively ingest surface sediments, and provides enough tissue for trace level tissue analysis. Laboratory bioaccumulation was performed following the EPA/USACE (1991) "Greenbook" protocol, modified to use one laboratory "replicate" instead of five as recommended. One composite sample of 25 clams was analyzed for chemistry at all stations except Station 2N in Mission Creek, to make use of the highly replicated sampling design (i.e., 6 stations in Islais & 8 stations in Mission). Station 2N was tested using the standard five laboratory

replicates as a quality control measure. The reduced number of laboratory replicates for the remaining samples (i.e., n=1 instead of n=5 in EPA/USACE [1991]) was validated, as chemistry results for the five laboratory replicates were extremely consistent (i.e., CV < 20% for all analytes). Laboratory control samples (e.g., zero time) also were analyzed for quality control purposes. Results were reported based on dry weight, wet weight and lipid weight. Only dry weight results are presented in Appendices A3 and B3.

Notes

4

4.0 PHYSICAL CHARACTERISTICS OF SEDIMENT

Grain size and total organic carbon (TOC) results for surface and subsurface sediments are presented in this section. These physical parameters are known to influence contaminant distribution and amphipod toxicity in sediment, and are therefore important in the interpretation of data. Grain size categories are summarized in Table 4-1. Interpretation of results focuses primarily on surface and near-surface sediments due to their influence on resident biota and contaminant bioavailability. For this reason, physical parameters were measured only at the surface and in the top two core intervals (i.e., 0-1 and 1-2 ft). Surface sediment results for each creek and reference area are summarized in Tables 4-2 through 4-3. Surface distributions of percent fines (silt + clay) and TOC are shown in Figures 4-1 through 4-4 for each creek. Surface sediment results are presented in Appendices A1 and B1 for each station. Results for core intervals are presented in Appendices A2 and B2.

Sediment grain size characteristics are emphasized for their controlling influence upon benthic community dynamics, and because they correlate with biologically meaningful variables such as sediment porosity, compaction, oxygen tension, water content and retention of organic matter. Grain size characteristics are equally important in controlling sediment chemical concentrations due to an increase in adsorptive capacity with finer-grained particles. Total organic carbon concentrations provide an indication of the amount of organic matter present in sediment. High organic content is typical of fine-grained sediments from low-energy depositional areas and areas impacted by anthropogenic activities, such as discharges from sewage outfalls. High levels of organic carbon also occur naturally in sediments from detrital inputs from terrestrial and aquatic plants.

Most studies of marine and brackish sediments show a high positive correlation between fine-grained particles and organic carbon. Since contaminants are strongly bound to organic particles that are complexed with fine mineral particles, there is a high potential for contaminant accumulation in habitats where settlement of finer-grained, organically enriched sediment occurs. Deposition, resuspension and sorting processes influenced by the nearshore wave and current regime normally create a gradient of diminishing grain size proceeding offshore. As they are introduced into the coastal system, the smallest particles remain in suspension for longer periods and, following deposition, are more readily re-suspended from the seabed by waves, currents and turbidity flows. Ultimately, fine-grained sediments progress offshore into the deeper stable basins that are the ultimate repositories for contaminants.

4.1 OVERVIEW

Most creek sediments were collected from less than 10 m water depth and consisted of greater than 90% fine-grained material. Predominantly fine-grained sediments were evident in each of the two creeks (see Figures 4-1, 4-3 & 4-5). However, gradients of increasingly fine-grained material with distance from Islais and Mission Creek ends were observed. These trends more than likely occurred because the necessary energy to move fine-grained particles toward the bay was provided from storm-related flow.

A full suite of grain size parameters including mean grain size for 12 classes, Phi sorting coefficient and percent gravel, sand, and fines (silt + clay) were reported for 1998 surface sediment data only. Percent fines and sand were the only grain size metrics reported in 1999 and 2000.

Sediment sorting (expressed as the "mean Phi sorting coefficient" in standard deviation units) influences pore space and water retention in sediment. Poorly sorted sediment (i.e., Phi sorting coefficients >2 standard deviation units) typically has reduced pore space and water retention compared to well-sorted sediment, and is generally more efficient in binding contaminants. Sediments collected in 1998 east of the mid-section of each creek were moderately well sorted (Phi sorting coefficient <1.5), where sediments collected near active CSOs were typically poorly sorted.

Table 4-1. Sediment grain size classes (adapted from Folk 1968).

Grain Diameter (mm)	Size Class	Grain Diameter (mm)	Size Class	Grain Diameter (mm)	Size Class
64	Pebble	0.50	Medium sand	0.031	Medium silt
16		0.42		0.0156	Fine silt
		0.35		0.0078	Very fine silt
		0.30			
4	Granule	0.25	Fine sand	0.0039	Clay
3.36		0.210		0.0020	
2.83		0.177		0.00098	
2.38		0.149		0.00049	
2.00	Very coarse	0.125	Very fine sand	0.00024	
1.68	sand	0.105		0.00012	
1.41		0.088		0.00006	
1.19		0.074			
1.00	Coarse sand	0.0625	Coarse silt		
0.84		0.053			
0.71		0.044			
0.59		0.037			

— denotes criterion (i.e., < 0.0625 mm) for fines (silt + clay)

Percent fines and TOC were not strongly correlated in any of the creek sediments (i.e., $r^2<0.2$). The strong correlation between TOC and percent fines typically observed in marine sediments was undermined primarily because of the high fraction of coarse-grained material (sands) associated with relatively high concentrations of TOC at the end of each creek. Likely sources of course material at both creeks include active CSOs and debris from the Interstate 280 overpass. Concrete debris and large rocks were observed in runoff from Interstate 280 into Mission Creek during the October 1998 field sampling.

4.2 REFERENCE AREA

Most reference area samples had greater than 90% fines (mean=79.2%) that remained consistent across surveys, except for North Site sediments (Figure 3-3, Section 3), which were sandy in 2000 (26.3% fines) yet fine-grained in 1999. South Site sediments were consistently coarser with less than 60% fines in two consecutive samplings. In general, reference site sediments had similar grain size distributions compared to most creek sediments. Only a few sediment samples collected at the end of Islais and

Mission Creeks were consistently coarser-grained than the reference area. Concentrations of total organic carbon in reference sediments ranged from 0.4 to 1.8% (mean=0.9%) for all three sampling events. These concentrations were significantly lower than TOC concentrations measured in most creek sediments, especially those located near active CSOs (which approached 4%). Reference surface sediment results are summarized in Table 4-2. There were no subsurface cores collected at any of the reference sites.

It is important that reference site sediment attributes, such as grain size and organic carbon content, are similar to those found at the creeks. These attributes can affect test results, including toxicity and chemistry, as discussed in Section 1. In particular, grain size and organic carbon affect adsorption and retention of sediment contaminants and their subsequent bioavailability. Many creek sediments had significantly higher concentrations of TOC compared to reference area sediments (see Tables 4-2 through 4-3). In order to "normalize" potential differences in bioavailability, contaminant concentrations are based on grams of organic carbon (OC) instead of grams dry sediment for all comparisons between creek and reference sediments (see Section 6). This approach is consistent with methods used to address varying TOC concentrations in other sediment investigations (Schwartz et al. 1994; MacDonald 2000).

4.3 ISLAIS CREEK

With the exception of sandy sediments that characterized the western end of the creek (Transect 1) (Figure 4-1), both surface and subsurface sediments along the creek length were characterized by fine (silt + clay) fractions exceeding 90% of sediment dry weight. Percent fines were variable in creek surface sediments, ranging from 5.4 to 99.48% (mean=85.8%); however, distribution patterns were consistent between study years (Figure 4-1, Appendix A1). Transect 1 stations, located at the end of the creek near the historical main CSO, were much more variable and had significantly coarser sediments compared to sediments east of the CSO Weir. Percent fines at Station 1S (located at the creek end) ranged from 5.4 to 96.3% fines across sampling events. Subsurface samples collected at Station 1C were notably lower in percent fines, ranging from 38.1% at 1-2 ft interval to 62.2% in the upper segment (0-1 ft). The mean and range of percent fines in creek and reference area surface sediments are shown in Table 4-2 for each year sampled.

Table 4-2. Islais Creek - percent fines and TOC in surface sediments.

Year Sampled	Area Sampled	No. of Stations	Mean % Fines	Range % Fines	Mean % TOC	Range % TOC
1998	Islais Creek	18	87.2	5.4 - 98.9	2.0	1.2 - 4.8
	Reference Sites	1	90.3	90.3 - 90.3	1.2	1.2 - 1.2
1999	Islais Creek	6	87.7	38.1 - 99.4	1.9	1.2 - 2.5
	Reference Sites	6	80.9	30.7 - 99.7	0.9	0.4 - 1.8
2000	Islais Creek	6	79.4	13.2 - 99.1	2.1	1.3 - 4.4
	Reference Sites	5	74.8	26.3 - 97.9	0.9	0.5 - 1.2
All	Islais Creek	30	85.8	5.4 - 99.4	2.0	1.2 - 4.8
	Reference Sites	12	79.2	26.3 - 99.7	0.9	0.4 - 1.8

na=not applicable; *Fines = silt+clay, < 0.063 mm diameter;

Total organic carbon results are summarized in Table 4-2 for creek and reference area surface sediments. Although chemical exchange processes in Islais Creek sediments have not been investigated, high organic content combined with low overlying oxygen levels from limited water circulation may present a reducing environment in creek sediments. As an indication of minimal oxygen tension, sediments collected at the creek end were darkened, suggesting a reducing environment that may be largely responsible for the reduced biological diversity of benthic infauna observed in previous studies (Hunt et al. 1998a).

Concentrations of total organic carbon ranged from 1.2 to 4.8% (mean=2.0%) in creek surface sediments, and from 0.4 to 1.8% (mean=0.9%) in reference sediments for all three sampling events. Total organic carbon concentrations were moderate to high (>1 to ~5%) for sediments collected west of the 3rd Street Bridge, and primarily low (<1%) at stations east of the bridge. However, higher organic carbon concentrations were not always associated with finer-grained sediments.

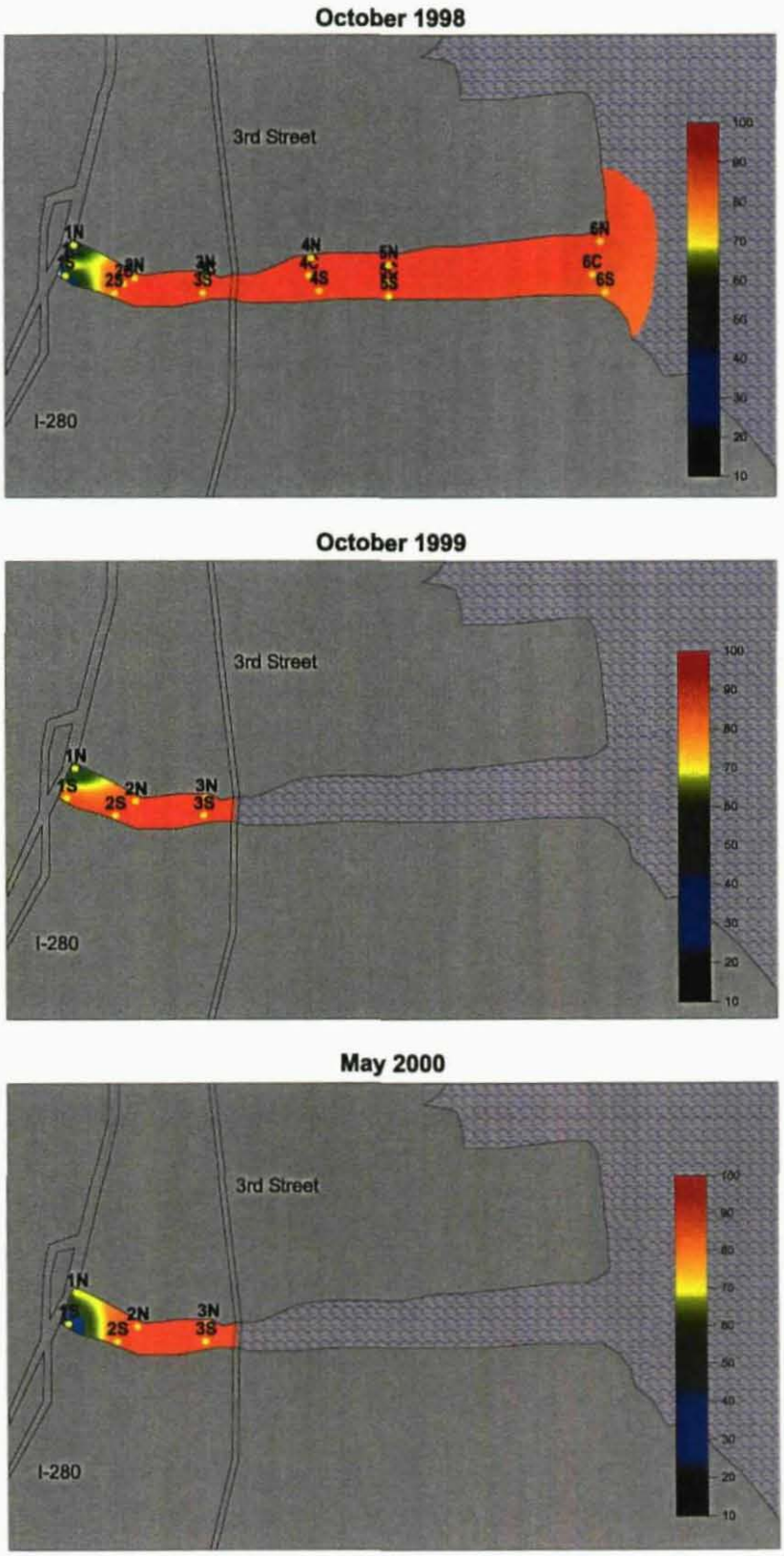

Figure 4-1. Percent fines (silt + clay) in Islais Creek.

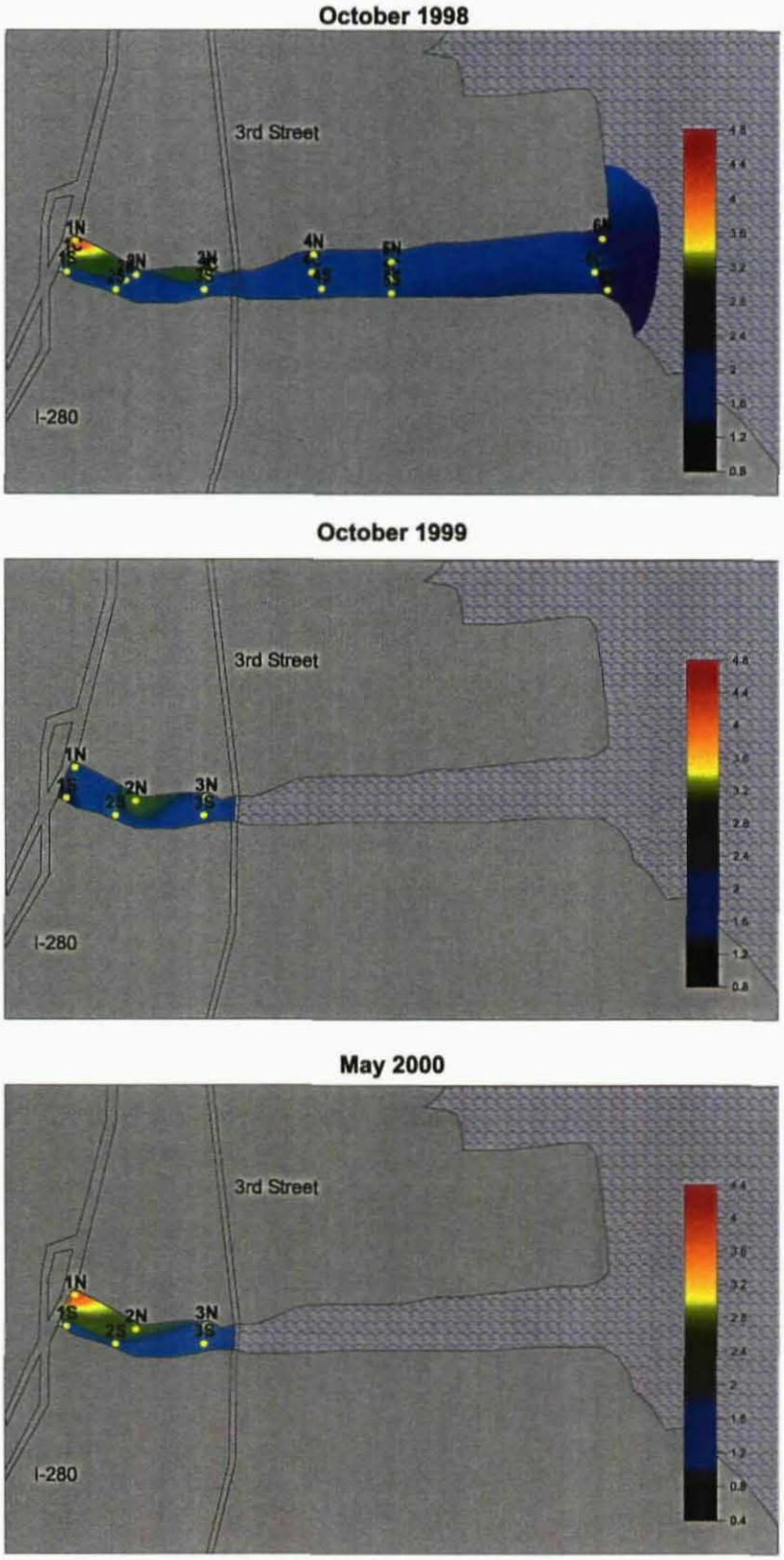

Figure 4-2. Total Organic Carbon (%) in Islais Creek.

4.4 MISSION CREEK

The distribution of fine-grained surface sediments was fairly consistent between sampling events in Mission Creek (Figure 4-3). In the two wet-weather sampling events (1998 & 2000), sands (particles >63μm diameter) dominated the western creek end, grading into fines (particles <63μm) in between 4th and 6th Streets. A similar trend was observed in the 1999 dry season, except that the gradient was comprised of finer-grained particles. Fine fractions at the creek end (Transect 1) ranged from 24-63.6% of sediment dry weight in surface sediments. Extending toward the creek mouth (Transects 2-6), fine fractions exceeded 78% in all surface samples, with most exceeding 90%.

The presence of coarser sediments from the creek-end gradient may be due to the episodic erosion of creek bed sediments near the Division Street overflow at the west end. This CSO accounts for approximately 95% of total overflow volume into the creek (Hunt et al. 1998a). Erosion may also be increased by the narrowing of the creek channel and turbulence created by the disruption of flows in the vicinity of the west end.

Total organic carbon content varied more than grain size between sampling events, with concentrations greater than 4% measured between 6th and 5th Streets (Transects 2-3) in 1998 (Figure 4-4). Sediments collected in 1998 were targeted for the dry season, but were collected during a storm event that produced a significant combined sewer overflow. This area remained elevated in the two following years sampled, with average concentrations of 2.1%, compared to remaining creek areas with about 1% TOC.

Subsurface sediments from the 0-1 ft composite approached 4% at the west end, significantly exceeding levels recorded elsewhere along the creek (Appendix B2). This may represent a past accumulation from the major CSO prior to improved design and reduction in overflows. However, the deeper (1-2 ft) sediments at Station 1N were the lowest amongst the creek stations. Interpretation of subsurface data in relation to surface data is confounded by the fact that samples were taken approximately six weeks apart. Sediments extending out to Transect 5 showed reduced TOC in subsurface sediments; however, concentrations exceeded corresponding surface TOC concentrations.

Table 4-3. Mission Creek - percent fines and TOC in surface sediments.

Year Sampled	Area Sampled	No. of Stations	Mean % Fines	Range % Fines	Mean % TOC	Range % TOC
1998	Mission Creek	13	72.7	24.0 - 98.2	2.7	1.3 - 4.5
1998	Reference	1	90.3	90.3 - 90.3	1.2	1.2 - 1.2
1999	Mission Creek	8	79.8	46.4 - 99.0	1.8	0.8 - 3.2
1999	Reference	6	80.9	30.7 - 99.7	0.9	0.4 - 1.8
2000	Mission Creek	8	63.6	28.8 - 96.8	1.8	1.4 -2.6
2000	Reference	5	74.8	26.3 - 97.9	0.9	0.5 -1.2
All	Mission Creek	29	72.1	24.0 - 99.0	2.2	0.8 - 4.5
All	Reference	12	79.2	26.3 - 99.7	0.9	0.4 - 1.8

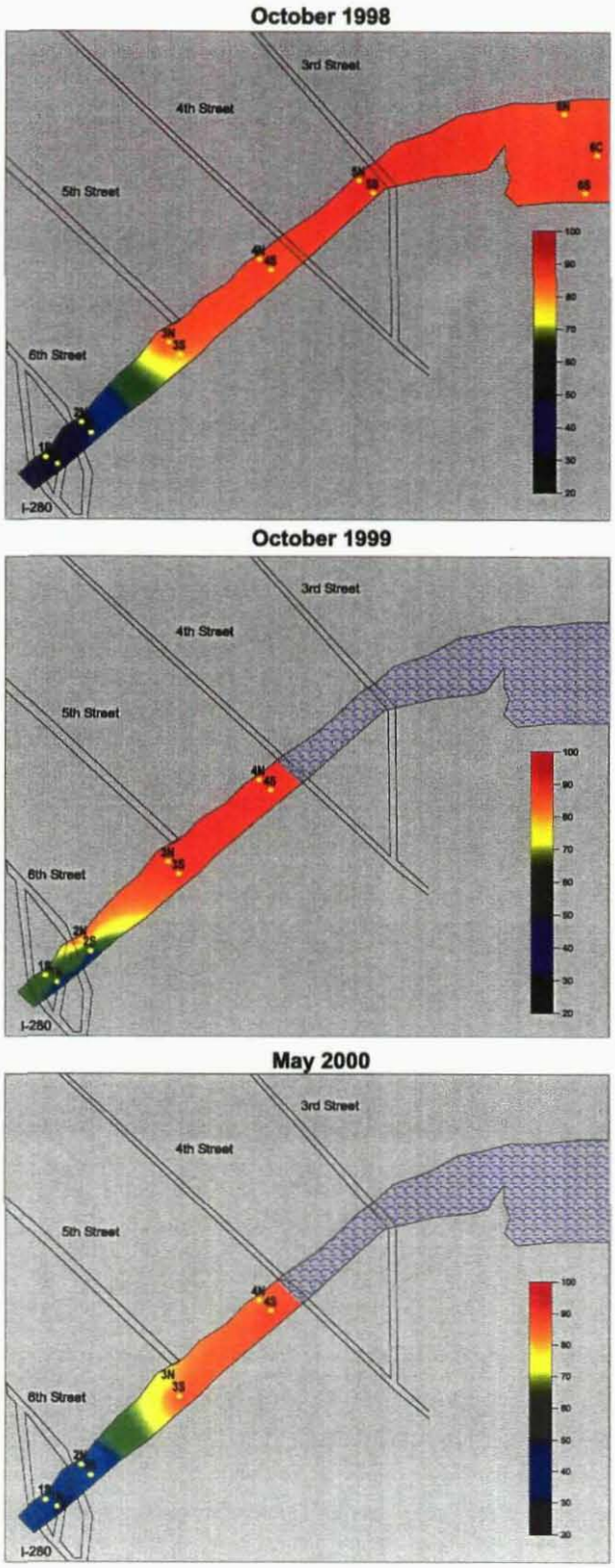

Figure 4-3. Percent fines (silt + clay) in Mission Creek.

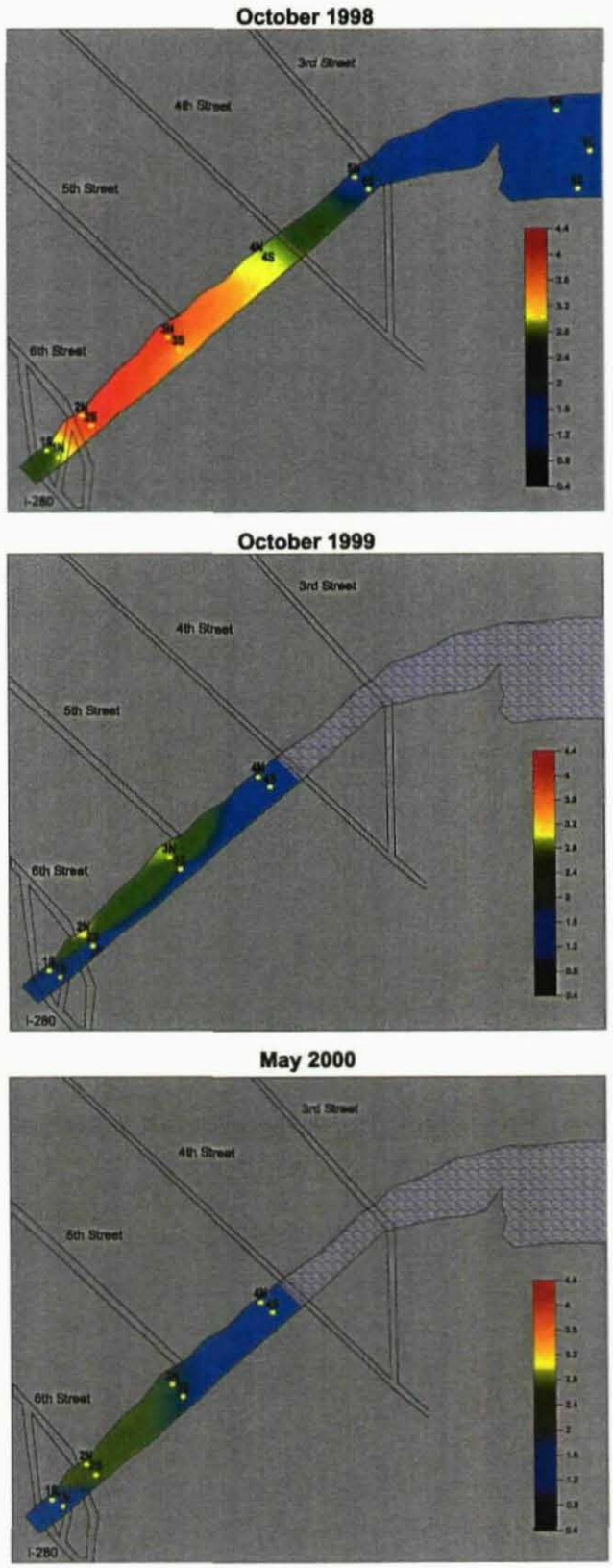

Figure 4-4. Total Organic Carbon (%) in Mission Creek.

Notes

5

5.0 SEDIMENT TOXICITY

Toxicity results for surface sediments are presented in this section. *Eohaustorius estuarius*, an estuarine amphipod of the family Haustoriidae, common in the evaluation of marine sediments, was used in a 10-day acute test. Percent survival, based on the average of five laboratory replicates, is summarized for reference and creek stations in Tables 5-1 through 5-4. Test results are compared to a reference envelope tolerance limit based on BPTCP and survey-specific data. Complete results are presented in Appendices A1 and B1 for Islais and Mission Creeks, respectively.

A total of 61 sediment stations were sampled and tested for acute toxicity to examine conditions over time and determine potential differences between wet (October 1998, April 2000) and dry (October 1999) seasons. These studies were responsive to RWQCB's requirement for site investigations, and were designed to address and/or reduce confounding factors apparent in previous BPTCP testing programs. Toxicity tests consistent with EPA and ASTM protocols were used to ameliorate four potential confounding factors: 1) high ambient levels of ammonia; 2) high ambient levels of hydrogen sulfide; 3) low levels of dissolved oxygen; and 4) experimentally induced organism sensitivity. Elevated levels of ammonia and hydrogen sulfide were reduced through careful replacement of overlying water, following a 24-hour equilibration period for each test chamber (see Section 3.3.2.3). This procedure has the potential for removing, not only unwanted confounding factors, but also soluble chemical contaminants. Considering the fact that contaminant chemicals sequestered in tested sediments have been subjected to continuous natural water exchange, it is believed that the benefits derived from reducing confounding factors far outweigh the potential minimal reduction of these chemicals. The renewal process, combined with the increased water aeration effectively eliminated low dissolved oxygen levels experienced in previous BPTCP testing of creek sediments. Experimentally induced test organism sensitivity was addressed through close interaction with the *Eohaustorius* supplier (Northwest Aquatic Sciences [NWAS], also used in the BPTCP). The salinity acclimation process for *Eohaustorius* was begun by NWAS prior to shipping the amphipods, and continued at SFPUC's Oceanside Biology Laboratory.

October 1998 samples were tested at two laboratories (SFPUC and Pacific EcoRisk) using identical protocols as a performance measure. Inter-laboratory comparisons support the findings of Jirik et al. (2000) that "Testing by multiple laboratories does not appear to reduce the precision of the results." Consequently, October 1999 and April 2000 samples were analyzed by SFPUC only. October 1998 toxicity test results evaluated herein are the laboratory-averaged results for each station, as there were no statistical differences between mean sample values for laboratory replicates ($p>0.05$ for all comparisons). October 1998 sampling was initially intended to establish "dry period" sediment conditions. Heavy rainfall, which produced combined sewer overflows in each of the two creeks just prior to and during sampling produced wet weather conditions. October 1999 samples were collected after a prolonged dry season; April 2000 samples were collected in the wet season, with many samples collected during rainfall.

5.1 OVERVIEW

With the exception of the October 1998 survey, in which creek toxicities are compared only to the BPTCP reference tolerance limit (Section 1.3.1.1), sediment toxicity is evaluated using a survey-specific reference tolerance envelope. Tolerance limits were calculated for the October 1999 and April 2000 surveys using toxicity values measured at six and five San Francisco Bay reference stations, respectively. All reference sites, except for Tomales Bay (measured in 1999 only), are established Regional Monitoring Program reference sites. The resulting survey-specific (SFPUC) tolerance limits were calculated using the same method used to calculate the BPTCP tolerance limit of 69.5% (Hunt et al. 1998a). The resulting SFPUC tolerance limits are 65.3 and 56.6% for October 1999 and April 2000 data, respectively. When results are compared to the historic BPTCP reference envelope, the tolerance limit (69.5%) is adjusted to account for control survival (i.e., 69.5% x fractional control survival) as recommended by Hunt et al. (1998a).

5.2 REFERENCE AREA

Toxicity results for reference area stations are shown in Table 5-1. Only one station (Paradise Cove) was sampled in October 1998 with a result of 65.0% survival, which was just below the BPTCP tolerance limit of 68.5% (i.e., 69.5% of 1998 control survival). Paradise Cove, an established RMP reference site, has shown intermittent toxicity in other studies (K.Taberski, RWQCB personal communication 5/99).

Survival results for the six stations sampled in October 1999 ranged from 59.0 to 99.0%, averaging 81.3%. One reference station, Island #1, fell below the BPTCP tolerance limit indicating toxicity by this standard. All other reference site survivals exceeded the BPTCP criterion of 68.8% (i.e., 69% of 1999 control survival). All 1999 stations, except Tomales Bay, were resampled in April 2000. In general, lower survivals were observed in 2000 under wet weather conditions, compared with October 1999, which was dry. Only Island #1 had a substantially higher survival value in 2000. North Site survival values of 83 and 89% were commensurate.

Table 5-1. Reference area toxicity results for the 10-day amphipod test with *Eohaustorius estuarius* and BPTCP (1998) and SFPUC (1999 & 2000) reference tolerance limits.

Station	Percent Survival		
	October 1998[1]	October 1999	April 2000
Island #1		59.0	68.0
Marconi Cove (Tomales Bay)		83.0	
North Site		83.0	89.0
Paradise Cove	65.0	94.0	65.0
South Site		99.0	80.0
Tubbs Island		70.0	59.0
Home Sediment Control	98.5	99.0	95.5
Tolerance Limit	**68.5[†]**	**65.3[‡]**	**56.6[‡]**

[1]=1998 results are for average data from SFPUC and Pacific EcoRisk laboratories; [†]=BPTCP tolerance limit; [‡]= SFPUC tolerance limit

5.3 ISLAIS CREEK

Mean survival for all creek stations sampled in October 1998 was 70.9%. These results were a significant improvement over 1994 and 1997 BPTCP test results, which showed significant toxicity at the upper end of Islais Creek. Results ranged from 58.5 to 83.0%, with the highest survivals measured at the end of the creek (Station 1N). Four of the six stations (Figure 5-1, Table 5-2) had survivals above the BPTCP tolerance limit of 68.5% (69.5% of control), indicating no significant toxicity by this standard. Stations 2N and 3S, located near the CSO Weir and the Quint Street outfall, exhibited results marginally below the standard, with average survivals of 58.5 and 61.5%, respectively. Four Islais Creek stations had greater survival values than the Paradise Cove reference area (i.e., > 65%).

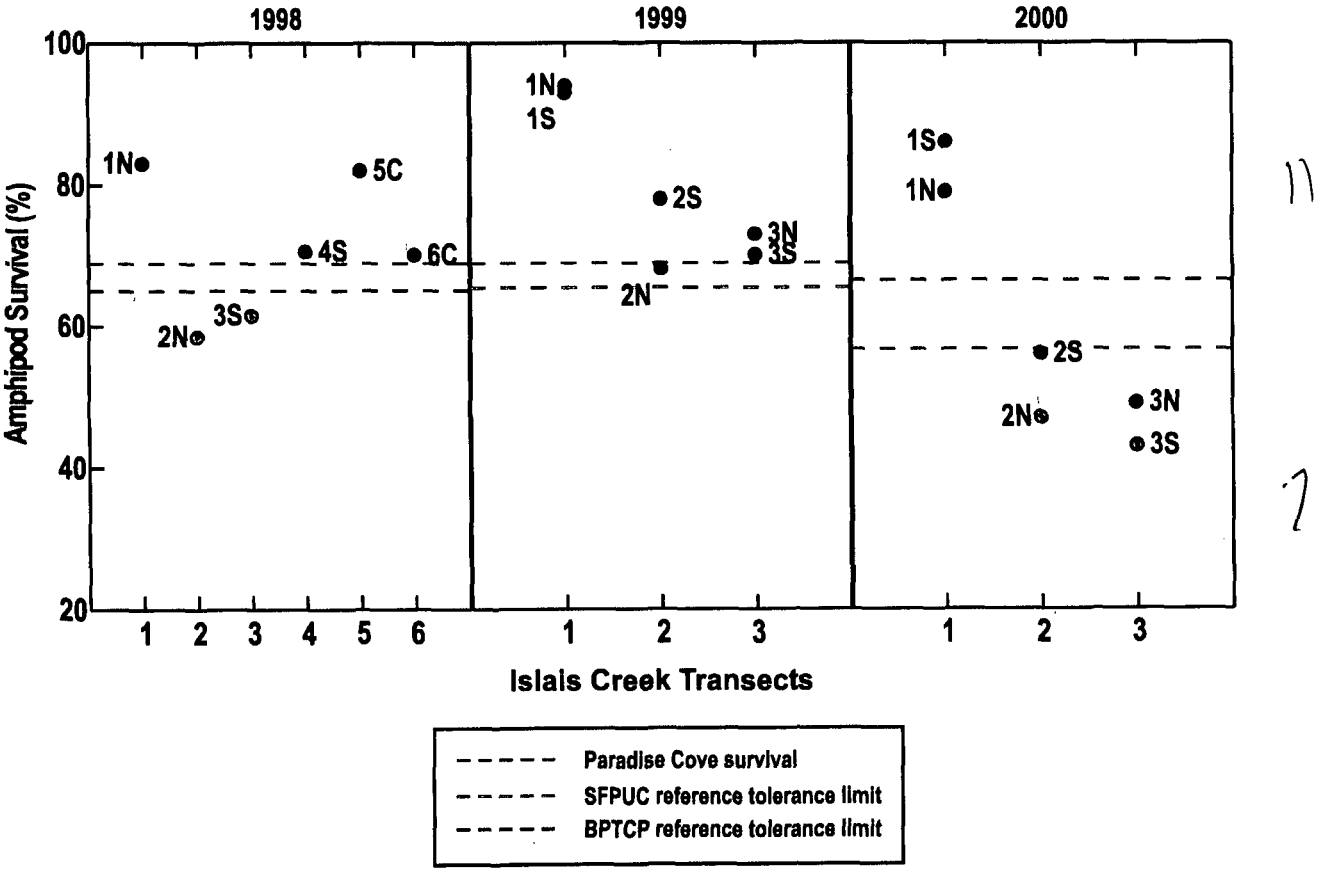

Figure 5-1. Islais Creek toxicity results and corresponding BPTCP and SFPUC survey-specific tolerance limits. Stations with recurrent toxicity (≥ 2 toxic events) are shown in red.

October 1999 survival was measured at the north and south stations of transects 1 through 3 (Figure 3-1, Section 3), focusing on the upper portion of the creek surrounding the CSO Weir and the Quint Street outfall. Stations included all October 1998 stations that had less than 68.5% survival in toxicity tests and ERM quotients greater than 0.5 (see Section 6). Average amphipod survival was 79.3%, ranging from

68.0 to 94.0%. Survival at Station 2N (68.0%) was slightly below the BPTCP tolerance limit of 68.8% (69.5% of control). However, no stations were below the study-specific tolerance limit of 65.3%. Results were comparable to the six concurrently sampled reference stations.

April 2000 sampling, conducted during wet weather, re-examined all October 1999 stations. Average survival was 60.0%, ranging from 43.0 to 86.0%. Four of the six stations sampled (2N, 2S, 3N, 3S) fell below the BPTCP reference threshold of 66.4% (69.5% of 2000 control survival) and the study-specific tolerance limit of 56.6%. Toxicity at these four stations, located near the CSO Weir and Quint Street outfall, suggest that toxicity was confined to a localized area at the time of the survey.

Table 5-2 compares amphipod survival at each of the 18 stations sampled during the three programmatic surveys to tolerance limits for the BPTCP (69.5% of control survival) and the 1999 and 2000 SFPUC surveys. Amphipod survival, observed at Stations 2S and 3N, indicated recurrent sediment toxicity located mid-creek at the west and east end of the CSO Weir for both tolerance limits. The extent of toxicity appears to be confined to this immediate area. General toxicity also appears to be influenced by seasonal rainfall. Bay-wide conditions appear stressed during the April 2000 sampling period (wet weather) as reflected in lower overall survival rates measured at both creek and reference stations.

Table 5-2. Islais Creek amphipod survival for each station and year. Stations with recurrent toxicity are shown in bold.

Station	Survey Year*	Percent Survival	SFPUC Tolerance Limit	BPTCP Tolerance Limit (69.5% of control)
1N	1998	83.0	NA	68.5
1N	1999	94.0	65.3	68.8
1N	2000	79.0	56.6	66.4
1S	1999	93.0	65.3	68.8
1S	2000	86.0	56.6	66.4
2N	1998	58.5	NA	68.5
2N	1999	68.0	65.3	68.8
2N	2000	47.0	56.6	66.4
2S	1999	78.0	65.3	68.8
2S	2000	56.0	56.6	66.4
3N	1999	73.0	65.3	68.8
3N	2000	49.0	56.6	66.4
3S	1998	61.5	NA	68.5
3S	1999	70.0	65.3	68.8
3S	2000	43.0	56.6	66.4
4S	1998	70.5	NA	68.5
5C	1998	82.0	NA	68.5
6C	1998	70.0	NA	68.5

Red=corresponding creek station below tolerance limit; Blue=wet weather event;
Bold=recurrent toxicity measured in ≥2 years based on exceedance of SFPUC and BPTCP tolerance limit

5.4 MISSION CREEK

October 1998 sampling produced an average amphipod survival of 80.3% from all creek stations, ranging from 74 to 85%. This represents a significant improvement over BPTCP amphipod survival results in 1995 and 1997, which indicated significant toxicity (5% and 19% survival) at the upper end of Mission Creek. Figure 5-2 and Table 5-3 compare amphipod survival at each of the 22 stations sampled during the three programmatic surveys to the BPTCP tolerance limit (69.5% of control survival) and the SFPUC survey-specific tolerance limit. All six stations examined produced survivals above the BPTCP reference tolerance limit of 68.5% (69.5% of control), indicating no significant toxicity by this standard. All six sites had survivals greater than the 65% measured at the Paradise Cove reference area.

October 1999 amphipod survival was measured at eight stations in the upper portion of the creek between the main CSO discharge to the 4th Street intersection (Figure 3-2, Section 3) during a dry sampling period. Sampling and testing focused on stations that had ERM quotients greater than 0.5, since no toxicity was measured in October 1998. Average amphipod survival was 81.5%, ranging from 70.0 to 90.0%. All eight stations (Figure 5-2) examined had survivals above BPTCP and SFPUC survey-specific tolerance limits (68.8 & 65.3%, respectively), indicating no significant toxicity by these standards. The average amphipod survival for all eight stations was slightly higher than the average of the six reference sites sampled at the same time: 81.5 and 81.3%, respectively.

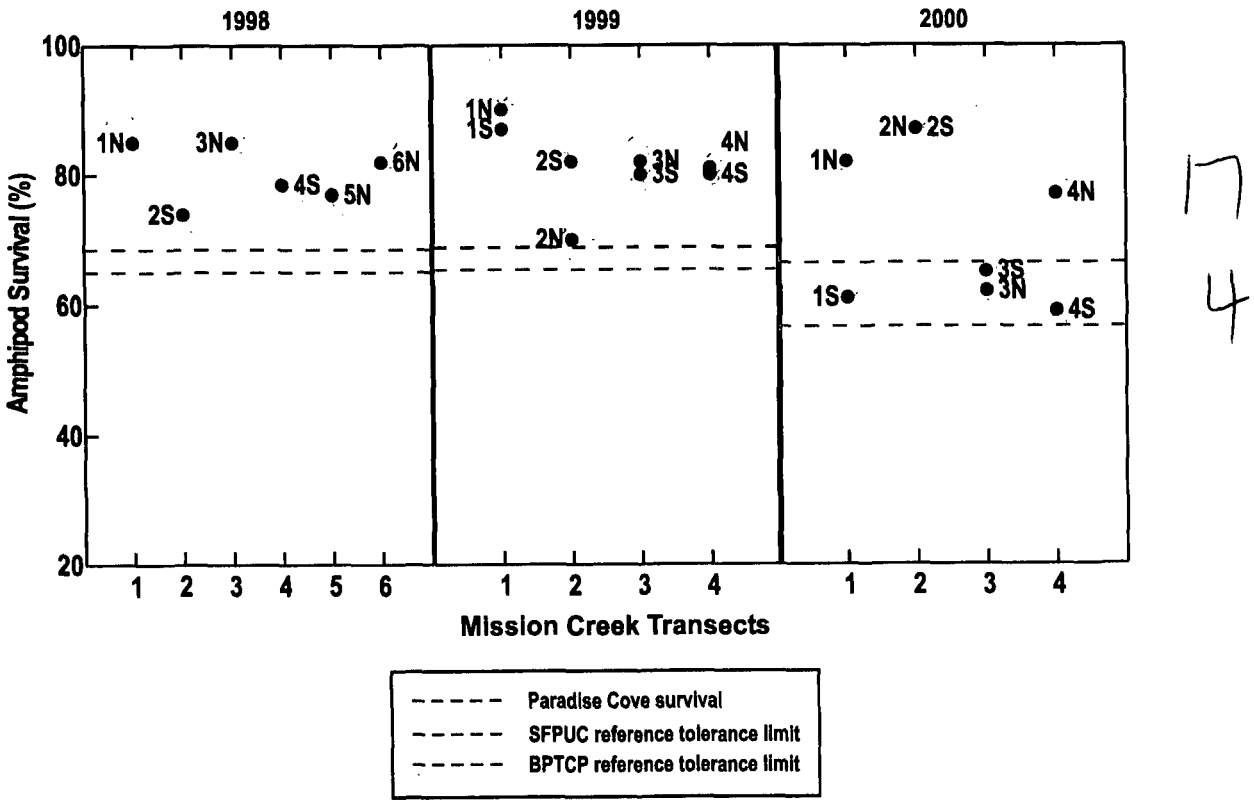

Figure 5-2. Mission Creek toxicity results and corresponding BPTCP and SFPUC survey-specific tolerance limits.

Table 5-3. Mission Creek amphipod survival for each station and year.

Station	Survey Year*	Percent Survival	SFPUC Tolerance Limit	BPTCP Tolerance Limit (69.5% of control)
1N	1998	85.0	NA	68.5
1N	1999	90.0	65.3	68.8
1N	2000	82.0	56.6	66.4
1S	1999	87.0	65.3	68.8
1S	2000	61.0	56.6	66.4
2N	1999	70.0	65.3	68.8
2N	2000	87.0	56.6	66.4
2S	1998	74.0	NA	68.5
2S	1999	82.0	65.3	68.8
2S	2000	87.0	56.6	66.4
3N	1998	85.0	NA	68.5
3N	1999	82.0	65.3	68.8
3N	2000	62.0	56.6	66.4
3S	1999	80.0	65.3	68.8
3S	2000	65.0	56.6	66.4
4N	1999	81.0	65.3	68.8
4N	2000	77.0	56.6	66.4
4S	1998	78.5	NA	68.5
4S	1999	80.0	65.3	68.8
4S	2000	59.0	56.6	66.4
5N	1998	77.0	NA	68.5
6N	1998	78.0	NA	68.5

Red=corresponding creek station below tolerance limit; Blue=wet weather event;
Bold=recurrent toxicity measured in ≥2 years based on exceedance of SFPUC and BPTCP tolerance limit

April 2000 amphipod survival was generally lower than that measured in 1998 and 1999. Average survival was 72%, ranging from 59.0 to 87.0%. Four of the eight stations sampled (1S, 3N, 3S, 4S) fell below the BPTCP tolerance limit of 66.4% (69.5% of control). However, all stations were above the SFPUC survey-specific tolerance limit (56.6%), indicating no significant toxicity compared with reference sites sampled during the same survey. April 2000 sampling took place during wet weather, which may have contributed to bay-wide stressed conditions reflected as an overall depression in amphipod survival at both creek and reference stations.

5.5 CONCLUSIONS

Recurrent toxicity was indicated at two stations in Islais Creek (2N, 3S) located mid-creek at each end of the CSO Weir. Mission Creek, in stark contrast to BPTCP investigations, produced no recurrent toxicity. In general, reduced amphipod survival observed in the April 2000 survey for both creeks and the five corresponding reference sites, may have been due to bay-wide stressed conditions. In addition, control survival at 95.5% was lower in 2000 than the previous two surveys (i.e., 98.5 and 99.0%), indicating that test animals may have been slightly stressed independent of sediment conditions in the creeks.

Notes

6.0 SEDIMENT CHEMISTRY

Sediment chemical results, consisting of organic compounds and metals for creek and reference areas, are presented in this section. Results describe distribution patterns within each creek and identify chemicals of potential concern (COPCs) through comparison with reference sediments and corresponding effects-range median (ERM) guideline values. Surface sediment distributions are examined in relation to distance from active and historic combined sewer overflows (CSOs) and across surveys, which included both wet and dry weather events. The distribution of subsurface sediment chemicals is discussed qualitatively to estimate the vertical extent of contamination and the resuspension potential of buried sediment. Results are organized by creek into chemical suites, consisting of metals, polycyclic aromatic hydrocarbons (PAH), organochlorine pesticides, and polychlorinated biphenyl (PCB) congeners. Surface sediment results for each station are presented in Appendices A1 and B1 for Islais and Mission Creeks, respectively. Corresponding subsurface results are presented in Appendices A2 and B2. Graphical displays of surface and subsurface results are shown in sub-appendices 4 and 5, respectively (e.g., A4 & A5 for Islais Creek).

Following the primary objective of the October 1998 survey, sediment chemical concentrations were evaluated using ERM guidelines (see Section 1.3.1.2) to compare results with previous Bay Protection and Toxic Cleanup Program (BPTCP) findings (study objective 1, Section 1). Sediment chemicals measured in October 1999 and April 2000 were compared to upper 95th percentile predictive limits (UPL), calculated using synoptically collected reference site data (see Section 3.1). This approach is similar to the reference envelope tolerance limit used to evaluate amphipod toxicity results (see Section 5). Comparisons of creek and reference area sediments were made using total organic carbon (TOC) normalized data (e.g., ng or µg [chemical] per gram TOC in dry weight). All other presentations and discussions of chemical data are based on sediment dry-weight.

6.1 OVERVIEW

Chemical concentrations in the two creeks varied considerably as a function of location, sediment type and TOC concentration. Most chemical concentrations were positively correlated with sediment TOC; however, with few exceptions similar relationships were not observed with grain size. In addition, many metals were positively correlated with either aluminum or iron, which are major constituents of sediment minerals. Sediment concentrations of chlorinated pesticides, polychlorinated biphenyls (PCB) and polycyclic aromatic hydrocarbons (PAH), which are nonionic organic compounds, increased with increasing TOC, as expected, due to their relative insolubility in water and high affinity for particulate matter. TOC-normalized chemical concentrations exceeding either the corresponding reference area upper-95th predictive limit or one-half of the ERM value in two or more surveys were identified as COPCs and evaluated further in Sections 7 and 9, which discuss bioaccumulation in clams and results of the applied decision matrix, respectively.

Overall PAH contamination was evaluated using separate sums of seven low-molecular-weight (LMW) PAH compounds and six high-molecular-weight (HMW) PAH compounds based on Long et al. (1995). An additional 28 PAH compounds were analyzed to provide information on hydrocarbon type and

source. Potential contaminant sources of PAH and other COPCs to creek sediments are discussed in Section 8.

Organochlorine pesticides measured in sediments included five categories of compounds: 1) six isomers of DDT (including DDD and DDE degradation products), 2) four Chlordane isomers and congeners: alpha-Chlordane, gamma-Chlordane, cis-Nonachlor and trans-Nonachlor, 3) Aldrin and its metabolites: Dieldrin and Endrin, 4) Lindane, and 5) Mirex. Each of these compounds has potentially toxic effects upon marine organisms if sufficiently concentrated and bioavailable. Some compounds, such as DDT, are notable for their biomagnification in fatty tissues at successively higher levels of the food chain. These pesticides also are nonionic organic compounds that have a high affinity for organic carbon (EPA 1993), preferentially concentrating in TOC-enriched sediments.

Polychlorinated biphenyls are also nonionic organic compounds, which generally increase with increasing TOC due to their relative insolubility in water and high affinity for organic matter (Section 2.3.3). The sum of 18 NOAA Status and Trends PCB congeners were used to assess the extent of contamination in creek sediments. PCB data used by Long et al. (1995) to derive a total PCB ERM value of 180 parts-per-billion ($ng \cdot g^{-1}$) include Aroclor data as well as other forms of congeners. ERM values for total PCB and chlorinated pesticides are based on sediments with an average of 1.2% TOC, and are therefore not directly comparable to corresponding concentrations found in TOC-enriched creek sediments. Additionally, these nonionic organic compounds tend to bioaccumulate in the food chain, but are not necessarily toxic in sediment bioassays, even at elevated concentrations (i.e., $>1\ \mu g \cdot g^{-1}$). Because of this, potential adverse effects from PCBs and pesticides were evaluated for bioaccumulation potential, using a standard 28-day test with clams (see Section 7).

6.2 REFERENCE AREA

San Francisco Bay reference area sediments were sampled at one location in October 1998, six locations in October 1999 and five locations in April 2000. Locations and sample inventory for each station are shown in Section 3, Figure 3-4 and Table 3-7, respectively. These primarily fine-grained, low-TOC sediments were relatively free of contamination across all three surveys. In particular, metal concentrations were commensurate with pristine sediments located along the California coast and elsewhere, with the exception of copper, mercury, nickel and silver, which were elevated 2-8 times at in-bay reference sites (Table 6-1). Mean reference area concentrations were in excellent agreement with Regional Monitoring Program (RMP) data collected from 1993 to 1997 from a total of 32 San Francisco Bay offshore and delta stations, including five locations sampled in this study.

Reference area concentrations of total PCB, total DDT and total Chlordane were similar to background concentrations measured in nearshore sediments of relatively unimpacted areas (Table 6-2). Trace concentrations of these ubiquitous anthropogenic contaminants to otherwise pristine sediments are due largely to atmospheric fallout and hydrodynamic transport of discharged waste. These and other chlorinated hydrocarbons are found at trace concentrations in areas far-removed from human populations, including the Antarctic (Kennicut et al. 1992).

Reference sediment concentrations of total PAH were moderately elevated compared to other pristine areas (Table 6-2); however, at less than 1 part-per-million (i.e., $<1000\ ng \cdot g^{-1}$), concentrations were well

below recognized threshold levels (e.g., ERL, ERM). Background concentrations measured at in-bay reference stations are most likely from atmospheric fallout of fossil fuel combustion related products (see Section 8).

Upper 95th predictive limits for TOC-normalized and sediment dry weight (non-normalized) data are shown in Table 6-3 for the 1999 and 2000 surveys. Upper predictive limits were not calculated for 1998 data, as only one reference station was sampled. Analyte results for individual creek stations are compared to corresponding UPLs shown in Table 6-3; results are presented in Sections 6-3 and 6-4 for Islais Creek and Mission Creek, respectively. TOC-normalized analyte concentrations that exceeded corresponding UPLs or non-normalized analyte concentrations that exceeded corresponding ERMs in two or more surveys were retained as COPCs for each creek.

Table 6-1. Mean metal concentrations for reference locations (all surveys combined) and other areas.

Metal ($\mu g \cdot g^{-1}$)	Reference Area	San Francisco Bay[1]	Clean California Coast[2]	Southwest English Estuary[2]	Continental Crust[3]
Arsenic	6.98	5.65 - 10.6	12	6.4	2
Cadmium	0.32	0.23 - 0.89	0.33	0.23	0.2
Chromium	96.4	64 - 123.4	22	30	*126
Copper	38.1	18.9 - 53.7	18.3	7	45
Lead	18.0	7.7 - 42	10	25	15
Mercury	0.23	0.09 - 0.53	0.04	0.03	0.06
Nickel	86.7	59.9 - 109.2	-	17	56
Selenium	0.25	0.06 - 0.65	-	0.11	0.12
Silver	0.52	0.01 - 0.56	-	0.07	0.07
Zinc	103.2	61.7 - 181.3	43	59	40

[1]ranges in mean concentrations from SFEI RMP Report 1999 (http://www.sfei.org/rmp/1999/RMP99_Results.pdf); [2]from Kennish (1997); [3]from Wedepohl (1995)

Table 6-2. Mean organic chemical(s) concentrations for reference locations (all surveys combined) and other "clean" areas.

Organic Chemical(s) ($ng \cdot g^{-1}$)	Reference Area	San Francisco Bay[1]	Clean California Coast[2]	North Atlantic[2]	Baltic Sea[2]
Total PAH	732	83.8 - 2695.5	160	120	258
Total DDT	5.67	0.39 - 17.84	5-30	0.4	2
Total Chlordane	0.9	0.18 - 7.77	-	-	-
Dieldrin	0.7	ND - 1.07	-	-	-
Total PCB	10.16	0.45 - 41.77	1-13	15	8.4-10.8

[1]ranges in mean concentrations from SFEI RMP Report 1999 (http://www.sfei.org/rmp/1999/RMP99_Results.pdf); [2]adopted from Table 2.1, Appendix 2 in Kennish (1997)

Table 6-3. 95th UPLs for reference stations sampled in 1999 and 2000 (reported for TOC-normalized and non-normalized data).

Analyte	October 1999 Survey		April 2000 Survey	
	TOC-normalized UPL	Non-normalized UPL	TOC-normalized UPL	Non-normalized UPL
Metals ($\mu g \cdot g^{-1}$)				
Arsenic	1179	13.7	1192	14.6
Cadmium	41.1	0.41	61.3	0.6
Chromium	11,116	156	10,275	119
Copper	6928	71	6329	73
Lead	2912	27	2213	26
Mercury	32.4	0.32	40.5	0.44
Nickel	10,088	166	8641	98
Selenium	29.3	0.39	46.8	0.49
Silver	87.3	0.85	28.5	0.25
Zinc	14,891	144	12,903	152
Organics ($ng \cdot g^{-1}$)				
Total LMW PAH	18,216	179	22,595	272
Total HMW PAH	112,581	1117	114,760	1056
Dieldrin	250.6	2.53	20.6	0.25
Endrin	34.7	0.44	20.6	0.25
Total Chlordane	70.5	1.4	20.6	1.8
Total DDT	944	9.4	1283	13.1
Total PCB	1952	20.2	1336	18.6

TOC-normalized=mass of chemical$\cdot g^{-1}$ TOC; samples with < 1% TOC were normalized using 1% TOC

6.3 ISLAIS CREEK

Sediments were sampled at 18 locations in 1998, spanning from the creek end (Transect 1) to the mouth (Transect 6) (see Figure 3-1, Section 3). In general, surface sediment chemical concentrations measured east of the 3rd Street Bridge (Transects 4-6) were commensurate with sediment concentrations measured at Paradise Cove and at the relatively unimpacted In-bay and Delta sites measured in the Regional Monitoring Program (SFEI 1997). These stations, along with the center stations from Transects 1-3, were omitted from subsequent sampling in 1999 and 2000.

Chemical distribution patterns in surface sediments were fairly consistent over time, with the highest concentrations measured directly below the Interstate 280 overpass at the creek end near the main CSO Weir. In addition, many chemical concentrations decreased with distance from the creek end, indicating the CSO Weir or runoff from Interstate 280 as likely sources without additional information. Surface sediment distributions of key chemicals are shown for each survey in Appendix A4. In general, chemical concentrations increased significantly with depth, indicating that buried sediments are most likely in-place and that inputs have diminished over time. Subsurface distribution plots for key chemicals sampled in October 1998 are shown in Appendix A5 for 1-ft core intervals sampled from 0-4 ft depths in October 1998. All core intervals were analyzed from Transects 1-3; only 0-2 ft depths were analyzed from Transects 4-6, since corresponding surface sediments from these stations were relatively clean.

Many organic as well as inorganic contaminants were significantly correlated with TOC; however, similar relationships were not observed for grain size characteristics, including percent fines, shown in Table 6-4.

Table 6-4. Islais Creek - correlation results for selected chemical concentrations with TOC and grain size.

	Copper	Mercury	Lead	Zinc	Total DDT	Dieldrin	HMW PAH	LMW PAH	Total PAH	Total PCB	Total Chlordane
Percent Fines											
r	-0.43	-0.50	-0.87	-0.60	-0.41	-0.37	0.22	0.23	0.22	-0.58	-0.61
p	0.02	0.005	<0.001	<0.001	0.02	0.04	0.25	0.22	0.24	<0.001	<0.001
TOC											
r	**0.81**	**0.83**	0.35	**0.75**	**0.85**	**0.75**	**0.52**	**0.49**	**0.52**	**0.66**	**0.80**
p	<0.001	<0.001	0.055	<0.001	<0.001	<0.001	0.003	0.006	0.003	<0.001	<0.001

r=correlation coefficient; p=probability; **bold**=significant positive correlation at $p < 0.05$.

6.3.1 Islais Creek Metals

Surface results. Surface sediment concentrations of mercury, lead, and zinc consistently exceeded corresponding ERM values at several stations in all three surveys. The ERM for nickel at 51.6 $\mu g \cdot g^{-1}$ (micrograms per gram; parts-per-million [ppm]), was exceeded at nearly all stations; however, nickel is generally not considered a COPC, as naturally elevated concentrations are found in non-toxic sediments throughout San Francisco Bay (Hunt et al. 1998a). Concentrations of nickel, as well as arsenic, cadmium, chromium, copper, selenium and silver were commensurate with concentrations measured at in-bay reference stations, showing little evidence of anthropogenic enhancement. Selenium concentrations ranged from 0.13 to 0.75 $\mu g \cdot g^{-1}$ with an average concentration of 0.40 $\mu g \cdot g^{-1}$. These results are comparable to RMP results reported from 1993 through 1997 with a mean concentration of 0.37 $\mu g \cdot g^{-1}$ (and a standard deviation of $\pm$ 0.31 $\mu g \cdot g^{-1}$). There is no corresponding ERM value for selenium; however, concentrations below 0.33 $\mu g \cdot g^{-1}$ have been reported as uncontaminated background for San Francisco Bay sediments (Walters and Gartner 1985).

Concentrations of lead, mercury and zinc measured in 1998 were elevated at the creek end (Transect 1, Figure 6-1), somewhat less at Transects 2 and 3 (near the main CSO Weir and Quint Street Outfall) and not identifiable at Transects 4, 5 and 6 (east of 3rd Street bridge). These metals remained elevated in 1999 and 2000, again with the highest concentrations measured at the creek end. Station 1N sediments posted consistently high concentrations of lead, exceeding the ERM of 218 $\mu g \cdot g^{-1}$ in all three sampling events. However, concentrations were an order of magnitude lower in Transect 2 sediments (Figure 6-1). Zinc exceeded the ERM of 419 $\mu g \cdot g^{-1}$ only once, at Station 1N in 1998. Mercury was elevated at Station 1N in all three sampling events, with the highest concentration (2.49 $\mu g \cdot g^{-1}$) measured in 1998. Station 3N, adjacent to the east end of the CSO Weir, also showed elevated concentrations of mercury, lead and zinc, often approaching ERM values. Table 6-5 shows that maximum metal concentrations from all three surveys were measured either at Station 1N, 3N, or 3S (arsenic only).

Subsurface results. Concentrations increased with depth and decreased with distance from the creek end for most metals, approaching background concentrations east of the 3rd Street Bridge. Asymptotic trends were observed for copper, mercury, lead, silver and zinc (Figure 6-2 & Appendix A5), confirming that loading of most metals to Islais Creek has decreased over time. These patterns also indicate that creek contaminants are not vertically well-mixed and likely are not being resuspended. Sediment age-dating studies should be performed to confirm this premise. Only concentrations of arsenic, nickel, and selenium remained constant across depth and distance, or actually increased with distance from the creek end. Summary results for lead, mercury and zinc are presented in Table 6-6.

Table 6-5. Islais Creek – Surface metal concentrations, Transects 1-3 (21 stations), all surveys (μg·g^{-1}, ppm dry weight).

Metal	Minimum	Maximum	Maximum Station	Mean	Standard Deviation	ERM[1]	Reference Mean[2]
Arsenic	1.94	13.4	3S	8.36	3.08	70	6.98
Cadmium	0.48	2.42	1N	1.00	0.54	9.6	0.32
Chromium	69.9	143	3N	107.5	21.2	370	96.4
Copper	55.3	139	3N	83.1	24.3	270	38.1
Lead	30.0	**402.8**	1N	124.7	125.8	218	18.0
Mercury	0.22	**2.49**	1N	0.54	0.51	0.71	0.23
Nickel	49.0	**144.33**	3N	**98.11**	23.5	51.6	**86.7**
Selenium	0.05	0.77	3N	0.43	0.19	NA	0.25
Silver	0.50	2.40	3N	0.92	0.52	3.7	0.52
Zinc	140.0	**419**	1N	227.5	88.4	410	103.2

[1]=source Long et al. (1995); [2]=mean reference site concentration for all surveys; **bold** indicates > ERM

Table 6-6. Islais Creek – Subsurface lead, mercury and zinc concentrations (μg·g^{-1}, ppm dry weight).

	Lead		Mercury		Zinc	
Depth	Mean	Max. Station; Concentration	Mean	Max. Station; Concentration	Mean	Max. Station; Concentration
0-1 ft	65.3	1C; 232.0	0.34	1C; 0.78	192.2	1C; 402.0
1-2 ft	101.2	1C; 356.0	0.45	1C; 0.82	241.2	1C; 546.0
2-3 ft	182.1	1C; 355.7	0.79	1C; 1.30	448.1	2N; 586.7
3-4 ft	211.6	1C; 383.1	0.82	1C; 1.03	368.4	1C; 574.9

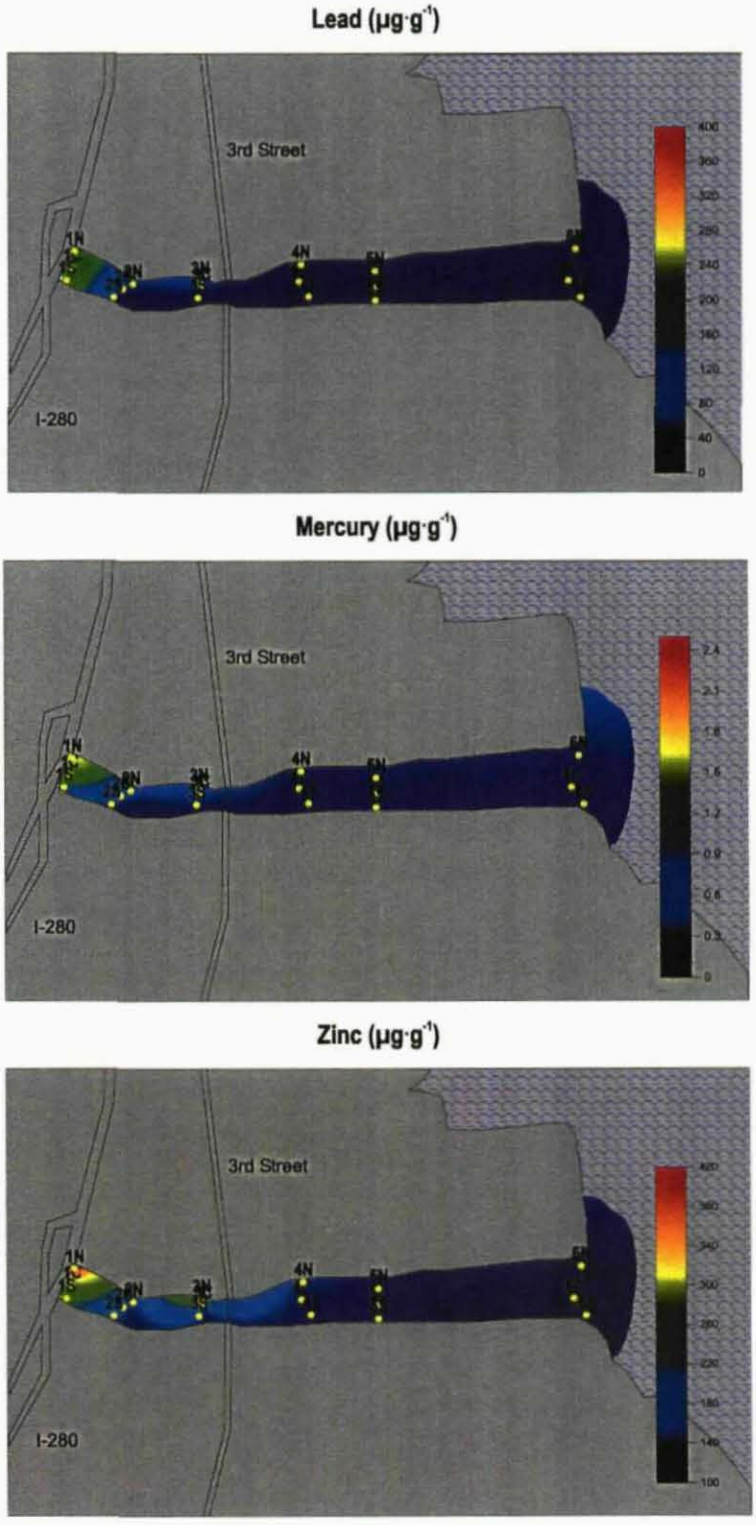

Figure 6-1. Distribution of lead, mercury and zinc at Islais Creek – October 1998

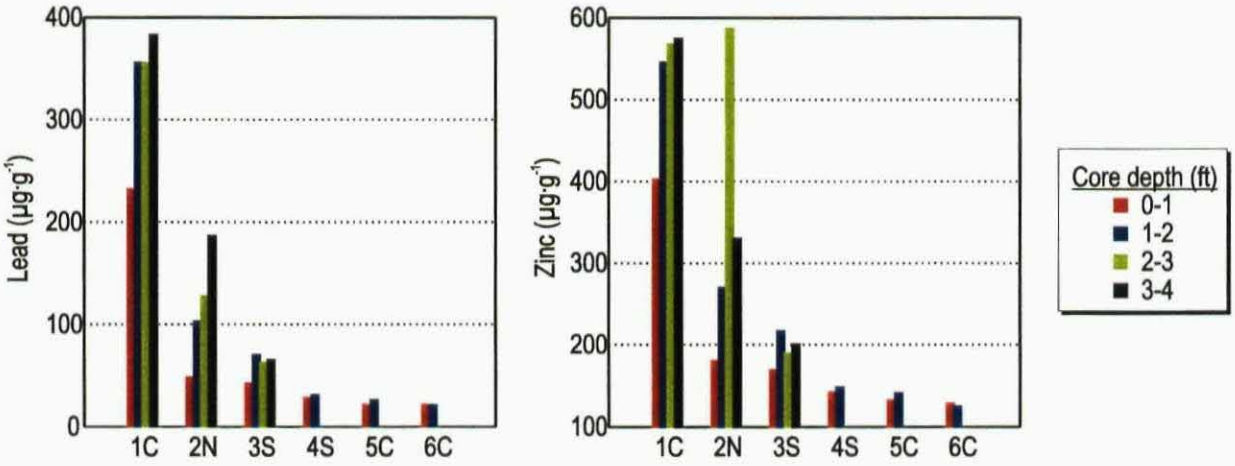

Figure 6-2. Subsurface distributions of lead and zinc at Islais Creek – October 1998.

6.3.2 Islais Creek Polycyclic Aromatic Hydrocarbons (PAH)

Surface results. Consistently higher concentrations of high molecular weight (HMW) PAH compared to low molecular weight (LMW) PAH were measured in surface sediments in all three surveys. Distribution patterns were similar to those observed for metals, with the highest concentrations measured near the creek end. Mean total PAH concentrations were relatively low, ranging from 1338 to 5324 nanograms per gram ($ng \cdot g^{-1}$, ppb) for Transects 4-6 (east of 3rd Street), which were sampled in 1998 only. Summary results for sediments collected west and east of the 3rd Street Bridge are presented in Table 6-7. The following discussion focuses on sediments collected west of the 3rd Street Bridge (Transects 1-3).

Table 6-7. Islais Creek - PAH in surface sediments, all surveys combined ($ng \cdot g^{-1}$ dry weight).

Parameter	Minimum	Maximum	Maximum Station	Mean	ERM[1]	Reference Mean[2]
Transects 1-3						
LMW PAH	269	4371	2N	1565	3160	269
HMW PAH	1330	22,330	2N	7237	9600	956
Transects 4-6 (1998 only)						
LMW PAH	326	1217	5S	552	3160	269
HMW PAH	1012	4107	5S	2043	9600	956

[1]=source Long et al. (1995); [2]=all surveys combined

The ERM value for HMW PAH was exceeded twice at two stations: 3N in 1998 and 1999 and 2N in 1999 and 2000. However, these stations also had high concentrations of TOC (mean = 2.9 & 2.3%, respectively), which tends to concentrate non-ionic organic compounds. Only Station 3N exceeded the ERM value for total LMW PAH, with a concentration of 4371 $ng \cdot g^{-1}$ in April 2000. Figure 6-3 shows the distribution of HMW PAH measured throughout the creek in October 1998. Normalization of HMW PAH to TOC produces a more even distribution of the relative concentrations of HMW PAH in surface sediments. As previously discussed in Section 1.2.4.2, EPA has draft criteria for PAH compounds based

on TOC content; however, ERM criteria are based on sediments with an average TOC concentration of 1.2%. The premise for TOC normalization for nonionic organic compounds, such as PAH, is based on substantial evidence that these contaminants adsorb to organic carbon, potentially reducing their toxicity (WDOE 1993; Swartz et al. 1990 & 1994).

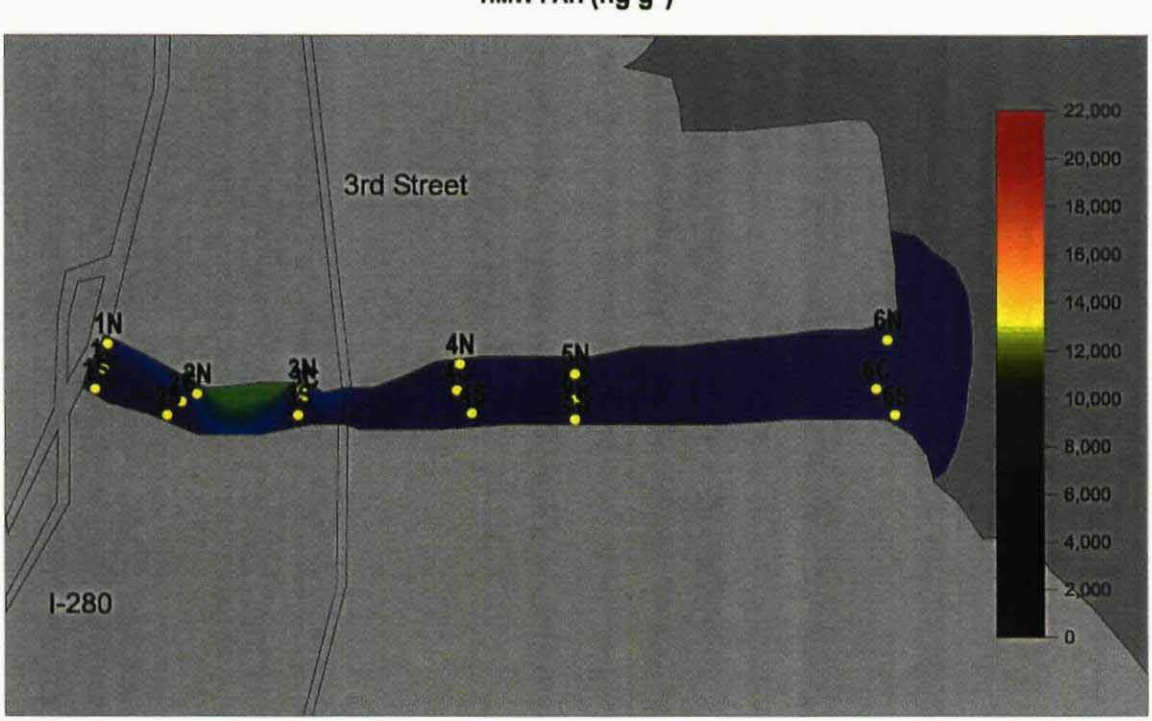

Figure 6-3. Distribution of HMW PAH at Islais Creek – October 1998.

Subsurface results. In general, concentrations of most individual PAH compounds, as well as total LMW and HMW PAH, were fairly consistent across depth, with the exception of extremely high concentrations (i.e., >44,000 $ng \cdot g^{-1}$ total PAH) observed in the 2-3 and 3-4 ft intervals at Station 2N (Figure 6-4). In general, PAH concentrations diminished with distance from Station 2N, both up and down the creek. Most subsurface LMW PAH concentrations were below the ERM guideline (i.e., <3160 $ng \cdot g^{-1}$), except for several core intervals collected below 1 ft at Stations 1C and 2N. Mean concentrations of LMW PAH ranged from 1240 to 3778 $ng \cdot g^{-1}$ across all depths. As with surface sediments, concentrations of subsurface HMW PAH were much higher, averaging 5302 to 20,638 $ng \cdot g^{-1}$ across all depths (Table 6-8).

Table 6-8. Islais Creek - mean concentrations of LMW PAH, HMW PAH and total PCB in subsurface sediment (ng·g^{-1}, ppb dry weight).

Depth	LMW PAH		HMW PAH		Total PCB	
	Mean	Max. Station; Concentration	Mean	Max. Station; Concentration	Mean	Max. Station; Concentration
0-1 ft	1240	2N; 2393	5302	2N; 14,210	79.1	1C; 342.2
1-2 ft	2022	1C; 5881	6556	2N; 12,530	94.3	1C; 345.9
2-3 ft	3778	2N; 7040	18,952	2N; 44,760	312.2	1C; 599.8
3-4 ft	2753	2N; 3784	20,638	2N; 47,120	363.5	1C; 577.9

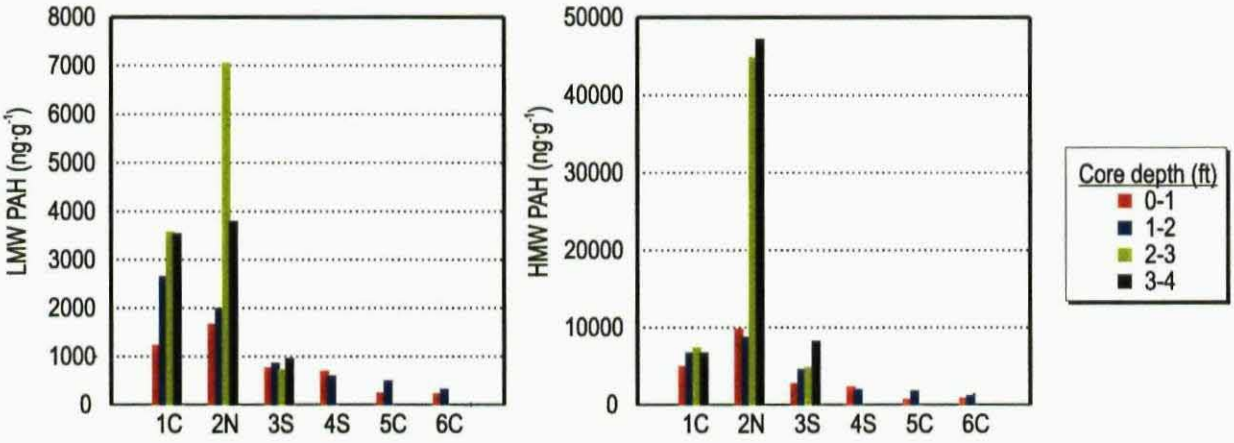

Figure 6-4. Subsurface distributions of LMW and HMW PAH at Islais Creek – October 1998.

6.3.3 Islais Creek Polychlorinated Biphenyls (PCBs)

Surface sediments. The horizontal distribution of total PCB in Islais Creek was similar to that for PAH, varying considerably as a function of location, sediment type and TOC concentration. Total PCB concentrations ranged from 13.97 to 414.1 ng·g^{-1} in surface sediments, with the highest concentrations measured at stations 1N and 3N (412.6 and 414.1 ng·g^{-1}, respectively). The concentration of 414.1 ng·g^{-1} reported for Station 3N in 1998, was the average of three field replicates measured at 220.85, 399.22 and 622.95 ng·g^{-1}. This high station variability along with the fact that low concentration samples were collected nearby at Stations 2C, 2N and 3C (all <40 ng·g^{-1}) indicate an extremely heterogeneous distribution of PCB at the west end of the creek. Surface distribution of total PCB measured in 1998 is shown throughout the creek in Figure 6-5. Concentrations also varied between surveys, with a distinct downward trend for the most contaminated stations. Stations 1N and 3N had concentrations of 166 and 172 ng·g^{-1}, respectively in October 1999, falling to 126 and 68 ng·g^{-1} in April 2000. Additional sampling is required to verify this downward trend. In the 1998 survey, total PCB concentrations east of 3rd Street approximated concentrations measured at reference stations throughout the study (reference mean = 10.2 ng·g^{-1}), indicating that PCBs at the creek end are not significantly transported to the creek mouth and bay. The distribution of total PCB, like total PAH, was significantly correlated with TOC (Table 6-4). Summary statistics for total PCB in surface sediments including concentration mean and range are shown

in Table 6-9. Results from the 1998 survey indicated that all PCBs were present in approximately equal concentrations of Aroclor 1254 and 1260. Total Aroclor concentrations were approximately double those measured for total PCB, which was based on 18 out of 209 possible PCB congeners. Aroclors were not quantified in the following two surveys.

Table 6-9. Islais Creek – pesticides and total PCB in surface sediments, all studies combined (ng·g^{-1}, ppb dry weight).

Parameter	Minimum	Maximum	Maximum Station	Mean	ERM[1]	Reference Mean
Transects 1-3 (21 stations)						
Total DDT	10.8	86.6	1N	32.9	NA	5.67
Total Chlordane	2.9	79.0	1N	21.4	6[#]	0.90
Dieldrin	0.5	34.3	3N	7.3	8[#]	0.70
Total PCB	31.4	*414.1	3N	148.0	180[&]	10.16
Transects 4-6 (1998 only - 9 stations)						
Total DDT	7.1	12.1	4C	9.6	NA	5.67
Total Chlordane	0.3	2.1	4N	1.4	6[#]	0.90
Dieldrin	1.2	1.8	5S	1.5	8[#]	0.70
Total PCB	14.0	25.7	4S	18.4	180[&]	10.16

[&]=source Long et al. (1995); [#]=source Long & Morgan (1991);*=average value for 3 field replicates: 220.8, 399.2, 622.9

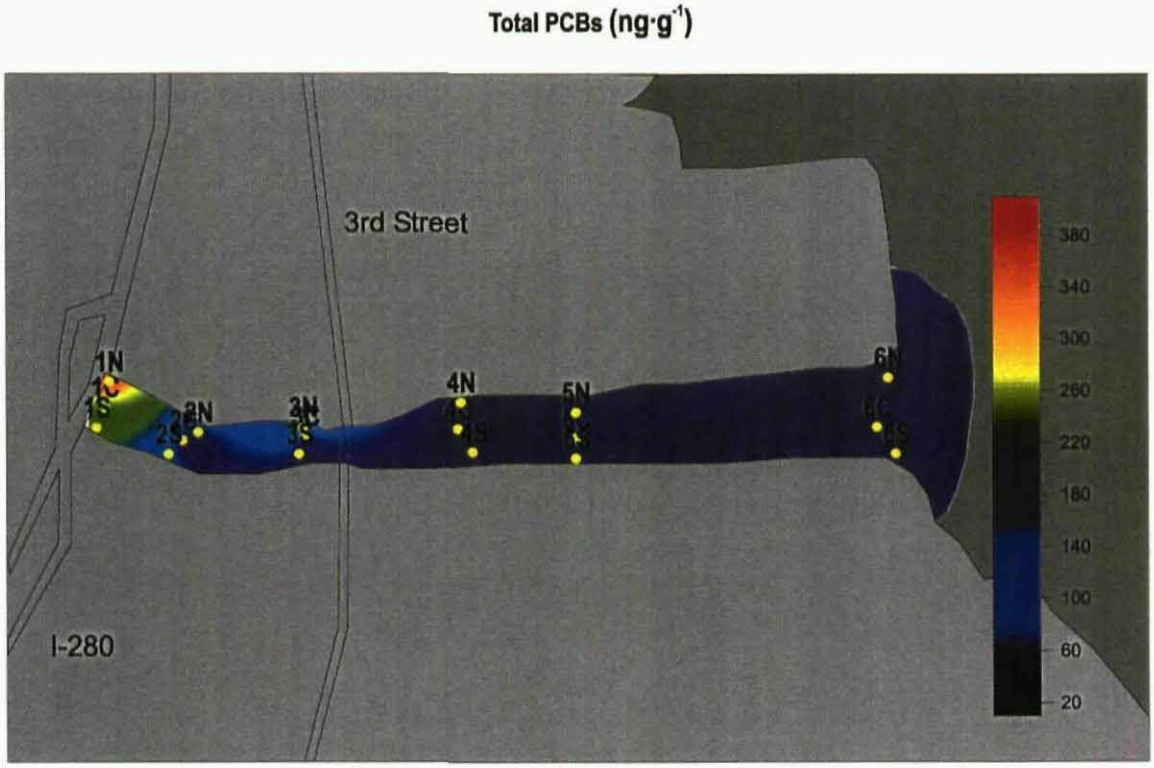

Figure 6-5. Distribution of Total PCB at Islais Creek – October 1998.

Subsurface sediments In general, total PCB concentrations increased with depth and decreased with distance from the creek end, returning to background surface concentrations in the 0-1 and 1-2 ft core segments collected east of the 3rd Street Bridge (Table 6-8, Figure 6-6). Core segments deeper than 2 ft were not analyzed east of the bridge.

The highest concentrations were measured at Station 1C, located at the center of the creek end near the historical CSO (Table 6-8), ranging from 342.2 to 599.8 $ng \cdot g^{-1}$ in the 0-1 and 2-3 ft core segments, respectively. The only other core segments with concentrations greater than 100 $ng \cdot g^{-1}$ were collected below 2 ft at Stations 2N and 3S.

6.3.4 Islais Creek Organochlorine Pesticides

Many individual pesticide compounds were below laboratory detection limits (usually <0.5 $ng \cdot g^{-1}$), including Aldrin, Endrin, Lindane, Mirex, and certain individual Chlordane and DDT isomers. Total DDT (including DDE and DDD isomers), total Chlordane and Dieldrin were routinely detected at concentrations exceeding 10 $ng \cdot g^{-1}$, usually at stations with correspondingly high TOC concentrations (e.g., >2%). Like metals and total PCB, the most elevated pesticide concentrations were measured at Station 3N. Summary results for DDT, Chlordane and Dieldrin in surface sediments are presented in Table 6-9. Distributions of these compounds in surface sediments are shown in Appendix A4.

Subsurface concentrations generally increased with depth and decreased with distance from the creek end. Subsurface distributions for total Chlordane are shown in Figure 6-6; other pesticide distributions are shown in Appendix A5. Station 1C had the highest concentrations of Chlordane, DDT and Dieldrin of all core segments measured (Table 6-10).

Table 6-10. Islais Creek - mean concentrations of total Chlordane, total DDT and Dieldrin in subsurface sediments ($ng \cdot g^{-1}$, ppb dry weight).

	Total Chlordane		Total DDT		Dieldrin	
Depth	Mean	Max. Station; Concentration	Mean	Max. Station; Concentration	Mean	Max. Station; Concentration
0-1 ft	13.3	1C; 60.8	41.9	1C; 181.5	7.4	1C; 30
1-2 ft	16.9	1C; 75.8	34.6	1C; 129.7	9.7	1C; 35
2-3 ft	42.8	1C; 91.0	71.5	1C; 134.9	7.7	1C; 14
3-4 ft	53.2	1C; 98.0	73.5	1C; 124.4	8.8	1C; 15

Total DDT. Total DDT averaged 32.9 $ng \cdot g^{-1}$ in surface sediments, with a maximum of 86.5 $ng \cdot g^{-1}$ at the creek end, near the Selby Street CSO (Station 1N). Total DDT also was elevated near the CSO Weir (Station 3N) in the October 1999 dry survey only. The major compounds contributing to total DDT were breakdown products 4,4-DDD and 4,4-DDE (Appendix A1), indicating weathered sources of this relic pesticide. There was little variation in between surveys, except that elevated concentrations observed at Station 1N in 1998 and 2000, were considerably reduced in October 1999 (a dry event). Subsurface sediments had higher total DDT concentrations than surface sediments, with a maximum concentration of 181.5 $ng \cdot g^{-1}$ measured in the 0-1 ft core at Station 1C. Unlike most other contaminants, increased concentrations with depth were not observed for DDT, indicating fairly consistent inputs over time, even though this pesticide was banned nearly 30 years ago.

All sediments had total DDT concentrations far below the RWQCB approved criterion of 100 $\mu g \cdot g^{-1}$ organic carbon (adopted from Schwartz et al. [1994]). DDT concentrations were highly correlated with sediment TOC levels ($r=0.85$, $p<0.001$), indicating that the most elevated concentrations of DDT may not be readily available to benthic organisms (Schwartz et al. 1994).

Total Chlordane. Total Chlordane concentration averaged 21.4 $ng \cdot g^{-1}$ in surface sediments collected west of the 3rd Street Bridge and 13.5 $ng \cdot g^{-1}$ throughout the entire creek. The highest surface concentration was measured in 1998 at Station 1N at 79 $ng \cdot g^{-1}$. Concentrations in all creek-end surface sediments (Transects 1-3) were elevated compared with east-end creek (Transects 4-6) and reference area sediments. Much higher subsurface concentrations were measured in the deeper core segments collected west of the 3rd Street Bridge (Figure 6-6). However, concentrations returned to reference area levels in the shallower depths (0-2 ft) throughout the creek, except at Station 1C.

The most prevalent isomers of Chlordane were alpha- and gamma-Chlordane, and trans-Nonachlor. Heptachlor and Heptachlor epoxide were not found above detection limits (ca. 0.5 $ng \cdot g^{-1}$). Chlordane, like other non-polar organic compounds, has high affinity for organic matter, as indicated in Table 6-4. Therefore, higher concentrations are expected in sediments with high TOC, providing a contaminant source exists. Use of a TOC-normalized criterion for total Chlordane might help explain why Station 1N (highest in total Chlordane) had the highest amphipod survival (83%) of all creek sediments in 1998.

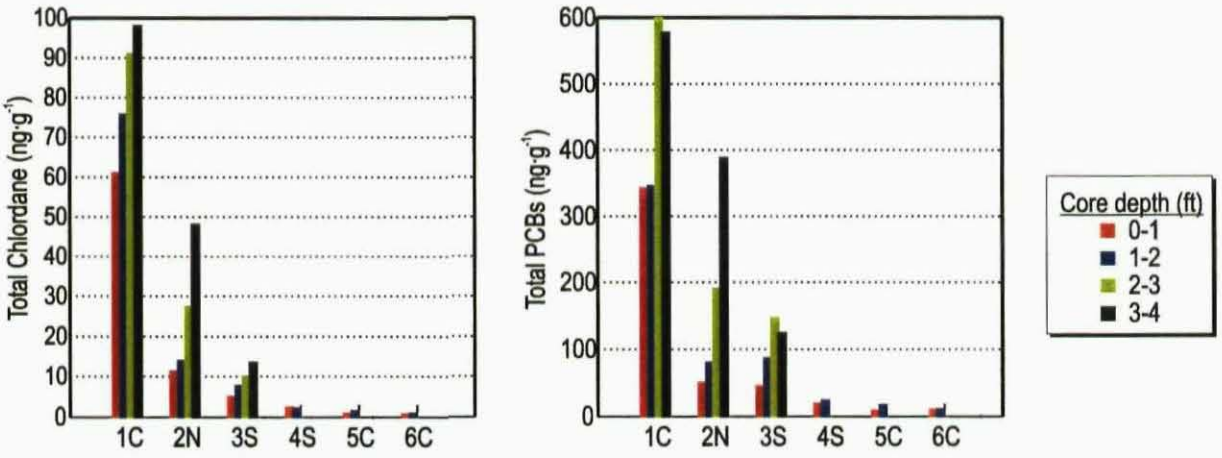

Figure 6-6. Subsurface concentrations of total Chlordane and total PCB at Islais Creek – October 1998.

Dieldrin. The average concentration of Dieldrin in surface samples was 7.3 $ng \cdot g^{-1}$, with a maximum of 34.3 $ng \cdot g^{-1}$ measured at Station 3N. Dieldrin had an ERM value of 8 $ng \cdot g^{-1}$ (Long and Morgan 1991), which was dropped from the 1995 listing do to lack of confidence in the previously published ERM value. Concentrations were substantially reduced in sediments east of the 3rd Street Bridge (see Appendices A1 and A4).

Subsurface core concentrations were significantly elevated compared with surface concentrations at Station 1C only. All other core segments were below 10 $ng \cdot g^{-1}$. A maximum of 35 $ng \cdot g^{-1}$ was recorded from the 0-2 ft segment from the creek center, near the Shelby Street overflow at the creek end (Station 1C) in 1998. Reduced surface concentrations indicate reduced inputs of Dieldrin in recent sediment deposits. Dieldrin, like DDT and Chlordane, was significantly correlated with sediment TOC (Table 6-4).

6.3.5 Islais Creek Chemicals of Potential Concern (COPCs)

Chemicals of potential concern were identified from the 16 individual or summary compounds used in the BPTCP. For 1998 data, 13 "compounds" from this list were used to calculate an ERM quotient for each station following BPTCP guidelines, modified as described in Section 1.2.4, where any compound or compound group (e.g., PCBs) with an ERM quotient greater than 0.5 (i.e., concentration > one-half of the ERM) was retained as a preliminary COPC. Chemicals without an ERM were retained as preliminary COPCs if creek concentrations were greater than the corresponding concentration measured at Paradise Cove.

Sediment COPCs were evaluated using TOC-normalized data (i.e., ng or µg chemical per gram TOC). For 1998 data, both creek concentrations and ERMs were TOC-normalized for comparison, where a 1% TOC concentration was assumed for ERM values (see Long et al. 1995). For 1999 and 2000 data, any compound or compound group greater than the 95th UPL (see Table 6-3) calculated using corresponding reference station data was retained as a preliminary COPC. Chemicals were retained as final COPCs if they exceeded either of these criteria at any station in at least two of the three surveys. Additional studies, such as ecological risk assessments, are necessary to determine whether elevated contaminant concentrations are biologically meaningful. This is especially important in the case of metals and PAH, where nearly all creek concentrations were statistically elevated compared to reference conditions; however, very few analytes exceeded one-half the ERM criterion when TOC-normalized.

The remaining chemicals, consisting entirely of chlorinated compounds (e.g., pesticides and PCBs), were elevated in relation to reference sediments and one-half the ERM. DDT was the only chlorinated contaminant that was statistically elevated compared to reference sediments but well below the 1998 numeric criterion – a normalized value published by Schwartz et al. (1994) of 100 $\mu g \cdot g^{-1}$ organic carbon. This inconsistency is due to the fact that TOC-normalized criterion for DDT is 2-4 orders of magnitude greater than ERM values for other chlorinated compounds. TOC-based criteria for sediment contaminants exist and are in use in other regulatory programs (e.g.,Washington Department of Ecology); however, DDT is the only compound routinely evaluated in this manner in San Francisco Bay regulatory programs.

Chemicals that were elevated in sediments and known to bioaccumulate in the food web were further evaluated using 28-day clam bioaccumulation tests. Bioaccumulation results are discussed in Section 7.

Chemicals of potential concern for Islais Creek are shown in Table 6-11, which displays exceedance factors for each station based on either one-half the ERM (1998 data) or the reference area UPL (1999 and 2000 data). For example, the value displayed for lead at Station 1N in 1999 indicates that the lead concentration was 7.83 times greater than the 95th UPL calculated using 1999 combined reference station data for TOC-normalized lead; and the 1998 lead concentration was 0.66 times one-half the ERM value of 109 $\mu g \cdot g^{-1}$ sediment or 10,900 $\mu g \cdot g^{-1}$ TOC (i.e., 1%).

All stations west of the 3rd Street Bridge had four or more COPCs, with Chlordane, DDT, PCBs and PAHs the most ubiquitous. Three metals - cadmium, lead and zinc, qualified as COPCs; however, only zinc was elevated east of Transect 1. Chlordane, DDT, PCBs and mercury were further evaluated for bioaccumulation potential in 28-day bioaccumulation tests (Section 7).

Although preliminary COPCs are statistically elevated at creek stations compared to the reference area or one-half of the ERM value, additional studies, such as ecological risk assessments, are necessary to determine whether concentrations are sufficient to negatively impact the local ecology.

Table 6-11. Islais Creek - Surface sediment COPCs and corresponding ratios for station concentrations and corresponding guideline values.

COPC	Survey Year	1N*	1S*	2N*	2S*	3N*	3S*
Cadmium	1998	0.08	0.17	0.06	0.05	0.11	0.07
	1999	**3.33**	**1.98**	0.68	0.85	**1.45**	0.86
	2000	0.57	**1.23**	**1.14**	0.65	0.51	0.72
Lead	1998	0.66	1.97	0.16	0.17	0.37	0.17
	1999	**7.83**	**6.78**	0.53	0.69	**1.33**	0.62
	2000	**2.29**	**12.43**	**1.32**	**1.19**	0.86	**1.22**
Zinc	1998	1.47	1.00	0.39	0.36	0.49	0.46
	1999	**1.54**	**1.4**	0.43	0.51	0.79	0.54
	2000	0.66	**1.55**	0.87	0.83	0.71	0.98
LMW PAH	1998	0.42	0.16	0.49	0.29	0.45	0.39
	1999	**1.32**	**1.28**	**4.9**	**3.8**	**3.79**	**3.83**
	2000	0.7	**1.33**	**9.4**	**3.15**	**4.96**	**9.83**
HMW PAH	1998	0.18	0.24	0.93	0.46	0.68	0.52
	1999	**1.25**	**1.21**	**5.37**	**3.03**	**4.28**	**3.17**
	2000	**4.09**	**1.17**	**9.45**	**2.58**	**4.82**	**5.84**
Total Chlordane	1998	0.27	10.2	1.1	1.9	4.4	0.85
	1999	**1.16**	**26.6**	**4.67**	**9.19**	**14.35**	**4.71**
	2000	**1.82**	**78.0**	**48.7**	**29.2**	**21.1**	**38.1**
Total DDT	1998	5.46	0.02	0.01	0.01	0.02	0.01
	1999	**22.5**	**3.74**	0.97	**1.53**	**2.06**	**1.01**
	2000	**51.4**	**1.82**	**1.06**	0.77	0.7	0.99
Dieldrin	1998	0.02	2.34	0.55	0.8	2.39	0.48
	1999	**2.39**	0.09	0.08	0.58	0.82	0.48
	2000	**1.2**	**9.39**	**8.5**	**6.01**	**5.49**	**12.83**
Total PCB	1998	1.76	2.02	0.25	0.58	1.28	0.21
	1999	0.93	**13.6**	**1.47**	**1.96**	**3.97**	**1.56**
	2000	**7.24**	**13.7**	**2.79**	**2.40**	**1.91**	**3.04**

Red > 0.5 x ERM (1998 only); **Bold** > reference upper 95% predictive limit (1999 & 2000); *=recurrent contamination measured in ≥2 surveys

6.4 MISSION CREEK

Sediments were sampled at 13 locations in 1998, spanning from the creek end (Transect 1) to the mouth (Transect 6). Transects 1-4, consisting of eight stations located from the creek end to the west side of the 4th Street Bridge, were resampled in 1999 and 2000. Sampling locations are shown in Figure 3-2, Section 3 for all surveys.

In general, surface sediment chemical concentrations measured east of 5th Street (Transects 4-6) and more often east of 4th Street (Transects 5-6) were commensurate with sediment concentrations measured at in-bay reference stations. Chemical distribution patterns in surface sediments were fairly consistent over time, with the highest concentrations measured near the CSO structures at 6th Street, approximately 150 m from the main CSO. Most chemical concentrations decreased with distance from the CSOs located at 6th and Berry Streets, and the Interstate 280 overpass, except for HMW PAH, which displayed elevated concentrations in sediments adjacent to creosote-soaked pier pilings located between 5th and 4th Streets (Transects 3 and 4). Surface sediment distributions of key chemicals are shown for each survey in Appendix B4. In general, chemical concentrations increased significantly with depth, indicating that buried contaminants are most likely in-place and that inputs have diminished over time. Subsurface distribution plots for key chemicals are shown in Appendix B5 for 1-ft core intervals sampled from 0-4 ft depth in October 1998.

Many organic as well as inorganic contaminant concentrations were significantly and positively correlated with TOC as shown in Table 6-12. Inverse relationships were observed for grain size (percent fines), as all significant correlations indicated a decrease in contaminant concentration with increasing percent fines (i.e., r<0).

Table 6-12. Mission Creek - correlation results for selected chemicals with TOC and grain size.

	Copper	Mercury	Lead	Zinc	Total DDT	Dieldrin	HMW PAH	LMW PAH	Total PAH	Total PCB	Total Chlordane
Percent Fines											
r	-0.18	-0.38	**-0.56**	**-0.52**	-0.27	**-0.49**	-0.19	**-0.55**	-0.32	**-0.46**	-0.26
p	0.35	0.05	<0.001	<0.001	0.16	0.01	0.33	<0.001	0.10	0.01	0.17
TOC											
r	**0.59**	**0.43**	**0.42**	**0.60**	**0.40**	**0.72**	**0.39**	0.14	0.33	**0.44**	0.36
p	<0.001	0.02	0.02	<0.001	0.03	<0.001	0.04	0.47	0.08	0.02	0.06

r=correlation coefficient; p=probability level; significant correlations (p<0.05) are shown in **bold**

6.4.1 Mission Creek Metals

Surface results. Concentrations of mercury, lead, nickel, silver and zinc exceeded their corresponding ERM value at several stations in all three surveys. Overall, the highest concentrations were found at Transects 1 and 2, located at the west end of the creek. Although highest at the creek end, concentrations of lead and mercury were extremely variable between stations and surveys. For example, at Station 2S, mercury was 3.76 $\mu g \cdot g^{-1}$ in 1999, and 0.72 and 0.84 $\mu g \cdot g^{-1}$ in 1998 and 2000, respectively. Mercury, lead, zinc and silver were highest in October 1999, a dry event, at Station 2N (Table 6-13, Figure 6-7).

Selenium concentrations ranged from 0.10 to 0.88 $\mu g \cdot g^{-1}$, with an average concentration of 0.38 $\mu g \cdot g^{-1}$. Selenium concentrations below 0.33 $\mu g \cdot g^{-1}$ are reported as uncontaminated background for San Francisco Bay sediments (Walters and Gartner 1985). The ERM for nickel at 51.6 $\mu g \cdot g^{-1}$, was exceeded at nearly all stations; however, nickel is generally not considered a COPC, as naturally elevated concentrations are found in non-toxic sediments throughout San Francisco Bay (Hunt et al. 1998a).

Most metals, including cadmium, copper, lead, mercury, silver and zinc were significantly correlated with sediment TOC. Correlation coefficients for selected metals are shown in Table 6-12. Like Islais Creek, sediments in Mission Creek with the highest concentrations of TOC also displayed the highest metal concentrations. TOC concentrations in Transects 2 and 3 were consistently greater than 2%, ranging up to 4.5% at Station 2N.

October 1998 surface distributions for lead, mercury and zinc throughout the creek are shown in Figure 6-7. Surface distributions for these and other metals for all surveys are shown in Appendix B4.

Table 6-13. Mission Creek Transects 1-4 (24 stations) surface sediment metal concentrations ($\mu g \cdot g^{-1}$, ppm dry weight).

Metal	Minimum	Maximum	Maximum Station	Mean	Standard Deviation	ERM[1]	Reference Mean[2]
Arsenic	5.5	17.72	4N	10.54	2.83	70	6.98
Cadmium	0.63	2.94	2N	1.57	0.5	9.6	0.32
Chromium	82	124	4S	103.28	12.19	370	96.4
Copper	89.6	161	2S	127.99	19.72	270	38.1
Lead	90.1	858.3	2N	296.27	170.11	218	18.0
Mercury	0.55	5.37	2N	1.47	1.18	0.71	0.23
Nickel	50.6	104	3N	81.15	15.95	51.6	86.7
Selenium	0.1	0.88	3N	0.38	0.2	NA	0.25
Silver	0.87	6.29	2N	3.18	1.53	3.7	0.52
Zinc	210	678.6	2N	377.41	105.40	410	103.2

[1]=source Long et al. (1995); [2]=mean reference site concentration for all surveys

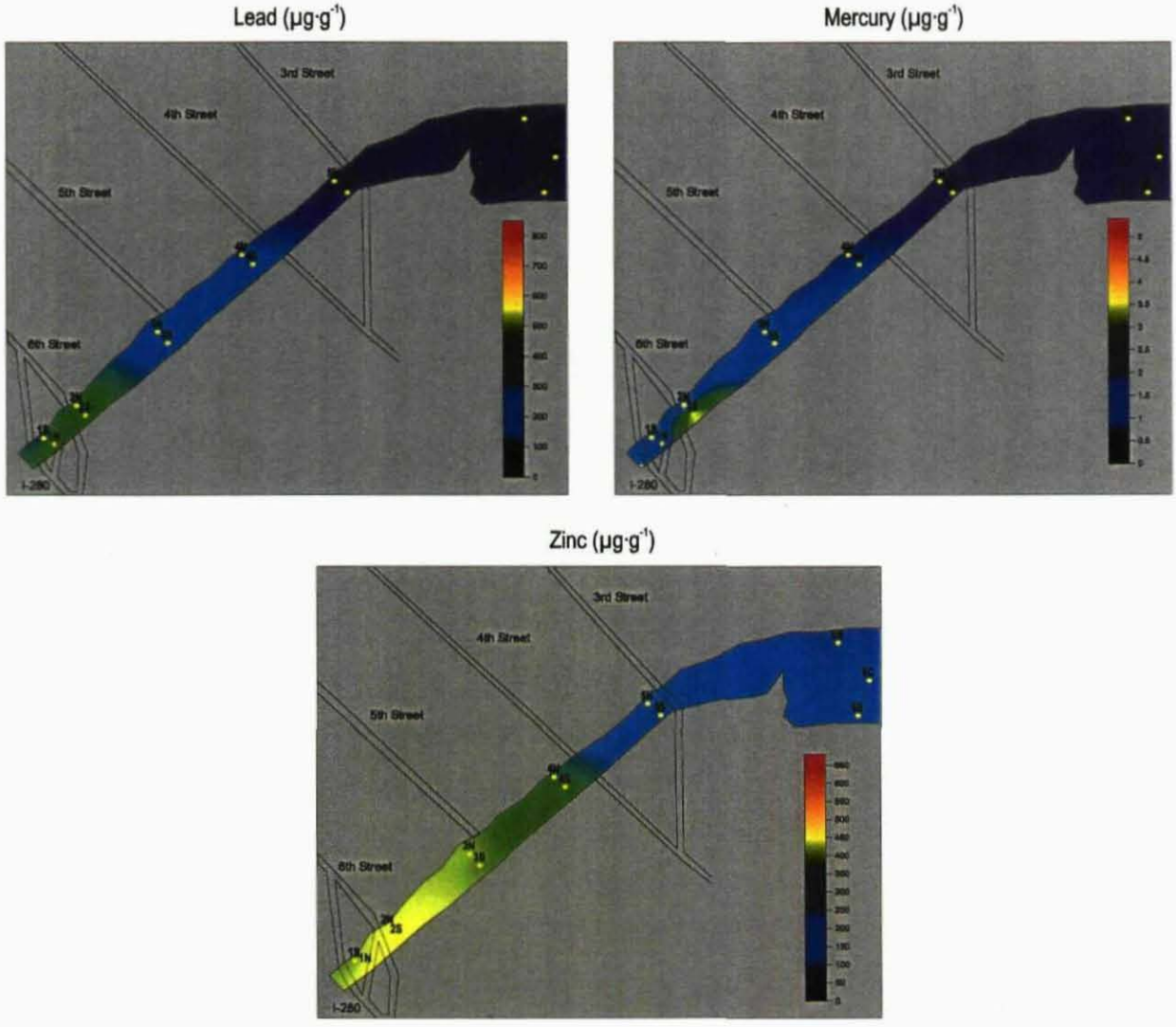

Figure 6-7. Distribution of lead, mercury and zinc at Mission Creek – October 1998.

Subsurface results. Mission Creek subsurface sediments displayed similar metal distributions to those measured in Islais Creek, with concentrations generally increasing with depth and decreasing with distance from the CSOs at 6th and Berry Streets, and the Interstate 280 overpass. Representative vertical profiles for lead and zinc are shown in Figure 6-8. Plots for other key metals are shown in Appendix B5.

The highest concentrations of lead, mercury and zinc were measured in the 3-4 ft interval at Station 2S (Table 6-14). Concentrations of these and other metals were commensurate with in-bay surface sediment reference concentrations in the 0-1 and 1-2 ft intervals, east of 4th Street, where deeper cores were not analyzed. Concentrations in the shallower cores were significantly lower, with the most dramatic decreases observed above 2 ft, indicating substantial decreases in metal inputs over time west of 4th Street. Concentrations of arsenic, chromium and nickel were fairly consistent across stations and depths, indicating no obvious anthropogenic inputs of these metals to creek sediments. Other metals, including

silver and selenium also were fairly stable, with the exception of localized spikes at the 2-4 ft depth at Transects 2 and 3 (see Appendix B5). Concentrations of aluminum and iron decreased significantly west of 6th Street, indicating an abrupt change in sediment mineralogy at the creek end. These metals, generally not considered contaminants, are used to identify various geological origins of sediment metals. Aluminum/metal relationships are evaluated to identify potential sources of elevated metals in Section 8.

Table 6-14. Mission Creek - mean concentrations of lead, mercury and zinc in subsurface sediment ($\mu g \cdot g^{-1}$, ppm dry weight).

	Lead		Mercury		Zinc	
Depth	Mean	Max. Station; Concentration	Mean	Max. Station; Concentration	Mean	Max. Station; Concentration
0-1 ft	202.0	1N; 372.0	0.76	3N; 1.28	295.8	3N; 455.0
1-2 ft	321.3	1N; 597.0	1.06	1N; 1.60	358.5	2S; 626.0
2-3 ft	1140.8	2S; 1646.5	2.40	2S; 3.77	781.5	2S; 1250.9
3-4 ft	1564.9	2S; 2362.7	3.74	2S; 6.27	893.1	2S; 1288.6

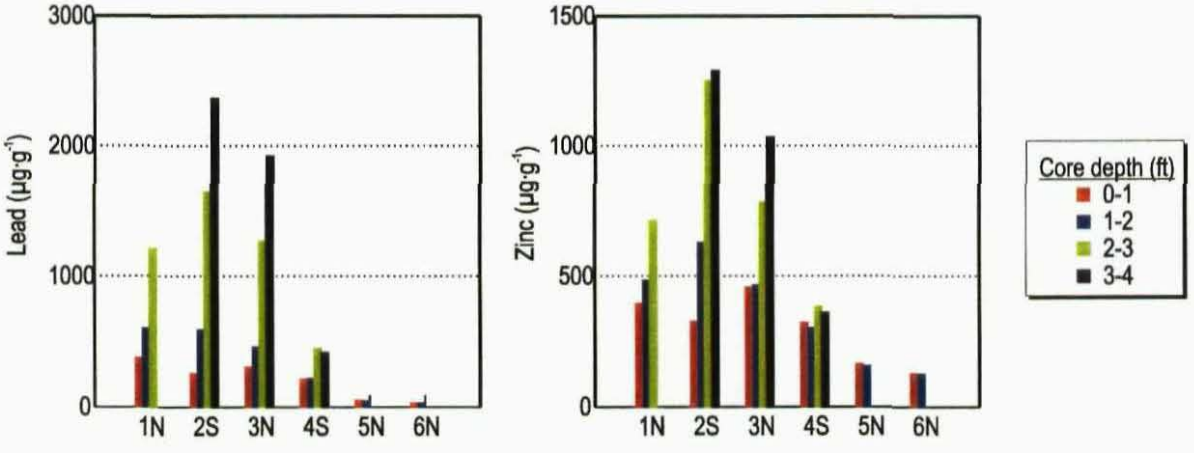

Figure 6-8. Subsurface concentrations of lead and zinc at Mission Creek.

6.4.2 Mission Creek Polycyclic Aromatic Hydrocarbons (PAH)

Surface results. Concentrations of PAH, like metals, in Mission Creek surface sediments varied considerably as a function of location, sediment type and TOC concentration. Higher relative concentrations of HMW PAH compared to LMW PAH were measured in all surface sediments. Mean concentrations were 2826 and 9741 $ng \cdot g^{-1}$, respectively, for LMW and HMW PAH measured in Transects 1-4 in all surveys (Table 6-15). PAH concentrations were consistently elevated at Stations 1N and 4S in all three surveys; however, distributions of individual PAH compounds indicated different contaminant sources for these two areas (see Section 8 for discussion on PAH source). Although

Stations 1N and 4S had consistently high PAH concentrations, high concentrations of TOC (i.e., > 2%) were measured only in 1998. A weak, but significant correlation was observed between TOC and HMW PAH only, using all station data (Table 6-12).

Figure 6-8 shows the horizontal distribution of LMW- and HMW-PAH in 1998, where both groups were elevated at the creek origin near the main CSO (Transect 1) and at 4th Street, primarily on the south side. Surface sediment concentrations east of the 4th Street Bridge (Transects 5 & 6) remained elevated in relation to reference sediments; however, these sediments were much lower than corresponding ERM values for LMW- and HMW-PAH (Table 6-15).

Table 6-15. Mission Creek - PAH in surface sediments, all studies combined (ng·g^{-1}, ppb dry weight).

Parameter	Minimum	Maximum	Maximum Station	Mean	ERM[1]	Reference Mean
Transects 1-4 (24 stations)						
LMW PAH	655	11,492	1N	2826	3160	118
HMW PAH	3140	23,390	1N	9741	9600	562
Transects 5-6 (5 stations)						
LMW PAH	441	690	5N	587	3160	118
HMW PAH	1451	2919	5S	2187	9600	562

[1]=source Long et al. (1995)

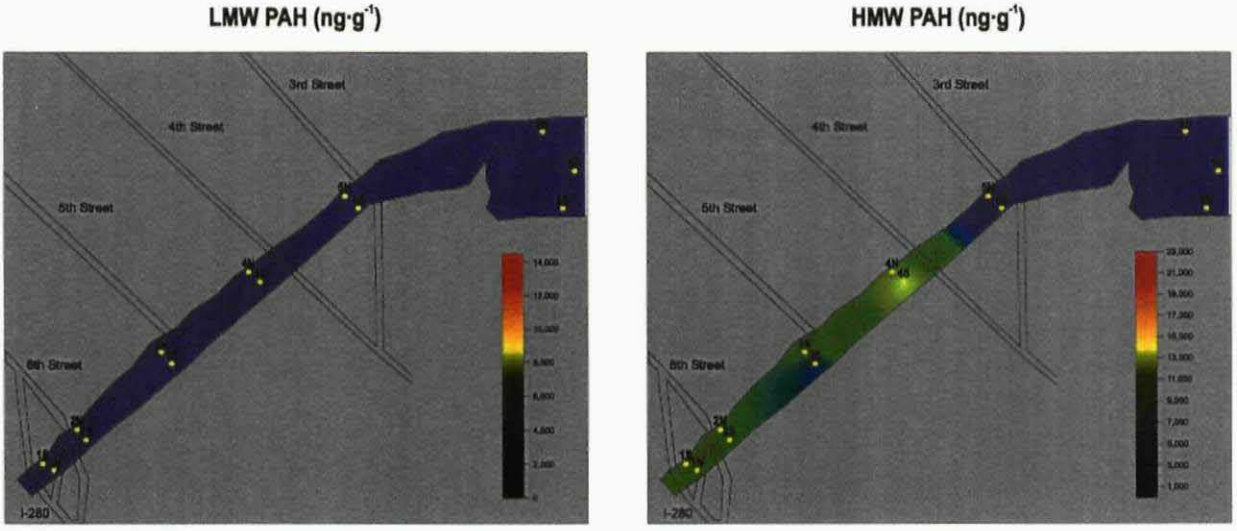

Figure 6-9. Distribution of LMW and HMW PAH at Mission Creek – October 1998.

Subsurface results. In general, concentrations of most PAH compounds, including summary compounds LMW- and HMW-PAH increased with depth and decreased with distance from Transect 2, located near the creek end; however, these trends were much more pronounced for LMW compounds (Figure 6-10). Concentrations of LMW PAH were especially elevated at Stations 2S and 3N, reaching a maximum concentration of 13,930 ng·g^{-1} in the 3-4 ft core segment at Station 2S. All of the subsurface cores

collected from 0-2 ft depth had LMW PAH concentrations below the ERM guideline (i.e., <3160 ng·g^{-1}); however, concentrations in the deeper cores were substantially higher, particularly near the creek end. Concentrations of HMW PAH were elevated across all depths in cores collected west of the 4th Street Bridge, with the highest concentrations measured in the deeper cores at Stations 2N, 3N and 4S. Subsurface sediment distributions indicate that diminishing but chronic inputs of varying PAH sources exist near the 6th and Berry Street CSO (Station 2S) and between Transects 3 and 4 (most likely from creosote-soaked pier pilings), as corresponding surface sediments had elevated concentrations as well. Potential PAH sources to these sediments are evaluated using chemical fingerprinting methods in Section 8.

Table 6-16. Mission Creek - mean concentrations of LMW PAH, HMW PAH and total PCB in subsurface sediments (ng·g^{-1}, ppb dry weight).

Depth	LMW PAH		HMW PAH		Total PCB	
	Mean	Max. Station; Concentration	Mean	Max. Station; Concentration	Mean	Max. Station; Concentration
0-1 ft	1344	1N; 2974	5428	3N; 9520	202.9	1N; 390.2
1-2 ft	1507	3N; 2850	5803	3N; 9890	292.3	3N; 570.8
2-3 ft	4648	2S; 8945	14,122	4S; 18,480	923.4	2S; 1471.9
3-4 ft	7462	2S; 13,930	11,570	2S; 16,280	1598.0	3N; 2760.4

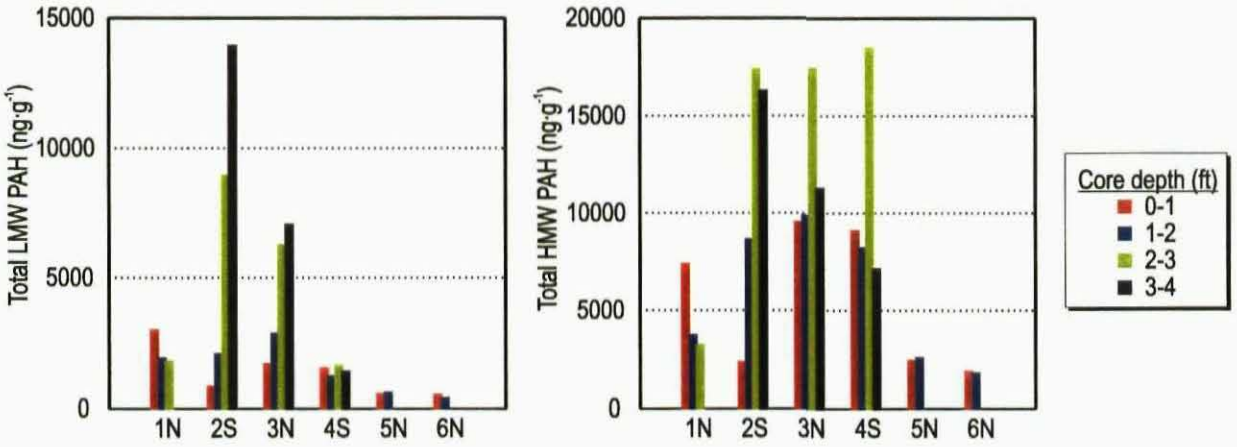

Figure 6-10. Subsurface concentrations of LMW- and HMW-PAH at Mission Creek – October 1998.

6.4.3 Mission Creek Polychlorinated Biphenyls (PCB)

Surface results. Horizontal distributions of total PCB in Mission Creek were similar to those observed for PAH, varying considerably as a function of location, sediment type and TOC concentration. Total PCB sediment concentrations ranged from 13.3 to 869.9 ng·g^{-1} throughout the creek, with the highest concentrations measured at the creek end (Transects 1 & 2). Figure 6-11 (left) shows the surface

distribution of total PCB measured in October 1998 throughout the creek. Surface distributions for sediments sampled in 1999 and 2000 are shown in Appendix B4. The mean total PCB concentration for sediments collected east of 4th Street was approximately double (25.2 $ng \cdot g^{-1}$) the mean concentration measured at in-bay reference stations for all surveys (10.16 $ng \cdot g^{-1}$), although concentrations were more than an order of magnitude (ca. 10x) lower than those measured west of 4th Street. Transect 6 concentrations were commensurate with in-bay reference areas, indicating that little, if any creek end PCBs are transported to the creek mouth and bay. The distribution of total PCB, like PAH, was significantly correlated with TOC (Table 6-12). Range and mean concentrations of total PCB measured in creek and reference area surface sediments in all three surveys are shown in Table 6-17.

Results from the 1998 survey indicated that all PCBs were present in approximately equal concentrations of weathered Aroclor 1254 and 1260. Total Aroclor concentrations were approximately double those measured for total PCB, which was based on 18 out of 209 possible PCB congeners. PCB congeners, but not Aroclors, were quantified in the following two surveys.

Table 6-17. Mission Creek – total PCB and selected pesticides in surface sediments, all surveys combined ($ng \cdot g^{-1}$, ppb dry weight).

Parameter	Minimum	Maximum	Maximum Station	Mean	Guideline Value	Reference Mean (all surveys)
Transects 1-4						
Total DDT	23.4	229	2N	71.4	NA	5.67
Total Chlordane	15.5	306	2N	71.6	6[1]	0.90
Dieldrin	0.5	60	1S	16.6	8[1]	0.7
Total PCB	107.3	870	2N	337.0	180[2]	10.16
Transects 5-6 (1998 only)						
Total DDT	7.8	18.4	5S	11.7	NA	5.67
Total Chlordane	0.6	6.6	5S	2.7	6[1]	0.90
Dieldrin	1.2	4.7	5S	2.4	8[1]	0.70
Total PCB	13.3	46.3	5S	25.2	180[2]	10.16

[1]=source Long & Morgan (1991); [2]=source Long et al. (1995)

Subsurface results In general, the vertical distribution of total PCB concentrations in sediments increased with depth and distance from Transects 1 through 3, where a maximum concentration of 2760 $ng \cdot g^{-1}$ was measured in the 3-4 ft core segment at Station 3N (Figure 6-11, right). Overall concentrations decreased rapidly east of the 4th Street Bridge (Station 4S) (mean=38.5 $ng \cdot g^{-1}$), following trends observed for other subsurface contaminants.

Subsurface PCB concentrations were highest in the deeper cores at all stations, except 1N. Concentrations greater than 1000 $ng \cdot g^{-1}$ were measured in the 2-3 and 3-4 ft core segments at Stations 2S and 3N (Figure 6-11). However, concentrations measured in the 0-1 and 1-2 ft core segments were fairly consistent west of 4th Street, averaging 202.9 and 293.3 $ng \cdot g^{-1}$, respectively. The maximum concentration measured in the 0-1 ft core segment was 390 ($ng \cdot g^{-1}$) at Station 1N, where a higher surface maxima was also recorded in 1998.

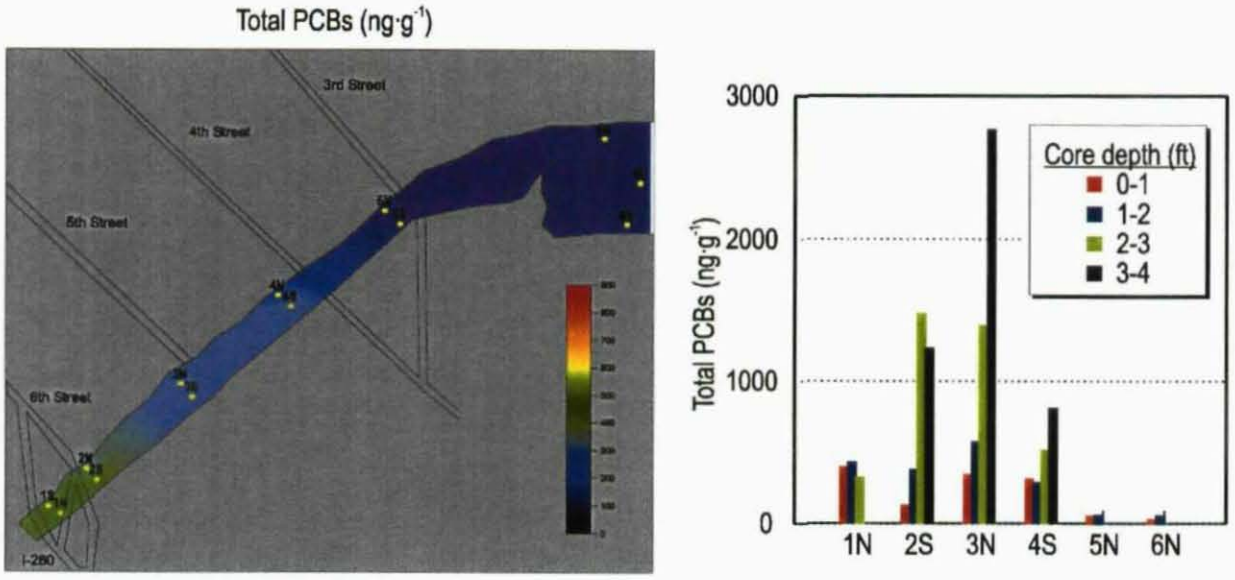

Figure 6-11. Surface and subsurface distributions of total PCB at Mission Creek – October 1998.

6.4.4 Mission Creek Organochlorine Pesticides

Many of the individual pesticide compounds were present at trace concentrations near the detection limit (usually < 0.5 ng·g^{-1}), including Aldrin, Endrin, Lindane, Mirex, and many of the individual Chlordane and DDT isomers. Total DDT, total Chlordane and Dieldrin were routinely measured at concentrations exceeding 1 ng·g^{-1}; however, all but total Chlordane were significantly correlated with TOC (Table 6-12). Surface sediment concentrations varied widely across surveys, with the greatest concentrations of DDT and Chlordane occurring in the 1998 and 2000 wet weather surveys. The highest concentrations of Dieldrin, the only other significantly elevated organochlorine pesticide, also were detected in October 1998 during wet weather. However, significantly decreased concentrations were measured in the following two surveys.

Subsurface maxima for all compounds were measured in the deeper cores at either 6th or 5th Street (Transects 2 or 3) near the creek end. Summary results for surface and subsurface sediments for selected pesticides are presented in Tables 6-17 and 6-18, respectively.

Table 6-18. Mission Creek - mean concentrations of total Chlordane, total DDT and Dieldrin in subsurface sediments (ng·g^{-1}, ppb, dry weight).

Depth	Total Chlordane		Total DDT		Dieldrin	
	Mean	Max. Station; Concentration	Mean	Max. Station; Concentration	Mean	Max. Station; Concentration
0-1 ft	41.1	1N; 94.2	63.0	4S; 107.5	20.8	3N; 40
1-2 ft	87.2	1N; 201	67.1	2S; 171.6	26.7	3N; 62
2-3 ft	362.1	3N; 626	274.6	2S; 510.3	44.3	2S; 93
3-4 ft	679.7	3N; 922	423.9	2S; 645.2	71.0	3N; 120

DDT. Total DDT averaged 44.6 $ng \cdot g^{-1}$ in surface sediments, with a maximum of 228 $ng \cdot g^{-1}$ at Station 2N, near the 6th and Berry Street CSO. Following patterns observed in Islais Creek, the major DDT metabolites contributing to total DDT were weathered 4,4-DDD and 4,4-DDE isomers (Appendix B1). Total DDT concentrations of 60 $ng \cdot g^{-1}$ and higher in surface sediments also were recorded at Stations 1N, 2N, 3N and 3S in the creek end west of 5th Street. Subsurface sediments had higher DDT concentrations than surface sediments, averaging 63.0 to 423.9 $ng \cdot g^{-1}$ from core segments of 0-1 to 3-4 ft, respectively. Maximum concentrations of 645.2 and 510.3 $ng \cdot g^{-1}$ were collected from the deeper cores of 2-3 and 3-4 ft at Station 2S. Comparatively lower total DDT concentrations in surface sediments indicate a trend of declining DDT in more recent deposits.

All surface sediments had total DDT concentrations below the BPTCP criterion of 100 $\mu g \cdot g^{-1}$ organic carbon, even in samples containing 1% or less TOC. A maximum total DDT concentration of 229 $ng \cdot g^{-1}$ was measured at Station 2S in April 1999, which had a corresponding TOC concentration of 3.2%. The corresponding sediment dry weight criterion (adopted from Schwartz et al. [1994]) would be 3200 $ng \cdot g^{-1}$ for this sample. DDT was significantly correlated with sediment TOC as indicated in Table 6-12. Further examination showed that stations with greater than 50 $ng \cdot g^{-1}$ total DDT had correspondingly high concentrations of TOC (i.e., >2.5%). However, this relationship was not verified for subsurface sediments collected below 2 ft, as TOC was not measured in these samples.

Chlordane. Total Chlordane concentrations averaged 71.6 and 2.7 $ng \cdot g^{-1}$ in all surface sediments collected from Transects 1-4 and 5-6, respectively. The average concentration for all in-bay reference sediments was extremely low at 0.25 $ng \cdot g^{-1}$. Concentrations measured in the deeper core segments reached 922 $ng \cdot g^{-1}$, averaging 10-100 times most creek surface concentrations (Table 6-18). The highest surface concentration was measured at Station 2N during dry weather in 1999 at 382 $ng \cdot g^{-1}$. The highest concentrations of subsurface Chlordane concentrations were measured west of 5th Street in the 2-3 and 3-4 ft core segments at Station 3N, located adjacent to the CSO Weir. The most prevalent isomers of Chlordane were alpha- and gamma-Chlordane, and trans-Nonachlor. Heptachlor and Heptachlor epoxide were not measured above detection limits (<0.25-0.5 $ng \cdot g^{-1}$) in any creek sediments.

Chlordane, like other nonionic organic compounds, usually has high affinity for organic matter; no significant correlation was observed between total Chlordane and TOC for all Mission Creek surface sediments (Table 6-12); however, the relationship was significant (i.e., $r=0.82$, $p<0.001$) when total Chlordane concentrations exceeded 30 $ng \cdot g^{-1}$.

Dieldrin The average concentration of Dieldrin in surface sediments collected from Transects 1-4 was 16.5 $ng \cdot g^{-1}$, with a maximum of 60 $ng \cdot g^{-1}$ at Station 1S near the creek origin. Similar to other contaminants, concentrations of Dieldrin dropped significantly east of 5th Street, returning to background levels of less than 3 $ng \cdot g^{-1}$ at the creek mouth (Transect 6).

Subsurface sediment concentrations at shallower depths were similar to surface concentrations, averaging 20.8 and 26.7 $ng \cdot g^{-1}$ from the 0-1 ft and the 1-2 ft segments, respectively. Subsurface maxima of 93 and 120 $ng \cdot g^{-1}$ were recorded from the 3-4 ft core at Stations 2S and 3N, respectively. All surface and subsurface concentrations near the creek mouth (Transects 5 and 6) were at or below 5 $ng \cdot g^{-1}$. Dieldrin showed the same pattern as total DDT and total Chlordane, with concentrations generally increasing with depth and decreasing with distance from Transect 2 (Appendix B5).

Other Pesticides. Nearly all other organochlorine pesticides, including Aldrin, Endrin and Mirex had surface sediment concentrations below detection limits (i.e., <0.5 $ng \cdot g^{-1}$). Only Lindane was detected in surface sediment slightly above the detection limit west of 5th Street in October 1999, with all concentrations below 0.5 $ng \cdot g^{-1}$. Lindane and Mirex were detected in the deeper cores at the creek end; however, all concentrations were below 5 $ng \cdot g^{-1}$.

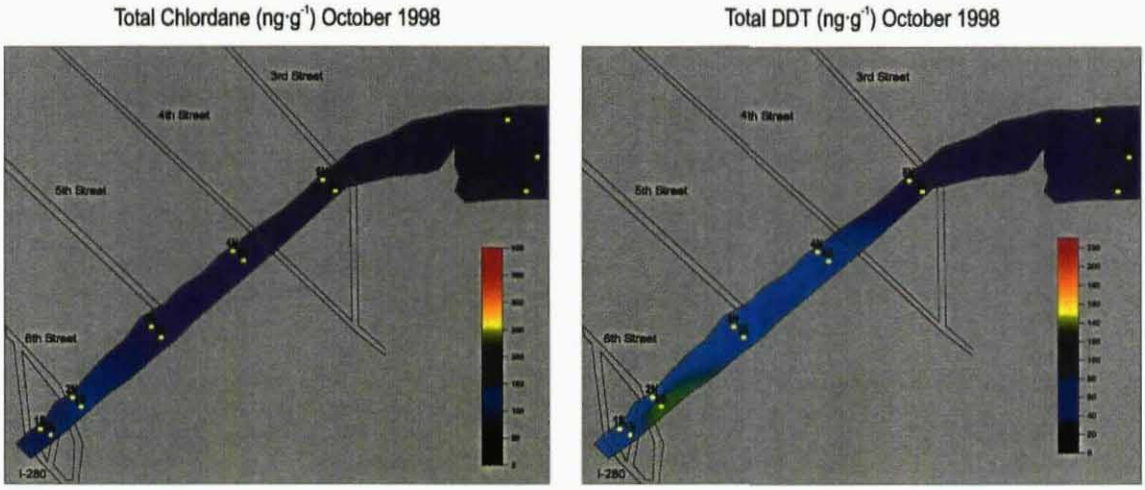

Figure 6-12. Distribution of total Chlordane and total DDT in Mission Creek – October 1998

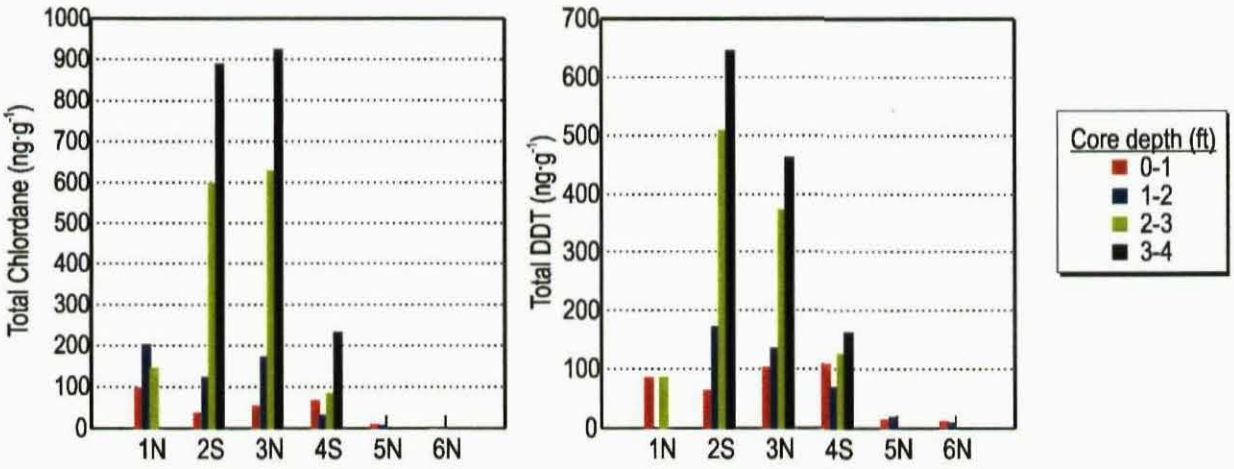

Figure 6-13. Subsurface distributions of total Chlordane and total DDT in Mission Creek – October 1998.

6.4.5 MISSION CREEK CHEMICALS OF POTENTIAL CONCERN (COPCS)

Chemicals of potential concern were selected following the same procedure used for Islais Creek (see Section 6.3.5). Table 6-19 displays Mission Creek COPCs, identified for each station by exceedance factors using TOC-normalized data based on either one-half the ERM (1998 data) or the upper 95th predictive limit for corresponding reference stations (1999 and 2000 data). For example, the "exceedance factor" displayed for cadmium at Station 1N in 1999 indicates that the TOC-normalized concentration was 2.97 times greater than the upper 95th predictive limit calculated using 1999 combined reference station data; and the value for the same station in 1998 was 0.13 times one-half the ERM for cadmium (i.e., 0.5 x ERM = 4.8 $\mu g \cdot g^{-1}$).

All stations west of the 4th Street Bridge had seven or more COPCs, with lead, zinc, Chlordane, DDT, PCBs and PAHs the most ubiquitous. Six metals qualified as COPCs primarily because they were statistically elevated compared to reference concentrations. Only lead, mercury and marginally silver (1.03x at one station) exceeded half the corresponding ERM value, and this occurred only at the creek end. Many of the chlorinated pesticides, including Chlordane, DDT, and Dieldrin posted exceedance factors much greater than one (1) in Table 6-19, primarily because either all or most of the reference area concentrations were at or below sub-part-per-billion detection limits. DDT was the only chlorinated contaminant that was statistically elevated compared to reference sediments but well below the 1998 numeric criterion – a normalized value published by Schwartz et al. (1994) of 100 $\mu g \cdot g^{-1}$ organic carbon.

Table 6-19. Mission Creek - Surface sediment COPCs and corresponding ratios for station concentrations and corresponding guideline values.

COPC	Survey Year	1N*	1S*	2N*	2S*	3N*	3S*	4N*	4S*
Cadmium	1998	0.13	0.13	0.07	0.09	0.09	0.1	0.07	0.08
	1999	**2.97**	**3.39**	**2.23**	**3.52**	**1.65**	**2.67**	**2.01**	**2.4**
	2000	**1.73**	**1.37**	**1.09**	**1.01**	**1.09**	**1.11**	0.75	0.84
Copper	1998	0.31	0.31	0.21	0.28	0.26	0.33	0.27	0.27
	1999	**1.26**	0.93	0.71	**1.29**	0.75	**1.23**	**1.41**	**1.22**
	2000	**1.11**	0.97	0.87	0.96	0.99	**1.12**	**1.31**	**1.43**
Lead	1998	1.31	1.12	0.77	0.93	0.52	0.62	0.44	0.52
	1999	**10.0**	**7.24**	**9.19**	**9.4**	**2.66**	**4.42**	**3.37**	**3.75**
	2000	**13.7**	**8.45**	**8.25**	**8.08**	**3.49**	**3.55**	**2.96**	**3.1**
Mercury	1998	1.46	1.53	0.67	2.54	0.68	0.88	0.7	0.74
	1999	**1.79**	**1.69**	**5.17**	**2.21**	**1.01**	**1.59**	**1.88**	**1.59**
	2000	**3.01**	**2.07**	**2.79**	**3.74**	**1.8**	**1.13**	0.99	**1.08**
Silver	1998	1.03	0.45	0.37	0.75	0.43	0.4	0.3	0.5
	1999	**2.2**	**2.84**	**2.25**	**2.98**	**1.27**	**2.04**	**1.35**	**1.56**
	2000	**9.65**	**5.53**	**7.75**	**7.2**	**4.73**	**3.71**	**2.22**	**2.43**
Zinc	1998	0.79	0.79	0.49	0.57	0.47	0.57	0.45	0.45
	1999	**1.71**	**1.67**	**1.42**	**2.14**	**0.89**	**1.56**	**1.28**	**1.28**
	2000	**2.19**	**1.93**	**1.43**	**1.36**	**1.15**	**1.24**	**1.18**	**1.18**
LMW PAH	1998	0.72	0.76	0.35	0.31	0.3	0.27	0.53	0.48
	1999	**42.1**	**5.65**	**4.13**	**3.6**	**2.75**	**3.67**	**10.3**	**6.12**
	2000	**34.0**	**8.71**	**5.15**	**4.37**	**3.04**	**2.56**	**3.52**	**7.98**
HMW PAH	1998	0.62	0.64	0.36	0.38	0.38	0.4	0.85	0.88
	1999	**13.6**	**3.73**	**3**	**2.79**	**2.55**	**3.26**	**8.02**	**7.35**
	2000	**15.0**	**5.22**	**2.46**	**2.63**	**2.23**	**2.63**	**3.78**	**8.3**
Total Chlordane	1998	9.2	8.9	6.3	7.9	4	4.3	2.8	3.9
	1999	**95**	**78**	**169**	**56**	**25**	**34**	**22**	**36**
	2000	**376**	**148**	**258**	**124**	**92**	**57**	**54.8**	**94**
Total DDT	1998	0.02	0.02	0.01	0.03	0.01	0.02	0.01	0.02
	1999	**7.7**	**7**	**7.5**	**4.5**	**2.5**	**4.6**	**3.1**	**4.2**
	2000	**4.2**	**3.9**	**2.7**	**1.7**	**1.6**	**1.5**	**1.2**	**1.8**
Dieldrin	1998	3.1	5.9	1.9	3.4	1.6	1.9	1.2	1.4
	1999	**4.5**	0.08	**4.7**	0.09	0.05	**1.4**	**1.3**	**1.5**
	2000	**39.5**	**18.4**	**18.1**	**10.6**	**24.1**	**7.42**	**8.1**	**9.1**
Total PCB	1998	1.59	2.18	0.83	1.22	0.74	0.76	0.57	0.7
	1999	**13.7**	**16.3**	**13.9**	**10.1**	**8.4**	**6.6**	**6.5**	**10.6**
	2000	**14.7**	**18.5**	**17.5**	**11.0**	**8.5**	**6.1**	**5.7**	**8.3**

Red > 0.5 x ERM (1998 only); **Bold** > reference upper 95% predictive limit (1999 & 2000); *=recurrent elevated contamination measured in ≥2 surveys

6.5 CONCLUSIONS

Additional studies or data evaluations, such as ecological risk assessments or comparison to other sites, are necessary to determine whether statistically elevated contaminant concentrations found in the creeks are biologically meaningful. This is especially important in the case of metals and PAH, where nearly all creek concentrations were statistically elevated compared to reference conditions at two or more stations; however, very few concentrations exceeded one-half the ERM criterion when TOC-normalized. The remaining contaminants, consisting entirely of chlorinated compounds (i.e., pesticides and PCBs), were elevated in relation to reference sediments and half the corresponding ERM value at many stations. DDT was the only chlorinated contaminant that was statistically elevated in both creeks compared to reference sediments but well below the 1998 numeric criterion – a TOC-normalized value proposed by Schwartz et al. (1994) of 100 $\mu g \cdot g^{-1}$ organic carbon and accepted by the RWQCB. This discrepancy is due in part to the fact that the TOC-normalized criterion for DDT is generally 2-3 orders of magnitude greater than the corresponding ERM criterion (i.e., 46 $ng \cdot g^{-1}$ sediment dry weight) when applied to sediments containing 1-3% TOC. TOC-based criteria exist for many sediment contaminants and are in use in other regulatory programs (e.g.,Washington Department of Ecology); however, DDT was the only contaminant compared to a numeric criterion originally based on organic carbon instead of sediment dry weight, following the primary method of evaluation used throughout the BPTCP.

Notes

7.0 BIOACCUMULATION IN CLAMS

This section presents results from chemical analyses of tissues of the bentnose clam *Macoma nasuta* following 28-day laboratory exposures to surface sediments collected from each of the two creeks and reference area in April 2000. The bentnose clam was chosen as an appropriate test species for reasons presented in Section 3.3.2.4. Additionally, *Macoma nasuta* bioaccumulation tests are in the process of standardization by EPA and will become be the primary benchmark species for near coastal waters. Chemicals of potential concern (COPCs) known to bioaccumulate in the food web elevated in creek sediments (see Section 6) were examined, consisting of mercury, PCBs, Chlordane, DDT and Dieldrin. Dry weight tissue results are presented for Islais and Mission Creeks in Appendices A3 and B3, respectively. Each appendix also presents results for reference area tissue data.

Evaluation of chemical bioaccumulation in clams relies primarily on statistical comparisons of individual station results to the upper 95th predictive limit (UPL) calculated using lipid-normalized tissue concentrations for the five reference stations tested during the April 2000 survey. This method is similar to that used to identify sediment COPCs in Section 6, except tissue concentrations are compared. Tissue concentrations are associated with corresponding test sediment concentrations through the use of biota-sediment accumulation factors (BSAFs), to evaluate the biomagnification potential of COPCs in the aquatic food web.

It is important to note that there are several different ways to interpret bioaccumulation data, including: 1) an estimate of direct uptake from sediment into the test organism or a proxy; and 2) a predictive measure of transfer across trophic levels. When evaluating direct uptake from sediment, tissue concentrations are compared to various criteria that usually are established on a wet or dry weight basis, and data must be converted if they are reported in dissimilar units. In general, if tissue data are used to estimate the amount of contaminant in the test organism as a food source, wet weight concentrations are used (as they represent the unadjusted concentration per mass of prey). Dry weight tissue concentrations are often used when comparing data across species or studies. When examining transfer between organisms, results are often based on lipid weight, following the assumption that many contaminants concentrate in the fatty tissues of animals. Summary statistics for bioaccumulation data are presented on a dry weight basis, to provide consistency with raw data presented in the appendices as reported by the laboratories, and to compare with dry weight values reported in the literature. Comparisons between creek and reference tissue concentrations and evaluation of BSAFs are on a lipid weight basis following guidance from the EPA (1996). Moisture in clam tissue ranged from 87.5 to 91.6% with a mean of 90.0%; and dry weight lipids ranged from 8.4 to 12.5%, with a mean of 10.2%. Therefore, with respect to COPCs, dry weight tissue concentrations are approximately an order of magnitude (10x) greater than wet weight tissue concentrations; and lipid weight concentrations are approximately 10x greater than dry weight concentrations. There were no differences in results for creek and reference comparisons due to variances in normalization. For example, the same creek tissues were elevated compared to the reference tissue UPL, for dry weight, wet weight and lipid weight data.

7.1 OVERVIEW

Chemical concentrations in clam tissues varied considerably for Islais and Mission Creeks, as a function of chemical type, sample location and physical features of the exposure sediment. For all data combined, lipid-normalized tissue concentrations of chlorinated COPCs were strongly correlated with TOC-normalized sediment concentrations and grain size, suggesting that sediment physical features influence the direct uptake of these persistent compounds in biota (Table 7-1).

Mercury, the only metal examined, was not appreciably concentrated in any creek tissues, even though it was elevated in one or more sediment samples in each creek. Bioaccumulation of mercury in the aquatic food chain has been a concern since elevated levels of methylmercury in fish tissue from a highly contaminated Japanese harbor were discovered to have toxic effects in humans in 1956. Elevated fish concentrations and increasing trends in mercury in shellfish have been observed in multi-year monitoring programs conducted in San Francisco Bay, resulting in a 303(d) impaired water body listing.

PCBs and one or more of the chlorinated pesticides were elevated compared to reference tissue concentrations for the two creeks. Concentrations of chlorinated organic compounds in tissues, including PCBs, depend on many organism-related factors including, size, lipid content, trophic level, mode of ingestion, metabolism and diet. PCB concentrations found lethal to fish in laboratory experiments range from 10 to 300 $\mu g \cdot g^{-1}$ (or 10,000 to 300,000 $ng \cdot g^{-1}$) (Rice and O'Keefe 1995). Similar to mercury, elevated PCBs in fish also contributed to the 303(d) impaired water body listing for the bay.

The chlorinated pesticides, Dieldrin, DDT and Chlordane, were elevated in nearly all Mission Creek tissues compared to reference tissue levels; however, only tissues exposed to Transect 1 sediments collected from the terminus were elevated at Islais Creek. These relict pesticides are all highly fat soluble, with a propensity to bioaccumulate in marine organisms. DDT and its metabolites have been detected in aquatic organisms from every coastal state and from nearly every estuary in the U.S., as well as from many offshore and deep-sea locations. Chlordane is a broad-spectrum poison that affects many organisms. The 1986-1987 Bioaccumulation Study of the U.S. EPA found high levels in fish and shellfish collected from 60 estuaries and coastal marine sites in the U.S., ranging from 6910 to 409,000 $ng \cdot g^{-1}$ and 7500 to 42,500 $ng \cdot g^{-1}$ wet weight, respectively (Kennish 1997). Results from the National Status and Trends Program from 1984 and 1990 suggest that Dieldrin is less ubiquitous than DDT and Chlordane, but persists on the west coast at high part-per-billion levels, and is commonly found in shellfish at the low part-per-million level (O'Conner and Ehler 1991).

Table 7-1. Correlation results for COPC concentrations in lipid-normalized tissue vs. normalized sediment – all data combined (n=27).

	Tissue – lipid normalized				
	Mercury	Total DDT	Dieldrin	Total PCB	Total Chlordane
Sediment – percent fines normalized					
Correlation coefficient (r)	0.09	**0.62**	**0.80**	**0.77**	**0.68**
Probability (p)	0.66	<0.001	<0.001	<0.001	<0.001
Sediment - TOC normalized					
Correlation coefficient (r)	-0.14	**0.75**	**0.94**	**0.93**	**0.92**
Probability (p)	0.39	<0.001	<0.001	<0.001	<0.001

bold=significant positive correlation at $p < 0.05$.

7.2 REFERENCE AREA

COPC concentrations in tissues exposed to reference area sediments were very low, commensurate with concentrations in marine organisms from pristine coastal environments (Table 7-2). Total Chlordane was below detection limits (i.e., < 0.7 $ng \cdot g^{-1}$ dry weight) in two of the five reference tissues. Only total DDT and total PCBs exceeded 10 $ng \cdot g^{-1}$ dry weight for the organic contaminants. Mean total DDT and total PCB dry weight concentrations of 10.3 and 27 $ng \cdot g^{-1}$ correspond to wet weight concentrations of approximately 1.0 and 2.7 $ng \cdot g^{-1}$, respectively, for these tissues. Mercury was extremely low, with the maximum dry weight concentration of 0.24 $\mu g \cdot g^{-1}$ recorded for Tubbs Island. Table 7-2 summarizes Reference Area results and includes UPL values on a dry weight basis for COPCs measured in tissues. Actual comparisons between creek and reference tissues were made using dry-lipid weight normalized data; results of these comparisons are shown in Figures 7-1 and 7-2.

Table 7-3 shows BSAFs for reference area data. Although BSAFs provide insight on bioaccumulation in tissues exposed to contaminated sediments, they are less meaningful when chemical concentrations are extremely low in tissues and sediments, such as those reported for the reference area.

Table 7-2. Reference Area – summary statistics for COPC tissue dry weight concentrations (5 stations)

COPC	Minimum	Maximum	Maximum Station	Mean	95TH UPL
Mercury ($\mu g \cdot g^{-1}$)	0.18	0.24	Tubbs Island	0.20	0.26
Chlorinated COPCs ($ng \cdot g^{-1}$)					
Dieldrin	0.8	2.4	North Site	1.3	2.7
Total DDT	2.2	14.1	Paradise	10.3	21.3
Total Chlordane	<0.7	3.0	North Site	1.1	4.0
Total PCB	10.5	36.7	Paradise	27.0	51.0

UPL=upper predictive limit

Table 7-3. Reference Area – summary statistics for biota-sediment accumulation factors (BSAFs).

COPC	Minimum	Maximum	Maximum Station	Mean	Standard Deviation
Mercury	0.056	0.28	Tubbs Island	0.14	0.08
Dieldrin	0.69	1.33	North Site	1.01	0.25
Total DDT	0.10	2.00	Paradise	0.64	0.77
Total Chlordane	0.17	0.84	North Site	0.42	0.30
Total PCBs	0.42	4.13	Paradise	1.49	1.51

7.3 ISLAIS CREEK

Tissues exposed to sediments collected from Stations 1N and 1S accumulated the highest chemical concentrations in Islais Creek. Sediments from these stations were coarser-grained and lower in chemical concentrations relative to the remaining sediments. Stations 1N and 1S had 28.1 and 86.8% sand, respectively, compared with remaining sediments that ranged from 0.9 to 3%. Four chlorinated COPCs (total PCBs, total Chlordane, total DDT, & Dieldrin) that were elevated in sediments were

significantly elevated in clam tissues at Stations 1N and 1S relative to reference tissues. The remaining chlorinated pesticides were not detected at the sub-part-per-billion level in tissue (<1 $ng \cdot g^{-1}$). Relative differences observed for total Chlordane primarily were due to reference tissue concentrations that were below the detection limit for two stations. Summary statistics for bioaccumulating chemicals measured in tissues are shown in Table 7-4. Mercury, the only metal measured, was detected at sub-part-per-million dry weight concentrations in both creek and reference tissues. Sediment COPC concentrations normalized to percent fines (silt + clay sediment fraction) and TOC strongly correlate to tissue concentrations of the chlorinated COPCs (correlation coefficient [r^2] ranging from 0.68 to 0.96), supporting the contention that sediment physical features influence the uptake of these persistent chemicals. Tissue mercury; however, only very weakly associates with percent fines and TOC-normalized sediment mercury (r^2 =0.031 and 0.053 respectively). Figure 7-1 graphically presents the strongest associations (linear regression) between tissue concentrations and sediment chemical concentrations normalized to either percent fines or TOC.

BSAFs were less than unity (one) for all COPCs, indicating that these chemicals do not readily biomagnify at the bottom of the food web at Islais Creek (Table 7-5).

Table 7-4. Islais Creek – summary statistics for COPC tissue dry weight concentrations (6 stations).

COPC	Minimum	Maximum	Maximum Station	Mean	Standard Deviation	Reference Mean
Mercury ($\mu g \cdot g^{-1}$)	0.09	0.63	1N	0.24	0.19	0.20
Chlorinated COPCs ($ng \cdot g^{-1}$)						
Dieldrin	1.4	8.2	1S	3.8	2.9	1.3
Total DDT	13.6	52.6	1S	26.5	14.3	10.3
Total Chlordane	2.4	29.3	1S	12.9	12.2	1.1
Total PCB	36	248	1S	98	78	27

Table 7-5. Islais Creek – summary statistics for biota-sediment accumulation factors (BSAFs).

COPC	Minimum	Maximum	Maximum Station	Mean	Standard Deviation
Mercury	0.07	0.40	1N	0.17	0.12
Dieldrin	0.11	0.78	1S	0.42	0.29
Total DDT	0.20	0.40	1S	0.31	0.07
Total Chlordane	0.05	0.46	1N	0.22	0.15
Total PCBs	0.16	0.39	3N	0.25	0.08

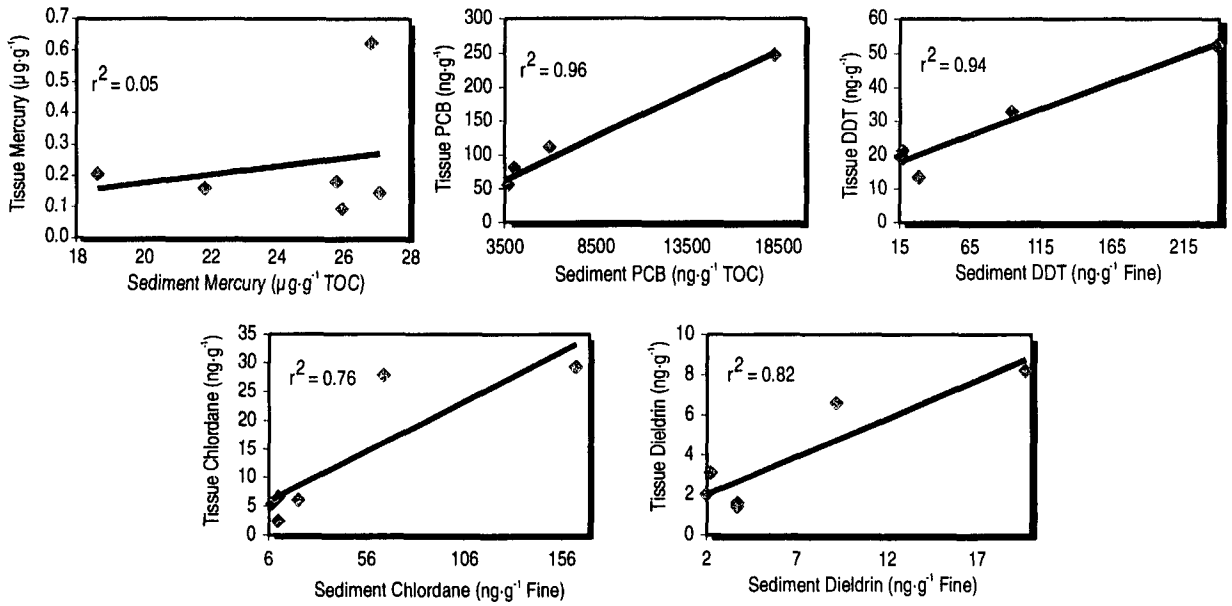

Figure 7-1. *Macoma* tissue concentration compared to sediment concentration normalized to TOC or percent fines. Blue line represents strongest linear regression.

7.3.1 Mercury

None of the tissues, except those exposed to Station 1N sediments, exceeded the lipid-normalized reference UPL for mercury of 5.15 $\mu g \cdot g^{-1}$ lipid (Figure 7-2).

Average dry weight concentrations of mercury in creek tissues at 0.24 $\mu g \cdot g^{-1}$ were comparable to both in-bay reference tissues and to average concentrations recorded in the related bivalve species *Mytilus* (i.e., 0.24 $\pm 0.08\ \mu g \cdot g^{-1}$), collected from relatively clean sediments from U.S. and Canadian waters (Fowler 1990). Only tissue exposed to Station 1N sediment had a significantly higher concentration at 0.63 $\mu g \cdot g^{-1}$ dry weight. Sediment collected from Station 1N had the second highest mercury concentration (1.19 $\mu g \cdot g^{-1}$) and the highest TOC concentration (4.43%) measured in the April 2000 survey. However, this station also had a BSAF of 0.40, indicating that mercury in sediment was not readily bioavailable to exposed clams. Remaining BSAFs were even lower, averaging 0.12. The average BSAF for all stations was 0.17 (Table 7-5).

There was no significant correlation between tissue and sediment mercury concentrations for Islais Creek; however, this is not unexpected as all concentrations were low and fairly uniform, except those observed for Station 1N (tissue & sediment) and Station 1S (sediment only).

7.3.2 Polychlorinated Biphenyls (PCBs)

Total PCB concentrations in creek tissue ranged from 36 to 248 $ng \cdot g^{-1}$ (Table 7-4), with an average concentration of 98 $ng \cdot g^{-1}$ (dry weight). Tissue concentrations for five out of six stations exceeded the

lipid-normalized reference UPL of 858 ng·g^{-1} lipid (or 51.0 ng·g^{-1} dry weight) (Figure 7-2), with the highest levels observed at Station 1S. Although elevated compared to in-bay reference tissues, creek tissue concentrations were significantly lower than many concentrations reported for bivalves collected from other populated shorelines (Table 7-6). Total PCB concentrations in tissues correlated well with TOC normalized sediment total PCB concentrations (Figure 7-1); however, the mean BSAF of 0.25 indicates that these contaminates are not biomagnifying.

The relative abundances of individual congeners in tissue samples generally were consistent with abundances in the sediments. The lower and higher chlorinated congeners typically were undetected, or present at low part-per-billion concentrations, whereas, the pentachloro- and hexachloro- biphenyls (especially congener numbers 101, 118, 138, and 158) were detected the most frequently. The two more toxic coplanar congeners measured, PCB 77 and PCB 126 (3,3',4,4'-tetrachlorbiphenyl and 3,3',4,4',5-pentachlorbiphenyl, respectively), were not detected in any Islais Creek tissues.

Table 7-6. Ranges of PCB and DDT concentrations (ng·g^{-1} dry weight) in the mussel *Mytilus* and closely related species (adapted from Fowler 1990).

Study Area	Total PCBs		Total DDT	
	Minimum	Maximum	Minimum	Maximum
Baltic Sea	179	778	62	739
North Sea	106	362	15	143
Irish Sea	57	1070	92	590
English Channel	380	480	35	112
US Northwest Atlantic	10	6808	2.8	1109
US Pacific Coast	607	2052	5.4	1077
Northeast Atlantic (France)	96	1345	-	-
Mediteranean (Spain)	10.8	1264	60	288

7.3.3 Chlorinated Pesticides

DDT. Tissues exposed to sediments from Stations 1N and 1S and marginally 3S were statistically elevated compared to the lipid-normalized reference UPL of 345.7 ng·g^{-1} lipid (Figure 7-2). Total DDT (sum of 2,4'- and 4,4'- DDT, DDE, and DDD isomers) dry weight concentrations ranged from 13.6 to 52.6 ng·g^{-1}, averaging 26.5 ng·g^{-1} in creek tissues. Maximum dry weight concentrations reported for related species exposed to sediment from other populated areas reach concentrations 10 to 50 times higher than the maximum Islais Creek concentration (Table 7-6). Tissue total DDT associated more strongly with sediment DDT normalized to percent fines (r^2 =0.94) than it did with sediment normalized to total organic carbon (r^2 0.81). The BSAF was well below unity, indicating that this nationally ubiquitous contaminant is not being biomagnified.

In general, the breakdown products of DDT (i.e., DDD and 4,4'-DDE) displayed the highest concentrations in tissues, consistent with DDT distribution patterns in sediment.

Chlordane. All creek tissues, except those exposed to Station 3S sediments, exceeded the lipid-normalized reference UPL of 71.5 $ng \cdot g^{-1}$ lipid; however, three stations (2N, 2S & 3S) only slightly exceeded this threshold (Figure 7-2).

Total Chlordane concentrations again were highest in clam tissues exposed to the coarser-grained sediments from Stations 1N and 1S. Dry weight concentrations for all tissues ranged from 2.4 to 29.3 $ng \cdot g^{-1}$, averaging 12.9 $ng \cdot g^{-1}$. Tissues exposed to sediments collected east of Transect 1 were similar to reference levels, averaging 5.1 $ng \cdot g^{-1}$. Alpha-, cis-, and trans-Chlordane were the dominant forms measured. Heptachlor and Heptachlor Epoxide were not detected in any tissues.

Dieldrin. Only tissues exposed to Stations 1N and 1S sediments were significantly elevated compared with the lipid-normalized reference UPL of 49.6 $ng \cdot g^{-1}$ lipid.

Dieldrin dry weight concentrations in creek tissues ranged from 1.4 to 8.2 $ng \cdot g^{-1}$ (mean=3.8 $ng \cdot g^{-1}$), posting the closest values to reference tissues (mean=1.3 $ng \cdot g^{-1}$) of the chlorinated compounds measured.

Tissue concentrations of Dieldrin more strongly associated with sediment Dieldrin concentrations normalized to percent fines compared to TOC normalized sediments (Figure 7-1). The BSAF for Dieldrin was highest (mean=0.42) of the chlorinated compounds measured in tissue (Table 7-5); however, all values were less than unity (1.0) indicating a low biomagnification potential for sediment-dwelling organisms exposed to Dieldrin at Islais Creek.

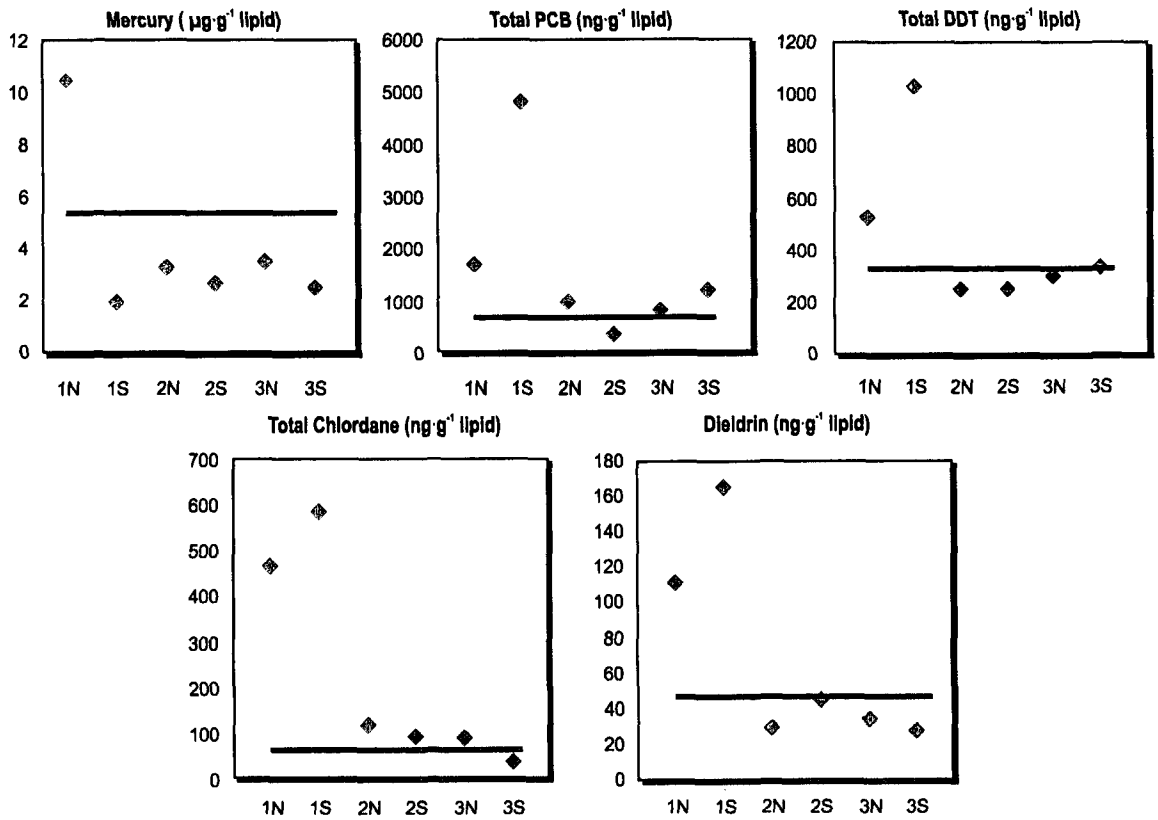

Figure 7-2. Islais Creek tissue concentrations compared to the upper 95th predictive limit (blue line) established for tissues exposed to reference area sediments (all results are lipid-normalized).

7.4 MISSION CREEK

In general, COPCs, excluding mercury, were elevated in Mission Creek tissues compared to tissues exposed to reference area sediments. Mercury, the only metal measured, was detected at sub-part-per-million dry weight concentrations in both creek and reference tissues. Tissues exposed to sediments collected west of Transect 4, except Station 1S, accumulated the highest concentrations (Figure 7-3). Corresponding sediments from this area were fairly coarse-grained, ranging from 10.8 to 71.2% sand. The highest tissue concentrations were consistently recorded for Station 1N, which also had the highest concentration of sandy sediment. Two chlorinated pesticides (total Chlordane and total DDT) and total PCBs that were elevated in sediments were significantly elevated in creek tissues relative to reference tissues for nearly all stations. Dieldrin was slightly elevated in tissues exposed to creek-end stations only. The remaining pesticides were not detected at the sub-part-per-billion level in tissue (<1 $ng \cdot g^{-1}$). Relative exceedances observed for total Chlordane and Dieldrin in creek tissues were due primarily to non-detect or near-detection limit values for two or more reference tissue samples. Summary statistics for bioaccumulating chemicals measured in tissues are shown in Table 7-7.

When normalized to either percent fines or TOC, only sediment Chlordane and Dieldrin exhibited strong significant correlations with dry weight tissue concentrations (Figure 7-4). BSAFs were less than unity (one) for all COPCs, indicating that these chemicals do not readily biomagnify at the bottom of the food web (Table 7-8). The highest BSAFs were recorded at stations comprised of relatively sandy sediments that were generally less contaminated than the finer-grained, TOC-enriched sediments in the creek. (normalized to TOC) normalized to percent fines)

Table 7-7. Mission Creek – summary statistics for COPC dry weight tissue concentrations (6 stations).

COPC	Minimum	Maximum	Maximum Station	Mean	Standard Deviation	Reference Mean
Mercury ($\mu g \cdot g^{-1}$)	0.14	0.26	4S	0.19	0.05	0.20
Chlorinated COPCs ($ng \cdot g^{-1}$)						
Dieldrin	2.0	9.0	1N	5.1	2.5	1.3
Total DDT	23.5	52.1	2S	36.1	11.6	10.3
Total Chlordane	12.0	62.8	1N	29.1	20.0	1.1
Total PCB	94	225	1N	138	44	27

Table 7-8. Mission Creek – summary statistics for biota-sediment accumulation factors (BSAFs).

Analyte	Minimum	Maximum	Mean	Standard Deviation	Maximum Station	Reference 95th UPL
Mercury	0.02	0.10	0.05	0.03	3S	0.46
Total PCBs	0.06	0.31	0.18	0.09	4N	1.54
Total Chlordane	0.05	0.37	0.19	0.11	2S	0.64
Total DDT	0.06	0.37	0.23	0.10	2S	0.86
Dieldrin	0.12	0.60	0.28	0.14	2S	1.68

7.4.1 Mercury

None of the tissues exposed to Mission Creek sediments exceeded the lipid-normalized reference UPL of 5.15 $\mu g \cdot g^{-1}$ lipid (or 0.26 $\mu g \cdot g^{-1}$ dry weight) (Figure 7-3).

Average dry weight concentrations of mercury in creek tissues (mean=0.19 $\mu g \cdot g^{-1}$) were comparable to both in-bay reference tissues and to average concentrations recorded in the related bivalve species *Mytilus* (i.e., 0.24 ± 0.08 $\mu g \cdot g^{-1}$), collected from relatively clean sediments from U.S. and Canadian waters (Fowler 1990). The extremely low BSAF mean value of 0.05 provides further confirmation that mercury does not bioaccumulate in benthic organisms exposed to Mission Creek sediments (Table 7-8).

7.4.2 Polychlorinated Biphenyls (PCBs)

Total PCB concentrations in creek tissue ranged from 94 to 225 $ng \cdot g^{-1}$ (Table 7-7), with an average concentration of 138 $ng \cdot g^{-1}$ (dry weight). Tissue concentrations exceeded the lipid-normalized reference UPL of 858 $ng \cdot g^{-1}$ lipid (or 51.0 $ng \cdot g^{-1}$ dry weight) (Figure 7-3) at all stations, with the greatest exceedance observed at Station 1N.

The relative abundances of individual congeners in tissue samples generally were consistent with abundances in the sediments. The lower and higher chlorinated congeners typically were undetected, or present at low part-per-billion concentrations, whereas, the pentachloro- and hexachloro- biphenyls (especially congener numbers 101, 118, 138, and 158) were detected the most frequently. The two more toxic coplanar PCB congeners measured, PCB 77 and 126 (or 3,3',4,4'-tetrachlorbiphenyl and 3,3',4,4',5-pentachlorbiphenyl, respectively), were below detection limits in all tissues.

7.4.2 Chlorinated Pesticides

DDT. Tissues exposed to sediments from all stations, except 1S, were statistically elevated compared to the lipid-normalized reference UPL of 345.7 $ng \cdot g^{-1}$ (or 21.3 $ng \cdot g^{-1}$ dry weight) (Figure 7-3). Total DDT (sum of 2,4'- and 4,4'- DDT, DDE, and DDD isomers) dry weight concentrations ranged from 23.5 to 52.1 $ng \cdot g^{-1}$, averaging 36.1 $ng \cdot g^{-1}$ in creek tissues. Maximum dry weight concentrations reported for related species exposed to sediment from other populated areas often reach concentrations 10 to 50 times higher than the maximum Mission Creek concentration (Table 7-6).

In general, the breakdown products of DDT (i.e., DDD and 4,4'-DDE) displayed the highest concentrations in tissues, consistent with DDT distribution patterns in sediment.

Chlordane. All creek tissues exceeded the lipid-normalized reference UPL of 71.5 $ng \cdot g^{-1}$ lipid (Figure 7-2), corresponding to an extremely low reference dry weight concentration of 4.0 $ng \cdot g^{-1}$. Total Chlordane concentrations again were highest in tissues exposed to coarser-grained sediments from Stations 1N and 2S located at the creek end. Dry weight concentrations ranged from 12.0 to 62.8 $ng \cdot g^{-1}$, averaging 29.1 $ng \cdot g^{-1}$. The BSAF for total Chlordane was extremely low (mean=0.19), indicating a low biomagnification potential for Chlordane in creek biota.

Dieldrin. All tissues except for those exposed to sediment from Stations 3S and 4S were significantly elevated compared with the lipid-normalized reference UPL of 49.6 $ng \cdot g^{-1}$ lipid. This value corresponds to an extremely low reference dry weight concentration of 2.7 $ng \cdot g^{-1}$.

Dieldrin dry weight concentrations in creek tissues were low, ranging from 2.0 to 9.0 $ng \cdot g^{-1}$ (mean=5.1 $ng \cdot g^{-1}$). Dieldrin in tissues strongly associated Dieldrin measured in fine particle normalized sediments (Figure 7-4). The BSAF for Dieldrin was extremely low (mean=0.28), indicating a low biomagnification potential for Dieldrin in creek biota.

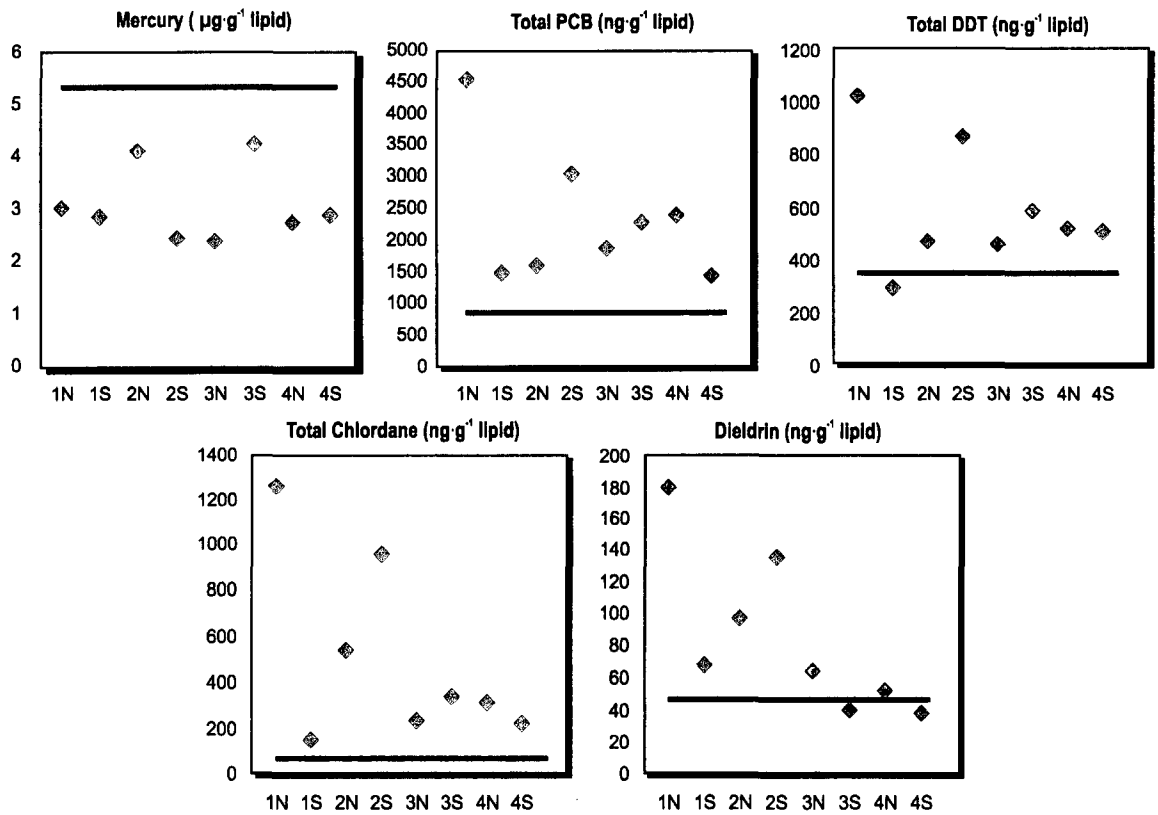

Figure 7-3. Mission Creek tissue concentrations compared to the upper 95th predictive limit (blue line) established for tissues exposed to reference area sediments (all results are lipid-normalized).

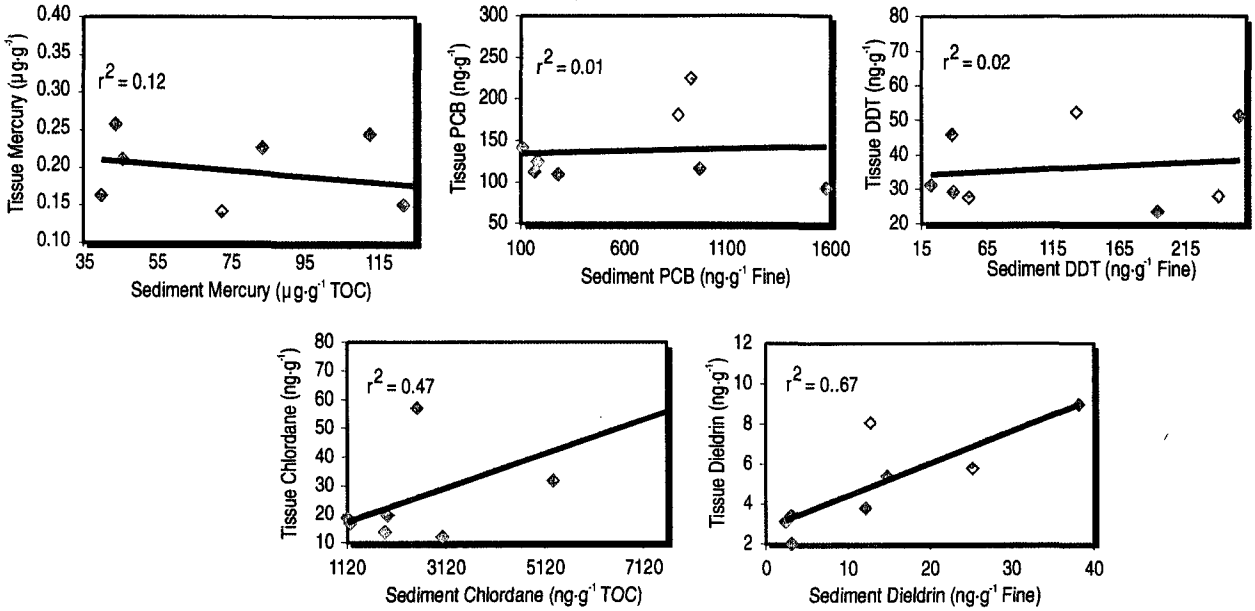

Figure 7-4. *Macoma* tissue concentration compared to sediment concentration normalized to TOC or percent fines. Blue line represents strongest linear regression.

7.4 CONCLUSIONS

Chlorinated pesticides and PCBs were statistically elevated in tissues exposed to creek end sediments compared to tissues exposed to in-bay reference sediments. However, sediment-tissue bioaccumulation factors were less than unity (one) for all samples, indicating that these chemicals may not biomagnify through the food web. Mercury tissue concentrations were lower than reference tissue concentrations for all creek stations except 1N, located at the west end of Islais Creek. The limited area of impact at the creek end (< 1 acre), coupled with strong evidence that contaminant concentrations are decreasing and have minimal biomagnification potential, make Islais Creek an ideal candidate for natural recovery.

Similar to Islais Creek, tissues exposed to west end Mission Creek sediments displayed statistically elevated concentrations of chlorinated compounds compared to reference tissues. However, biota-sediment accumulation factors were far less than one, again indicating a low biomagnification potential for these contaminants in the local food web.

Notes

8.0 SOURCE IDENTIFICATION OF SELECTED COPCs

The section explores sources of selected chemicals of potential concern (COPCs), identified in Section 6 for Islais Creek, the only study area that had any sediment with recurrent toxicity and elevated chemistry (see Section 9). Only those COPCs that had physical or chemical distribution patterns suggesting contaminant sources are evaluated – certain metals and PAHs. Methods used to identify potential physical and/or chemical sources are discussed in Section 8-1. Physical source refers to point locations of contaminant entry to the creeks that are linked to past or present activities; chemical source refers to the type of contamination, which can be inferred from a chemical signature (e.g., PAH from creosote) or relationship (e.g., correlations between metals). Chemical source identification was not performed for chlorinated pesticides or PCBs. Pesticides are largely comprised of single compounds or limited compound mixtures, and are therefore, not conducive to forensic chemical techniques. PCBs originate from Aroclors™, a limited suite of seven man-made ubiquitous mixtures that both complicate and reduce the importance of source identification.

Historical sources of COPCs to creek sediments are discussed in Section 2. These sources are of interest for several reasons: 1) to see if sources have changed over time; 2) to see if variations in contaminant distributions in sediment are related to different source terms; and 3) to see if source identification can be used to support future preventative measures or remedial alternatives analysis.

8.1 Overview of Source Identification Methods

8.1.1 Metals

Concentrations of trace metals in Islais Creek sediments varied considerably as a function of location, sediment type and contaminant loading. In some cases, concentrations were 10 to >30 times greater than typical background concentrations (see Section 6, Table 6-1). To better understand differences in metal concentrations that may result from variations in grain size and mineralogy and to identify creek locations where metal content may be influenced by anthropogenic inputs, metal concentrations were normalized to (divided by) iron and aluminum concentrations. Aluminum and iron are major constituents of sediment minerals and usually exhibit a positive relationship with trace metals. Aluminum is mostly present as a structural component of aluminosilicate minerals, whereas iron may occur as a structural component of aluminosilicates as well as an oxide coating on mineral grains. In general, when concentrations of aluminum or iron are higher in a sediment sample, concentrations of trace metals also are higher naturally. Lower concentrations of aluminum, iron, and metals are found for sediments composed primarily of quartz sand or shell carbonates, whereas higher values of a metal are common to more clay-rich, fine-grained sediments, such those found throughout much of Islais Creek. Thus, plots of metals versus aluminum or iron from a given area with little or no pollutant inputs often show a strong linear relationship. Positive deviations from this linear trend of a metal versus aluminum or iron help identify anthropogenic inputs of that metal to the sediment. The iron versus aluminum relationship for sediments sampled in 1998 in Islais Creek was strong and statistically significant

(r^2=0.87; p<0.001). Thus, either aluminum or iron is appropriate to normalize trace metal concentrations (i.e., remove natural variability). The normalized metal data can then be used to identify sediment locations with anthropogenic inputs of metals as well as to target sources for these inputs through the subsequent identification of transport pathways. However, these data cannot be used to identify elevated metals associated with natural deviations in mineralogy, since *a priori* assumptions exclude metals concentrations that are significantly elevated from background from the initial analysis.

8.1.2 Polycyclic aromatic hydrocarbons (PAH)

Source identification of petroleum hydrocarbons was performed using sediment results from the analysis of total petroleum hydrocarbons (TPH) and polycyclic aromatic hydrocarbons (PAH). This analysis was limited to data collected in 1998, the only year in which TPH was analyzed and samples were collected throughout the creek. A total of eight TPH and 41 PAH "compounds" were analyzed using laboratory methods described in Section 3. These results were used to support chemical forensic methods to identify potential hydrocarbon sources.

PAH in surface and subsurface sediments were first evaluated using principal component analysis (PCA). This multivariate statistical technique has been used to identify petroleum source in marine sediments (Kennicut et al. 1994; Maxon et al. 1997) and is not detailed here. PCA was used to provide insight to potential PAH sources for Islais Creek sediments. It is a useful technique as it removes investigator bias, and can evaluate large data sets with multiple analytes simultaneously. Log transformed concentrations of PAH, total petroleum hydrocarbons (8 range classes) and five linear alkylbenzenes (LAB) were analyzed together in the PCA. LABs were analyzed in 1998 only, as potential tracers of contamination associated with sewage discharges. For this investigation, PCA was used only as an exploratory tool to reveal sample relationships and to support other forensic methods. Other interpretive tools such as GC/FID chromatogram pattern recognition (Douglas, et al. 1992) and/or source ratio analysis (Douglas et al. 1996) also were used to identify potential hydrocarbon sources.

8.2 METALS

Sediment concentrations of COPC metals, lead and zinc, were most elevated at the west end of the creek (see Section 6, Table 6-5). Overall, the highest concentrations were found at Stations 1N, 1C (sampled only in 1998) and 1S. These elevated metal concentrations were distinguished by large positive deviations from the natural metal/aluminum relationship (solid line) as shown in Figure 8-1. Each of the anomalous data points suggests an anthropogenic input of lead or zinc at the specified station. Anthropogenic inputs of lead and zinc were greatest at Transect 1, somewhat less at Transects 2 and 3, and not identifiable at Transects 4, 5 and 6 (Figure 8-1; see Figure 3-1, Section 3 for station map).

To help identify metal sources and transport pathways, actual concentrations of anthropogenic lead and zinc were determined by subtracting natural concentrations (based on the solid line on each graph) from total metal levels. The solid line was generated through linear regression of unelevated metal creek concentrations with corresponding aluminum concentrations. A strong linear relationship was found for anthropogenic zinc versus anthropogenic lead with an overall ratio of the two components of 1.5 ± 0.4

(Figure 8-1). This strong linear relationship supports either a common source or a common partitioning mechanism (e.g., organic carbon adsorption) for the elevated sediment concentrations of lead and zinc. Based on higher concentrations at the creek end (Transect 1), and decreased concentrations at Transects 2 and 3, inputs of both metals can be traced to the CSO Weir and/or runoff from the Interstate 280 overpass. Interstate 280 is a likely co-contributor, as considerable storm water runoff from the overpass to the creek end was observed during the 1999 and 2000 wet-weather surveys. Additionally, the highest concentrations of COPC metals were observed in sediments directly below Interstate 280 and not at either end of the CSO Weir (Transects 2 and 3).

Sediments with the highest concentrations of COPC metals also had the highest concentrations of TOC (Figure 8-2). These results confound identification of metal sources because TOC adsorbs and concentrates metals (including dissolved metals from the water column). Therefore, elevated metals observed in the TOC-enriched sediments at the creek end may have been transported by a nearby source with the TOC, or they could have been partitioned from the water column into TOC accumulated at the creek end. Both processes most likely contribute to elevated metals concentrations observed at the end of the creek.

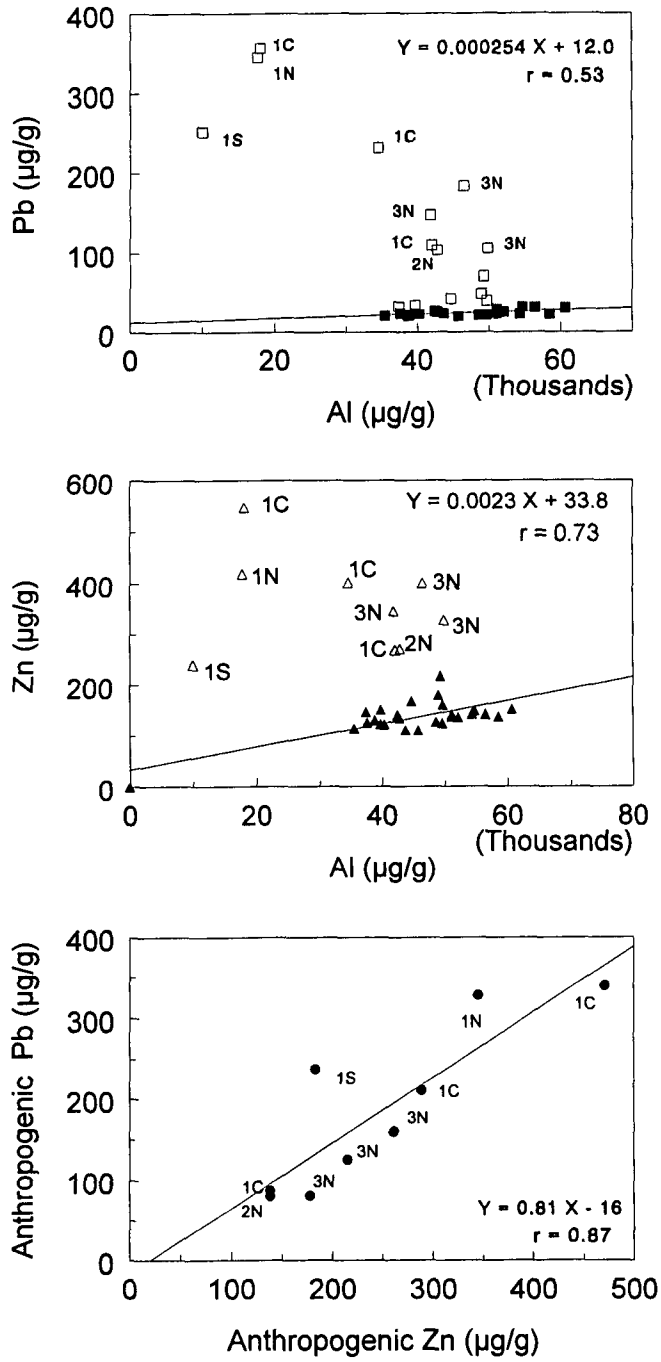

Figure 8-1. Concentrations of lead, zinc and mercury vs. aluminum, and elevated zinc vs. elevated lead in Islais Creek surface sediments.

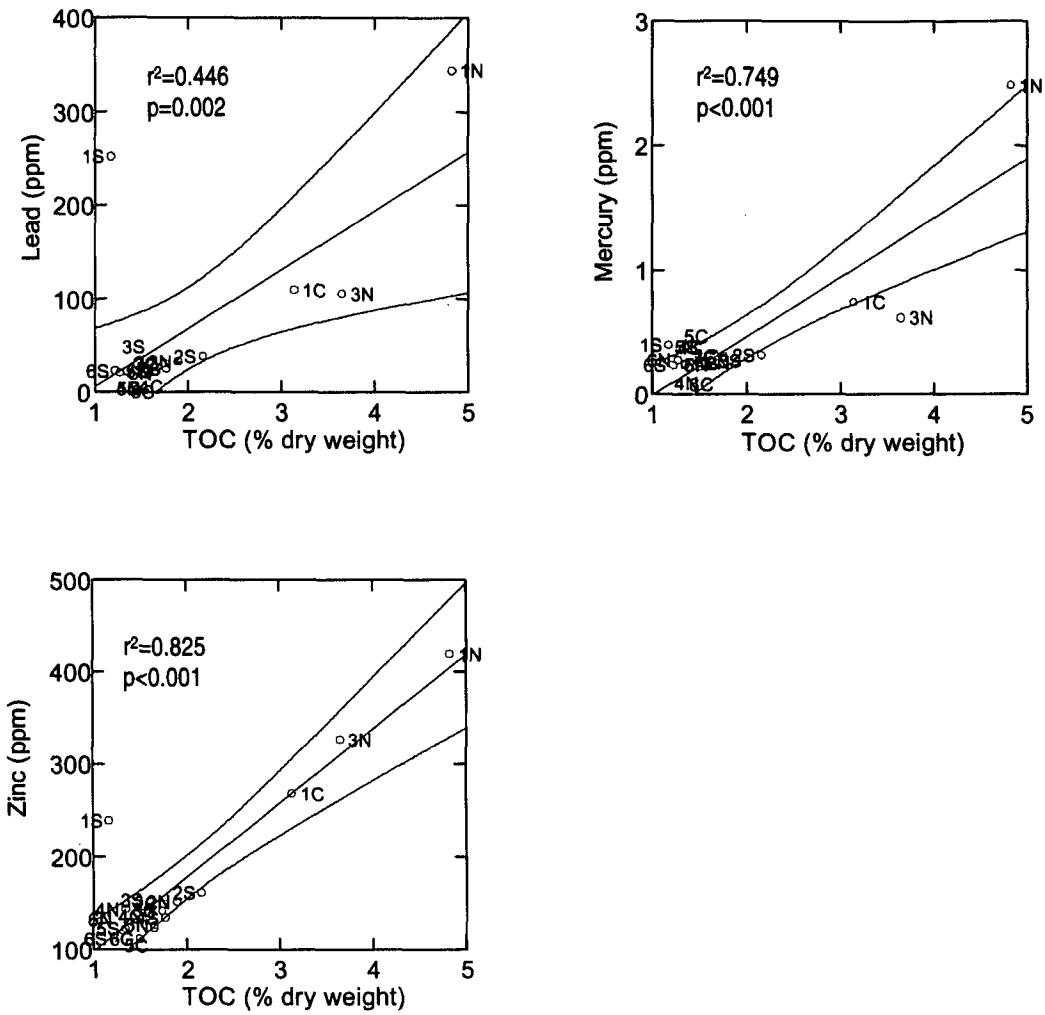

Figure 8-2. Lead, mercury and zinc concentrations vs. TOC in Islais Creek surface sediments.

8.3 HYDROCARBONS (PAH, TPH & LAB)

8.3.1 Results from Principal Components Analysis.

Principal components analysis was performed on 1998 samples only, including all creek surface and subsurface cores and the single reference site sampled at Paradise Cove. Results shown in Figure 8-3 indicate several likely sources of hydrocarbons to creek sediments, namely petroleum-based oils (e.g., lube oils) at Transect 1 and common combustion-related (pyrogenic) compounds associated with urban runoff and aerial fallout at all other stations, including the in-bay reference site at Paradise Cove. Minor inputs from either creosote or coal tar are seen in sediments located near the creek mouth (Transects 5 & 6); however, total concentrations at these stations were very low – close to reference concentrations of <2 $ng \cdot g^{-1}$ (ppm) total PAH. Figure 8-3 is a plot of the first two principal component vector scores (i.e., PCA1 and PCA2), which accounted for 65% of the total data variance. Figure 8-4 plots the sample "loadings" for the same two vectors. The scores describe how sediment samples are related and the loadings explain why the samples are similar or dissimilar. The farther the loadings are from the origin, the larger the impact of that compound on the variance. It is also possible that one compound class will drive the separation (e.g., combustion PAH); however the sample may also contain compounds that are not described in the loadings. For example, the sample set may be driven by combustion PAH versus PAH compounds associated with heavy oil. Although the sample relationship is driven by these two loadings, the heavy oil samples may also contain combustion PAH (e.g., phenanthrene, fluoranthene, and pyrene) and it is the lack of heavy oil in the samples with combustion PAH that separates the samples.

Principal component 2 (PCA 2), plotted on the y-axis of Figure 8-3, identifies additional information on chemical differences in the sample set, most importantly the source type of the combustion and petroleum inputs. The distribution of samples impacted by combustion sources along the y-axis is driven primarily by PAH sample differences due to atmospheric deposition or urban runoff (higher concentrations of benzo(b)fluoranthene [BBF]) versus coal tar or creosote (higher in fluoranthene [F], phenanthrene [P], pyrene [PY]). Weathering or biodegradation of lighter more labile PAH (e.g., 2-4 ring PAH) relative to the more refractory PAH (e.g., benzo[b]fluoranthene) could result in the relative enrichment of high molecular weight (HMW) PAH. Samples that fall between the extremes are likely due to mixing of these two sources. Additional samples from potential contaminant sources to Islais Creek are required to further delineate HMW PAH sources; however, this effort is not recommended as total HMW PAH concentrations were not significantly elevated in creek sediments (e.g., HMW is not a COPC).

The results of the PCA analysis clearly indicate multiple sources of pyrogenic and petrogenic related contamination to Islais Creek. Petroleum sources dominate the distribution in the upper creek with hydrocarbons characteristic of lubricating oils present. Combustion products dominate contamination in the middle and lower creek with hydrocarbon inputs from atmospheric deposition, and coal tar or creosote sources.

In Figure 8-3, the difference between pyrogenic (combustion related) and petrogenic (petroleum origin) hydrocarbons in the sample set drive PCA1, graphed on the x-axis. Stations names coupled with 0, 1 or

2 indicate PCA results for that station at the surface, 0-1 ft or 1-2 ft, respectively. Samples from Transect 1 (surface and core samples) plot on the right side of the graph due to heavy petroleum in the samples (e.g., Station 1C, depth 1-2 ft. shown as 1C2). Transect 3 and 4 stations plot toward the center of the graph because they have inputs from combustion-related and petroleum-related hydrocarbons. Even these samples separate across the x-axis depending on the relative proportion of hydrocarbons. For example, the surface sample at Station 3C (3C0), which is dominated by pyrogenic PAH, plots further to the left than the 1-2 ft subsurface sample from Station 3S (3S2), which is a mixture of petrogenic and pyrogenic sources. Subsurface sample 3S2 provides an excellent example of containing primarily combustion-related hydrocarbons with minimal input from oil. Sediments from transects 4, 5 and 6 have PAH distribution patterns and concentrations similar to background sediments from impacts from atmospheric fallout. These samples cluster on the plot with the Paradise Cove reference sample in the upper right quadrant.

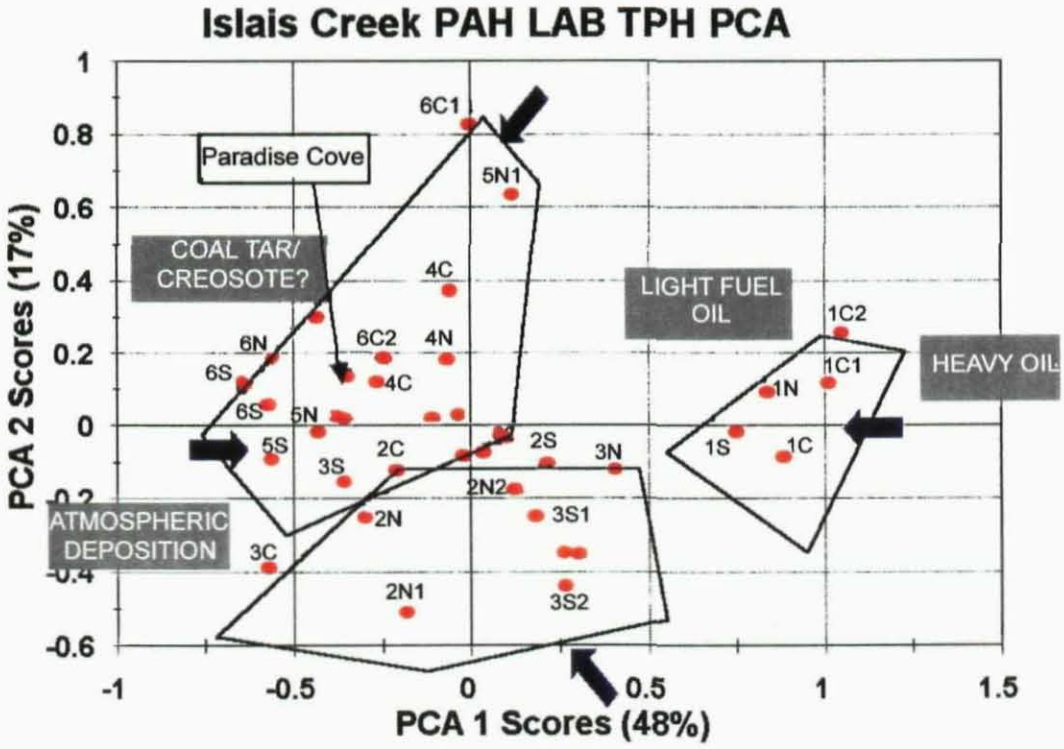

Figure 8-3. Plot of PCA Vector 1 vs. PCA Vector 2 scores showing different PAH sources between creek end (1), mid-section (2 & 3), and creek mouth (5 & 6) and Paradise Cove sediments.

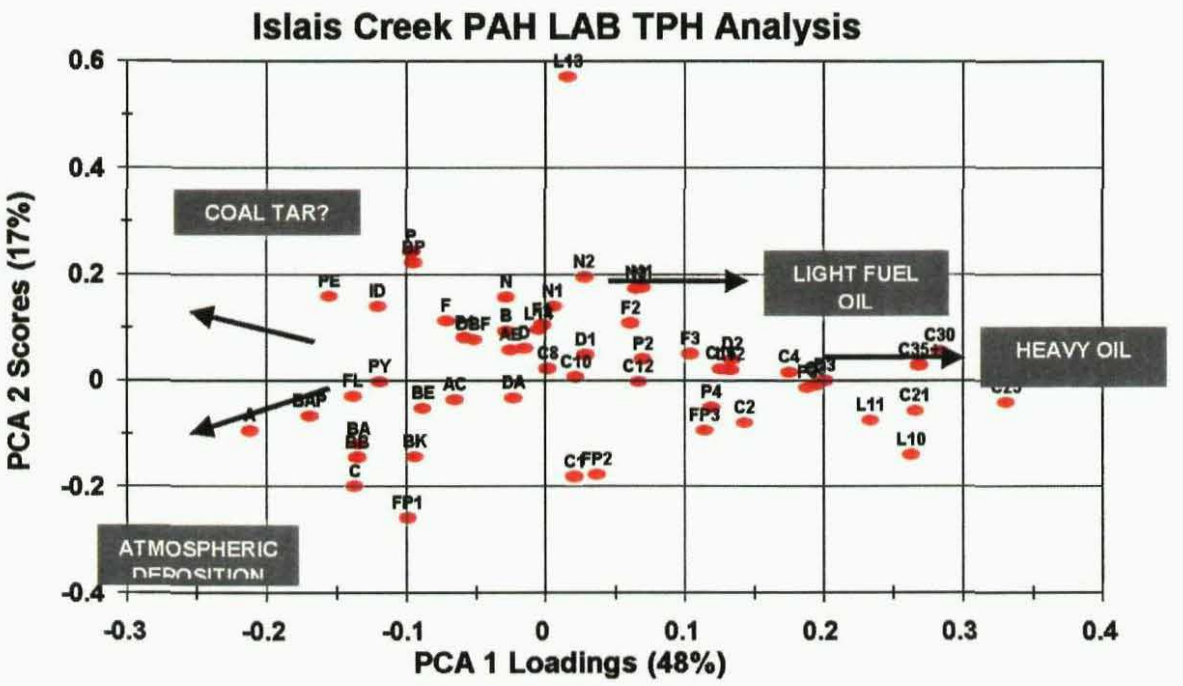

Figure 8-4. Plot of CA loadings showing individual PAH compounds (abbreviated) associated with different sources.

As noted in Section 8.1.2, PCA was utilized in an attempt to determine those PAH compounds that were responsible for the greatest differences between creek sediments. From this screening analysis, a number of PAH compounds were identified that could be used to help get a better understanding potential sources to Islais Creek. Sediment samples were compared, using a series of double ratio plots, with a diverse grouping of reference standards, including petrogenic (i.e., oil derived), pyrogenic (manufactured gas residues, wastes and distillates), pyrogenic dominated reference sediments (urban runoff reference standards), natural background reference sediments and in-bay reference sediments in an attempt to determine whether any source correlations could be made with specific contaminant types.

8.3.2 Diagnostic Ratios

Previous investigators have used C4-phenanthrenes in double ratio plots to identify co-occurring PAH-like compounds present from natural sources. An aromatic diterpane, retene, is commonly found within the C4-phenanthrene isomer pattern. Retene is derived from specific plant resins, and is commonly found in west coast sediments. Many of the sediment samples contained elevated C4-phenanthrenes, and while the extracted ion profiles were not available to review, it is assumed that the elevated C4-phenanthrene patterns seen in the sediments are partially due to retene.

Other PAH compounds such as benzo[*b*]fluoranthene, fluoranthene, pyrene, phenanthrene and anthracene also were useful in identifying various pyrogenic (via fossil fuel combustion) and pyrogenic dominated (via natural processes) input to sediments.

Fluoranthene/pyrene versus phenanthrene/anthracene are plotted in the double ratio plots shown in Figure 8-5. These ratios, when used together are effective in discerning petrogenic versus pyrogenic signatures. In the plot on the left, a suite of petroleum standards (samples in PINK) are plotted with the field samples (RED), pyrogenic (via fuel combustion processes - BLUE), pyrogenic dominated (via natural processes - GREEN) and in-bay reference sediments (GREEN). It is clear from this plot that there is little correlation (if any) to specific petroleum references in most of the sediments in Islais Creek. Transects 1 and 2 (and the Marconi Cove reference site) appear to contain more petrogenic input (plot on right, which is the same plot as on the left, with the petroleum standards removed) than the other sediments in the creek, as evidenced by the elevated phenanthrene/anthracene ratio, which is suggestive of petroleum input. Additionally, the field samples do not appear to have a significant input from any manufactured gas plant (MGP) residue or waste.

As noted above, most of the sediments contained elevated C4-phenanthrene concentrations, likely due to input from a naturally occurring biomarker compound, retene. Another compound that was present at elevated levels in most sediments was benzo[*b*]fluoranthene. When these two diagnostic compounds are plotted (as percent of total PAH), the pyrogenic signature is revealed. It is apparent that the petroleum (PINK) and coal derived standards (BLUE) that are flush against the Y axis (thus containing small percentages of C4-Phenanthrene relative to total PAH) are unrelated to the field samples, reference sediments (GREEN), Pet Tar (petroleum tars - BLUE) and Cre in sed (Creosote in sediment from Eagle Harbor, Washington - BLUE). This plot illustrates again that there are no specific petroleum or MGP residue/waste/distillate that are uniquely responsible for the contamination present in the sediments.

Based on evidence of retene and the results of double ratio plots using diagnostic PAH compounds, it appears that there is a single, overwhelming 'source' contaminant signature present in Islais Creek sediments, urban runoff. Since urban runoff is not a specific fuel or waste type, a brief description of its general makeup is presented below.

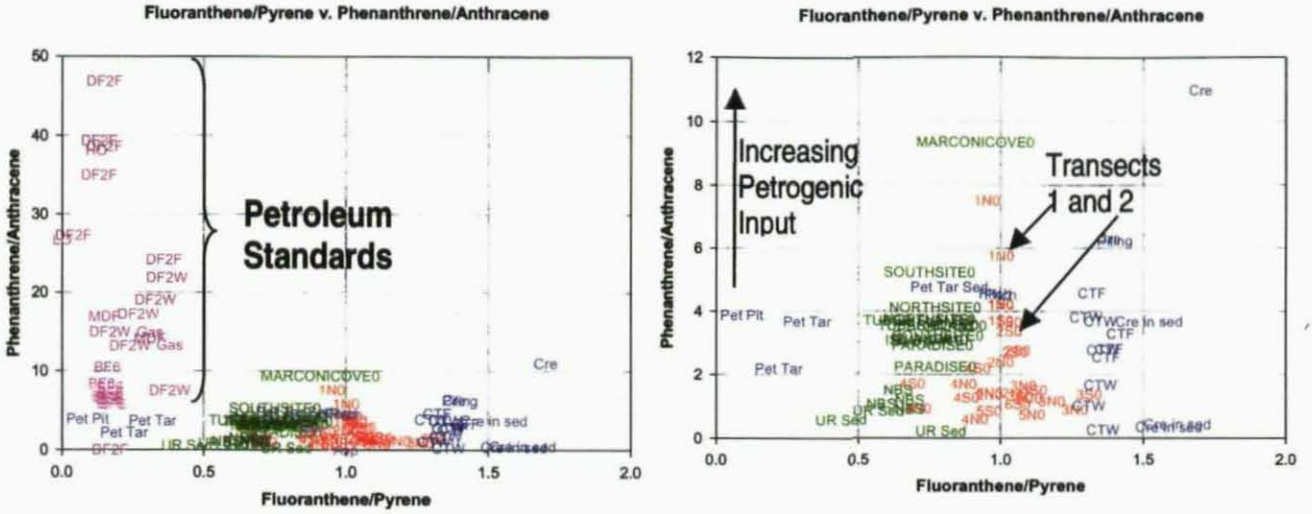

Figure 8-5. Diagnostic ratio plots showing increased petrogenic (combustion) inputs at the creek end (Transects 1 and 2).

Urban sediments can receive PAH derived from both 'point' and 'non-point' sources. Among the latter, urban background (derived from both runoff and atmospheric fallout) is considered ubiquitous in most urban water bodies. Numerous studies of PAH in urban runoff and atmospheric particulates have been conducted around the U.S. over the last two decades. Although 'non-point' sources of PAH in urban environmental vary, the most common sources are 1) urban dust containing combustion-related PAH (principally arising from internal combustion engines, especially diesel-based [e.g., Harrison et al. 1996]); 2) street runoff containing traces of lubricating oils (principally arising from releases from automobiles); and 3) illegal or unintentional discharging of waste oil and petroleum products into storm drain systems. In spite of the presence of a petroleum component in urban runoff, PAHs associated with urban runoff and, in turn, in receiving urban sediments are typically dominated by pyrogenic PAH (Eganhouse et al. 1982). This is because 1) the PAH in storm water run-off often have a pyrogenic PAH signature to begin with; and 2) the 2- and 3- ring PAH are more water-soluble and, therefore, degrade faster than the HMW PAH.

8.3.3 Chromatographic pattern recognition

From the results of the PCA, four "extreme" samples (samples at the outer boundaries of Figure 8-3) are examined to further identify product sources and possible sediment mixing. Sediments from the following stations were further examined: Station 1C, 0-1 ft (1C1), Station 3S, 1-2 ft (3S2), Station 6S, surface (6S0) and Station 6C, 0-1 ft (6C1).

Station 1C, 0-1 ft. The GC/FID chromatogram of this sample (Figure 8-6a) is dominated by the presence an unresolved complex mixture (UCM), which appears as a hump, in the lubricating oil range (approximately *n*-C_{20} to *n*-C_{30}). Resolved hydrocarbons at low levels are also observed in the diesel

range (approximately n-C_{10} to n-C_{20}). The PAH distribution profile for this sample (Figure 8-6b) exhibits a distribution pattern characteristic of a petroleum product that has been degraded. The relatively lower proportion of PAH and LAB to that of TPH is a characteristic of petroleum-derived sources. Alkylated PAH groups are higher than the corresponding parent PAH also indicating impacts from petroleum. The presence of these types of petrogenic distributions of PAH, from naphthalenes (2-ring PAH) through chrysenes (4-ring PAH), suggest possible fuel oil (e.g., diesel or #2 fuel oil) and lube oil sources. The sample also contains combustion-related PAH, indicating pyrogenic inputs.

Note that the distribution within each homologous PAH series has been altered from the initial "bell" shape typical of petroleum, to one dominated by higher alkylation and declining concentration with declining alkylation. This alteration is due to physical processes described as weathering, which includes volatilization, water dissolution and hydrolysis, as well as biological processes described as biodegradation (e.g., bacterial degradation). In petroleum derived sources, such as crude oil, PAH typically comprise a substantially lower proportion of total petroleum hydrocarbons (i.e., 1-5%) compared to those found in combustion derived hydrocarbon products such as coal tars which are enriched in PAH. PAH in coal tars typically comprise as much as 50% of the petroleum hydrocarbons. In this sample total PAH comprise 0.6% of the TPH. The hydrocarbon distribution in this sample indicates primary input from fuel oil and secondary inputs from lubricating oil.

Station 3S, 1-2 ft. The GC/FID chromatogram of this sample (Figure 8-7a) is also dominated by a UCM in the lubricating oil range. Compared to Station 1C, 01 ft., there are fewer resolved hydrocarbons in the diesel range. In fact, the diesel-range normal alkanes targeted in the analysis are below detectable levels. The PAH distribution profile of this sample (Figure 8-7b) is dominated by pyrogenic PAH, specifically pyrene and benzo[b]fluoranthene. Lower molecular weight PAH (i.e., 2-3 ring) are present but at relatively low levels. The bell-shape of the distribution of the phenanthrene/anthracene series indicates influence from a light-range petroleum. The overall sample distribution displays characteristics similar to that of typical atmospheric dust with the exception of the relative depletion of fluoranthene which is most often found at concentrations comparable to pyrene. Total PAH comprise a greater proportion (0.9%) of the TPH than the previous sample, but are lower than most combustion products such as coal tar and creosote. The hydrocarbon distribution in this sample suggests a mixture of lubricating oil and a combustion-related source.

Station 6S, surface. The GC/FID chromatogram of this sample (Figure 8-8a) is dominated by resolved and hydrocarbons in the lubricating oil range. The PAH distribution profile in Figure 8-8b is dominated by pyrogenic PAH, especially fluoranthene, pyrene, and benzo(b)fluoranthene. The distribution within several homologous series, especially phenanthrene and chrysene, exhibit characteristics typical of pyrogenic derived sources. In combustion related products the parent compound dominates each homologous series and concentration declines with greater alkylation.

The greatest difference between this sample and the Station 3S, 1-2 ft sample are that PAH (and LAB) comprise a greater percentage of the measured TPH. Total PAH comprise 2.6% of the TPH concentration in this sample. In addition, fluoranthene is not depleted as observed in the previous sample. The PAH distribution observed is characteristic of atmospheric deposition without a great deal of impact from lubricating oils, typically associated with highway runoff. This is indicative of the mixed sources contributing to the hydrocarbon distribution at this location.

Station 6C, 0-1 ft. The GC/FID chromatogram of this sample (Figure 8-9a) is dominated by resolved and unresolved hydrocarbons in the lubricating oil range. Overall levels of TPH and PAH are lower than the other samples discussed. The PAH distribution profile (Figure 8-9b) is dominated by pyrogenic derived PAH, especially fluoranthene, pyrene, and benzo(b)fluoranthene. The distribution within several homologous series, especially phenanthrene and chrysene, exhibit characteristics typical of pyrogenic derived sources. The proportion of total PAH to TPH is in the mid-range of those discussed (1.2%), which is why the PCA plot positions this sample near the x-axis origin. However, PCA 2 separates this sample from the main cluster of samples, which are from a mixture from pyrogenic and petrogenic sources due to the elevated levels of linear alkylbenzenes (LAB-13 in particular).

As previously discussed, the primary signature observed in the sediment samples is a mixture of a heavy oil, such as lubricating oil, and combustion-related hydrocarbons. This mixture is similar to that of urban runoff, which would include the lubricating oils from engine crankcases that are released to road surfaces and the atmospheric deposition of the combustion products of gasoline and other fuel oils. This contamination is ubiquitous in waterways in urban areas, especially those that drain highways. The relative concentrations of the lubricating oil component and the PAH content in any particular location is a function of localized inputs, weather and the energy of the depositional environment. Low energy depositional environments, such as Islais Creek, may accumulate substantial concentrations of these contaminants, which are associated with fine-grained particles and organic matter.

Figure 8-10 compares PAH distributions for a sediment from a pond that received direct drainage from a four lane urban highway and a representative sediment from the end of Islais Creek (Station 2S, surface). There were no CSO inputs associated with the pond sample, which has a PAH distribution that is typical of urban runoff. The ellipses on the plot indicate the presence of PAH generally associated with petroleum sources. Note that alkylated naphthalenes and alkylated dibenzothiophenes (associated with light fuels such as diesel) are present and of similar distribution in both samples. Alkylated chrysenes (associated with heavy oils) are present in both samples but relative concentrations are higher in the pond sample. The pyrogenic PAH distributions are remarkably similar in both samples. As discussed, these PAH, which are generated by combustion of gasoline and fuel oil (as well as other pyrogenic sources such as wood stoves and forest fires) are ubiquitous and enter near coastal sediment environments primarily through atmospheric fallout and storm runoff.

PAH concentrations in the pond sediment "comparison" sample are significantly higher than PAH concentrations measured in Islais Creek sediments. The fact that highway runoff and atmospheric fallout were the primary sources of elevated PAH concentrations in a typical non-CSO road-side sediment, indicates that similar sources could contribute substantially to the PAH contamination measured at Islais Creek. Characterization of similar sediment environments in San Francisco Bay are required to substantiate this conjecture.

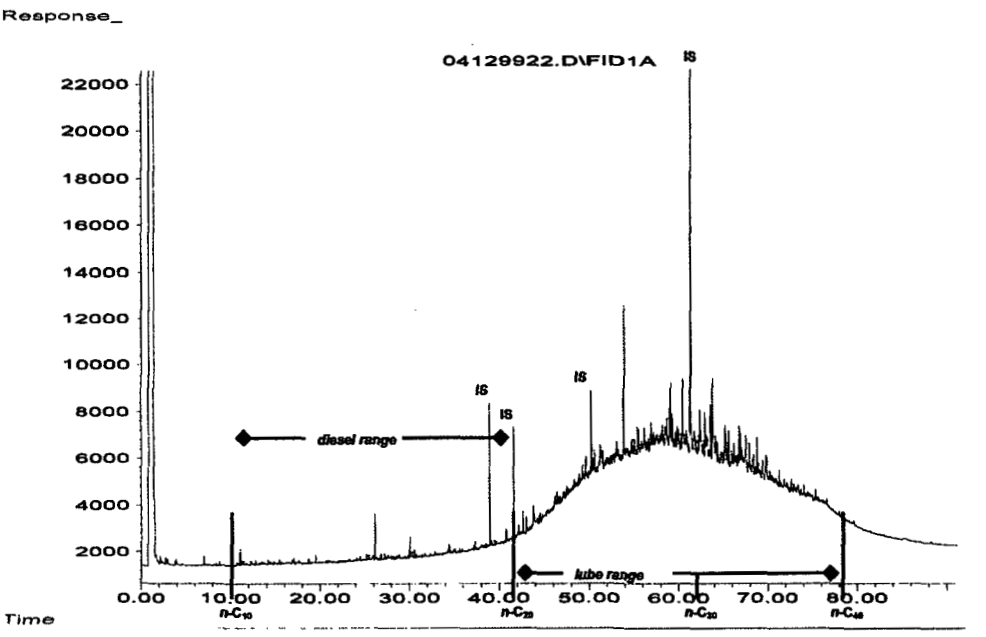

Figure 8-6a. TPH GC/FID chromatogram for Station 1C, 0-1 ft.

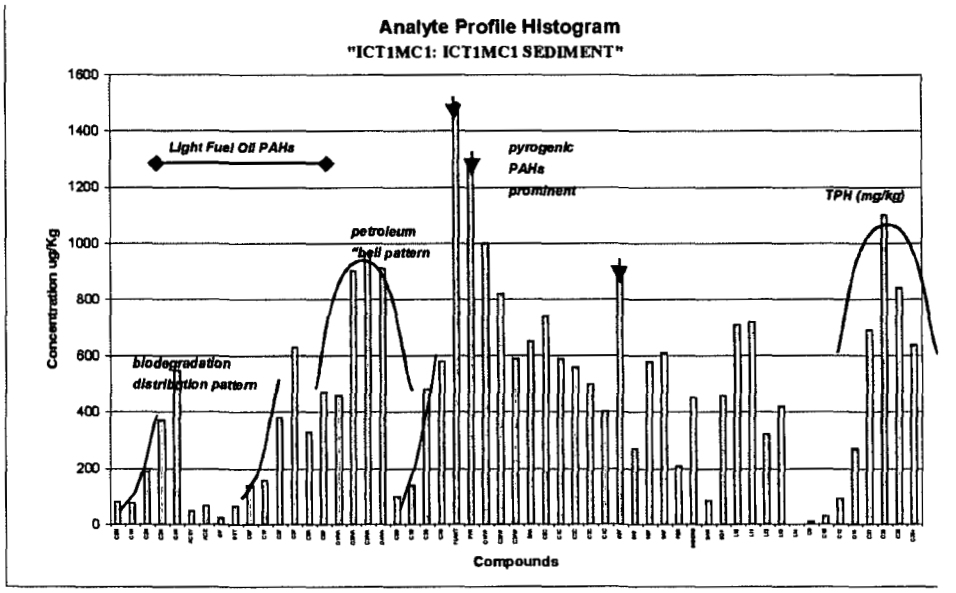

Figure 8-6b. PAH, LAB and TPH distribution for Station 1C, 0-1 ft.

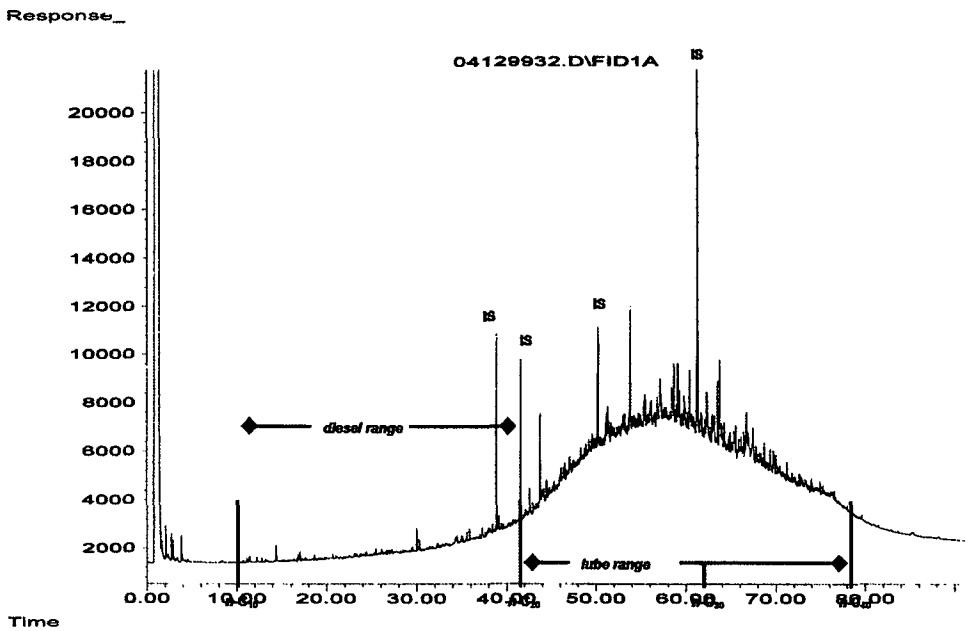

Figure 8-7a. TPH GC/FID chromatogram for Station 3S, 1-2 ft.

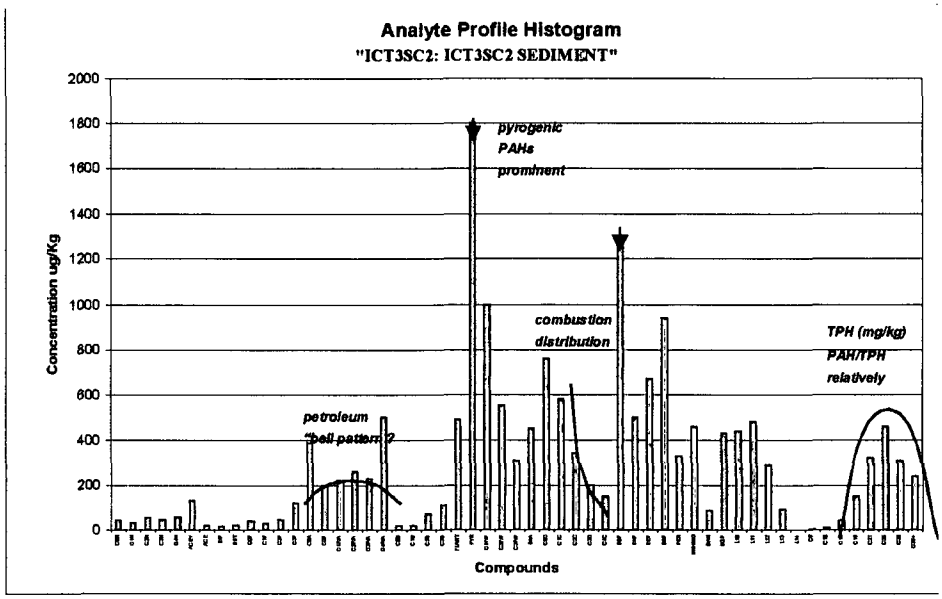

Figure 8-7b. PAH, LAB, TPH distribution for Station 3S, 1-2 ft.

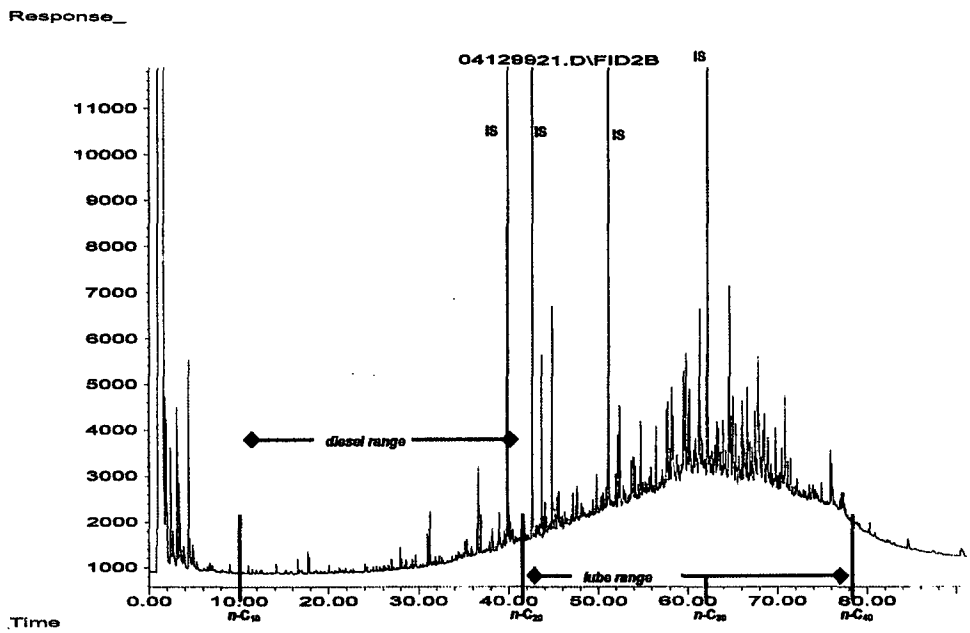

Figure 8-8a. TPH GC/FID chromatogram for Station 6S, surface.

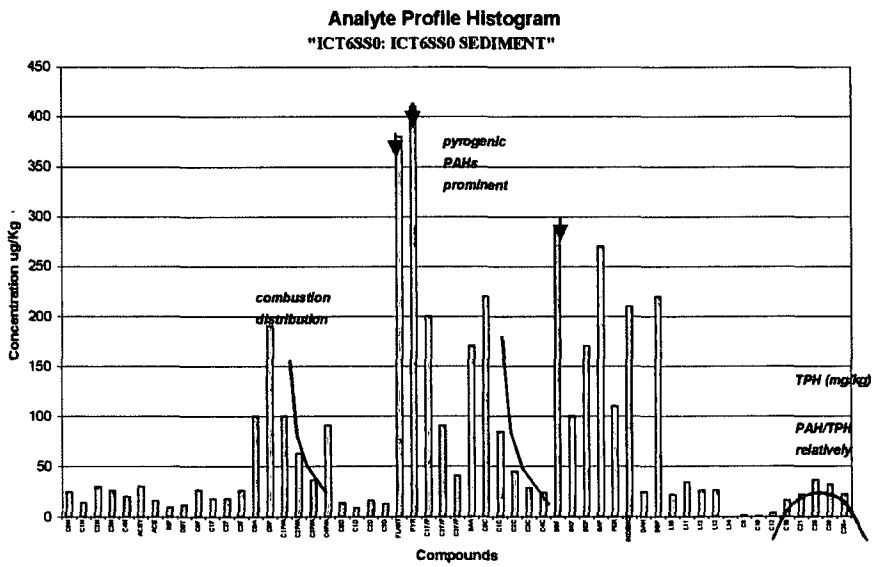

Figure 8-8b. PAH, LAB, TPH distribution for Station 6S, surface.

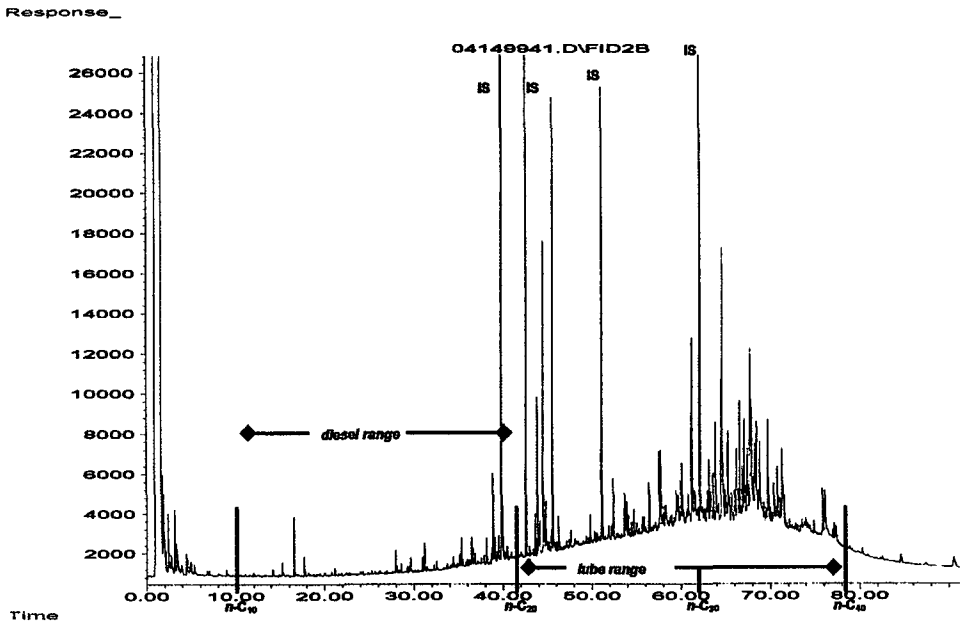

Figure 8-9a. TPH GC/FID chromatogram for Station 6C, 0-1 ft.

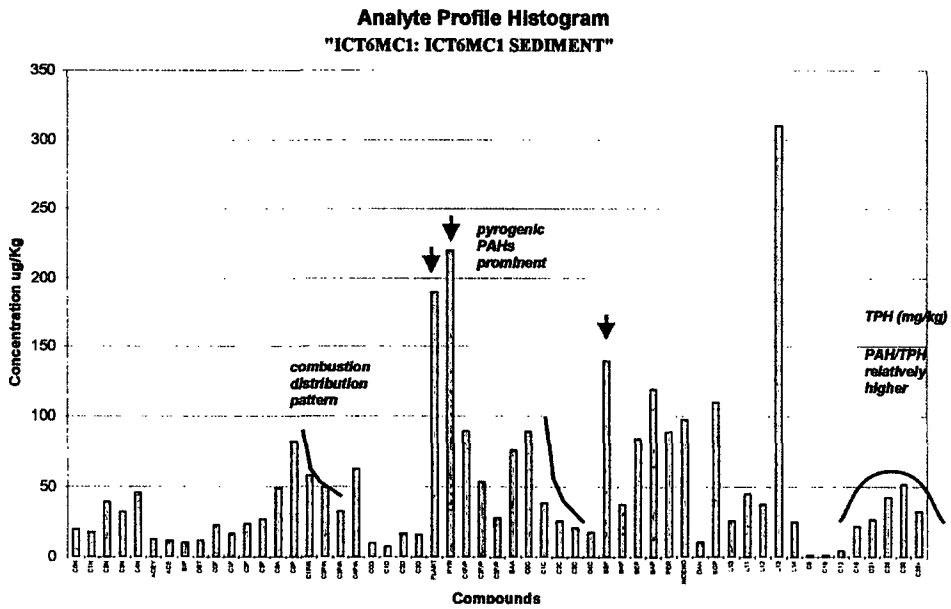

Figure 8-9b. PAH, LAB, TPH distribution for Station 6C, 0-1 ft.

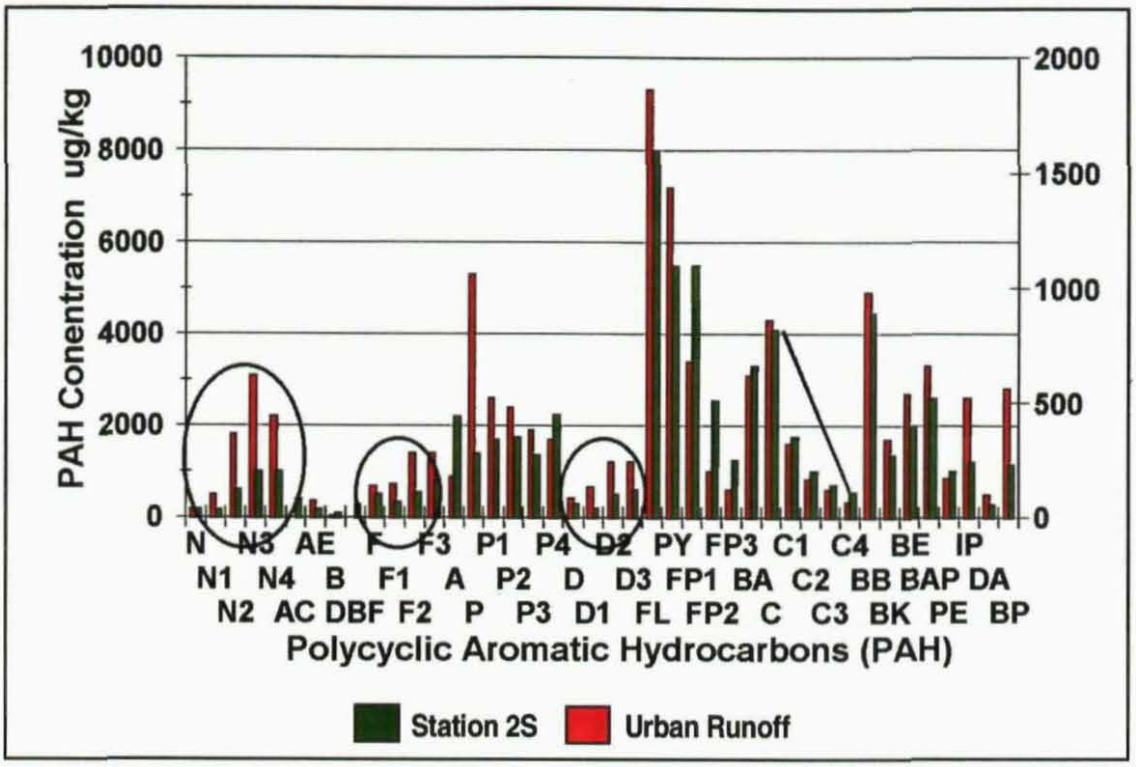

Figure 8-10. Pond sediment with highway drainage compared to Islais Creek surface sediment from Station 2S.

Notes

9.0 APPLICATION OF DECISION RULES AND RECOMMENDATIONS

The decision matrix initially introduced in Section 3 (Table 3-1) is applied to sediment chemistry, toxicity, and bioaccumulation results in this section. This approach identifies creek sediment locations that qualify as "toxic hot spots" (as defined in the BPTCP), as well as locations that show no significant toxicity but are potential sources of contaminant transfer to the food web. Also presented are recommendations for possible further study, including remedial alternatives analysis for localized creek areas.

The decision matrix proposes action based on three lines of evidence that are assumed to be proportional to ecological impact to creek sediments. These actions address not only the conditions necessary for toxic hot spot designation, but other potential outcomes based on the lines of evidence. One of these evidentiary lines, bioaccumulation, was investigated by SFPUC even though it was not used in the BPTCP. This was done because certain COPCs, confined to the western end of both creeks, are known to bioaccumulate in marine food webs even though they rarely cause toxicity in 10-day acute amphipod tests. SFPUC is not suggesting that these data be used to redefine a toxic hot spot, rather that they are considered ancillary information in the likely event that BPTCP data are used in other regulatory programs (e.g., 303[d] listing) for which they were not originally intended.

9.1 ISLAIS CREEK

Table 9-1 shows results for sediment chemistry, toxicity and clam bioaccumulation tests applied to the decision matrix, and where creek stations were statistically elevated compared to in-bay reference stations. The first row identifies only two stations (2N & 3S) that meet the BPTCP definition of a toxic hot spot using data from the three SFPUC surveys (1998, 1999 & 2000). These results refute previous BPTCP assertions that the entire creek is toxic, in that impacts are confined to a small localized area (<1 acre) at the west end of the creek. The BPTCP toxic hot spot listing relied on data collected from a total of three stations from which only a single location was sampled twice (in 1994 and 1997). SFPUC findings are based on a total of 18 stations, six of which were sampled in three consecutive surveys. Further, the BPTCP 1994 amphipod toxicity results for the confirmed hot spot remain suspect because unionized ammonia concentrations exceeded the test threshold subsequently required for the 10-day amphipod test (EPA/USACE 1998). Even though this requirement was established after the BPTCP tests were conducted, bioassay laboratories routinely took precautionary measures to reduce high ammonia and/or hydrogen sulfide levels, which were known to confound test results (pers. communication with F. Charles Newton, Director of MEC Analytical Systems Bioassay Laboratories, 8/98; pers. communication with Jeff Cotsifas, Pacific EcoRisk Laboratories, 6/99). Requirements for reducing ammonia to acceptable test levels (e.g., 0.8 $mg \cdot L^{-1}$ for *Eohaustorius estuarius*) were established by the EPA/USACE in 1999 (in PN-99-3). The laboratory (Granite Canyon) that performed toxicity testing for the BPTCP in San Francisco Bay did not reduce ammonia or hydrogen sulfide to acceptable levels, nor did they remove potential predators from the test chambers prior to testing. Any of these factors could have contributed to the complete mortality observed in the 1997 confirmation testing of Islais Creek; and the subsequent listing of this site as a confirmed toxic hot spot.

The COPCs for Islais Creek were similar to those identified in the BPTCP; however, they were confined to the west end of the creek near the CSO Weir and the Interstate 280 overpass. Extensive sampling of 18 surface sediment stations in 1998 confirmed that COPC creek concentrations were commensurate with in-bay reference levels east of the 3rd Street Bridge (see Figure 3-1, Section 3). Laboratory detection limits were typically at or below those used in the BPTCP. Analyte lists were essentially the same between the BPTCP and SFPUC investigations, except for the 1998 SFPUC study, which expanded the number of analytes to support contaminant source identification.

Table 9-1. Islais Creek - results of creek and reference station comparisons applied to decision matrix. Stations statistically elevated compared to in-bay reference stations are shown.

Chemistry	Toxicity	Bioaccumulation	Results	Action
2N, 3S	2N, 3S	2N, 3S	Toxic Hot Spot – as defined by RWQCB	Candidate for remedial analysis or preventative action
1N, 1S, 2S, 3N	-	1N, 1S, 2S, 3N	Not a toxic hot spot; possible contaminant transport to food web	Possible studies to determine potential food web effects (ecological risk)

Minuses (-) denote no significant differences between creek and reference sediments for 2 or more years.

The ancillary bioaccumulation data showed elevated COPC levels in a limited number of clams exposed to sediments confined to the west end of the creek. PCB and chlorinated pesticide concentrations were elevated based on a comparison to tissue levels in clams exposed to in-bay reference sediment. Biological impact cannot be inferred from these statistical comparisons alone; however, the action presented in the decision matrix calls for "possible studies to determine food web effects". An ecological risk assessment would be an appropriate study to determine if higher organisms exposed to creek COPCs through trophic transfer are at risk. For example, the bioaccumulation data coupled with conservative assumptions of prey exposure, contaminant bioavailability, and site use could be used to determine if creek sediments pose unacceptable risk to invertebrate-eating birds (e.g., diving ducks). Existing site data collected in the SFPUC surveys could be used to perform this analysis without collecting additional field data. However, based on the very small area of localized impact (site use) and the fact that bioaccumulation factors were less than unity (one) for all samples, it is unlikely that these sediments would pose unacceptable risk through trophic transfer.

The SFPUC confirmation of two impacted locations (Stations 2N & 3S) identifies "remedial analysis or preventative action" as an appropriate follow up action (Table 9-1). Any further action must be negotiated between the SFPUC and RWQCB outside of the scope of this report. However, SFPUC strongly urges that data presented in this report are considered in any subsequent remedial alternatives analysis. Subsurface data, which demonstrate that concentrations increase with depth and decrease with distance from the creek end, are of particular importance. These results strongly suggest that creek conditions are improving with time, and that buried, in place contaminants are not being transported to overlying waters or the greater San Francisco Bay.

9.2 MISSION CREEK

Table 9-2 shows results for sediment chemistry, toxicity and clam bioaccumulation tests applied to the decision matrix, and where creek stations were statistically elevated (compared to in-bay reference stations). Notably absent are any toxic hot spots from the 21 Mission Creek stations sampled during the three SFPUC surveys. These results are driven by the high, uniform survival demonstrated in the 10-day amphipod test conducted throughout the creek, which are in stark contrast to the BPTCP results (Hunt et al. 1998a). The BPTCP identified the entire area of Mission Creek (18 acres) as a toxic hot spot based on the confirmatory sampling of a single station sampled in 1995 and 1997 at the west end of the creek. Subsequent sampling by SFPUC in 1998, 1999 and 2000 of eight creek-end stations (located west of the 4th Street Bridge) failed to confirm a single toxic hot spot. Stations east of 4th Street were sampled only in 1998, as results showed that these sediments were consistent with in-bay reference conditions and did not warrant further studies. SFPUC results refute previous BPTCP assertions that the entire creek is toxic, in that sediment toxicity was at or below that measured at in-bay reference stations at all 22 samples tested during the three surveys. These results were achieved even when samples were split and tested by two laboratories (Pacific EcoRisk and SFPUC Oceanside) in 1998.

Table 9-2. Results of creek and reference station comparisons applied to decision matrix for Mission Creek. Stations statistically elevated compared to in-bay reference stations are shown.

Chemistry	Toxicity	Bioaccumulation[1]	Action
1N, 1S, 2N, 2S, 3N, 3S, 4N, 4S	–	1N, 1S, 2N, 2S, 3N, 3S, 4N, 4S	Possible studies to determine potential food web effects (ecological risk0

Minuses (-) denote no significant differences between creek and reference sediments for 2 or more years.

Similar to Islais Creek, clam tissues exposed to sediments collected at the west end of Mission Creek displayed elevated concentrations of selected COPCs compared to reference tissues. These COPCs consisted of PCBs and chlorinated pesticides. Mercury in Mission Creek tissues was below reference tissue concentrations in all samples (see Section 7). The action dictated in Table 9-2 for the chlorinated organic COPC results calls for possible studies to determine potential food web effects. Following the above discussion for Islais Creek, these studies should first make use of existing data to conduct a screening ecological risk assessment, focusing primarily on impacts to higher organisms via the food web. However, the limited area of impact at the creek end (< 5 acres) coupled with strong evidence that contaminant concentrations are decreasing over time make Mission Creek an ideal candidate for natural recovery.

Notes

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APPENDIX A

Islais Creek

APPENDIX A1

Islais Creek
Surface Sediment Data

Appendix A1
SURFACE SEDIMENT DATA - ISLAIS CREEK
October 1998

STATION	1C	1N	1S	2C	2N	2S	3C	3N	ERM
Sample Date	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	
Depth (ft)	0	0	0	0	0	0	0	0	
Replicate	1	1	1	1	1	1	1	1	
Toxicity (% Survival)		83			58.5				
Total Organic Carbon (%)	3.1	4.8	1.2	1.8	1.9	2.2	1.7	3.6	
Grain Size (%)									
Gravel	0	3.3	1.7	0	0	0	0	0	
Sand	12.4	65.5	92.9	1.7	2.8	3.3	1.6	8.3	
Silt	74.3	20.93	2.2	41.3	65.7	79.4	34.1	78.9	
Clay	13.3	10.3	3.2	57	31.5	17.3	64.3	12.8	
Fines (Silt+Clay)	87.6	31.23	5.4	98.3	97.2	96.7	98.4	91.7	
Metals (µg·g', dry weight)									
Aluminum	42016	17615	9930	54671	39703	49659	56467	49867	
Arsenic	7.5	6.5	2.8	11.3	8.6	7.2	10.2	7.4	70
Cadmium	1.19	1.76	0.96	0.6	0.52	0.54	0.48	1.19	9.6
Chromium	110	87	70	118	101	107	118	126	370
Copper	104	139	56	68	71	65	69	105	270
Iron	42152	23823	15333	47920	45446	40397	44693	45414	
Lead	110	345	252	31	33	39	31	106	218
Mercury	0.75	2.49	0.41	0.32	0.26	0.32	0.3	0.62	0.7
Nickel	115	84	49	112	119	106	110	135	51.6
Selenium	0.4	0.28	0.13	0.38	0.3	0.4	0.51	0.64	
Silver	<0.5	1	<0.5	<0.5	<0.5	<0.5	<0.5	1.1	3.7
Zinc	268	419	240	150	152	161	143	327	410
PAH (ng·g', dry weight)									
Naphthalene	35	82	20	27	41	35	32	68	
C1-Naphthalenes	36	79	15	24	44	33	32	79	
C2-Naphthalenes	120	140	28	48	120	120	69	330	
C3-Naphthalenes	200	140	32	72	200	200	96	510	
C4-Naphthalenes	270	260	41	82	260	200	200	600	
Acenaphthylene	47	82	24	50	100	77	120	110	
Acenaphthene	32	61	12	14	120	36	40	160	
Biphenyl	16	27	3.8	14	24	18	18	36	
Dibenzofuran	41	39	10	33	100	55	55	150	
Fluorene	76	69	17	49	150	100	96	270	
C1-Fluorenes	55	65	12	31	100	66	53	150	
C2-Fluorenes	110	210	27	51	160	110	87	260	
C3-Fluorenes	220	450	82	89	200	160	150	380	
Anthracene	330	380	73	350	680	440	790	1100	
Phenanthrene	220	610	140	160	320	280	340	860	
C1-Phenanthrenes/anthracenes	260	350	95	190	460	340	350	740	
C2-Phenanthrenes/anthracenes	360	580	100	170	470	350	320	800	
C3-Phenanthrenes/anthracenes	410	930	130	150	270	270	250	620	
C4-Phenanthrenes/anthracenes	430	1100	160	280	510	450	530	930	
Dibenzothiophene	50	73	12	26	80	58	44	120	

Appendix A1
SURFACE SEDIMENT DATA - ISLAIS CREEK

October 1998

STATION	1C	1N	1S	2C	2N	2S	3C	3N	ERM
Sample Date	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	
Depth (ft)	0	0	0	0	0	0	0	0	
Replicate	1	1	1	1	1	1	1	1	
PAH (ng·g^{-1}, dry weight)									
C1-Dibenzothiophenes	44	73	14	18	50	40	30	87	
C2-Dibenzothiophenes	160	370	46	42	100	100	64	230	
C3-Dibenzothiophenes	230	570	81	53	92	120	69	330	
Fluoranthene	1200	1900	380	980	3000	1600	2000	2900	
Pyrene	910	1800	360	740	1800	1100	1400	2300	
C1-Fluoranthenes/pyrenes	730	1100	230	750	1600	1100	1700	2100	
C2-Fluoranthenes/pyrenes	470	880	170	300	680	510	730	1000	
C3-Fluoranthenes/pyrenes	320	750	130	140	270	250	290	500	
Benzo[a]anthracene	500	760	170	440	1200	660	1200	1300	
Chrysene	570	860	210	590	1400	820	1800	1800	
C1-Chrysenes	380	630	130	220	560	350	550	710	
C2-Chrysenes	320	710	140	110	250	200	230	430	
C3-Chrysenes	320	700	130	61	110	140	100	310	
C4-Chrysenes	240	590	100	53	100	110	76	260	
Benzo[b]fluoranthene	740	1200	330	720	1500	890	1500	1900	
Benzo[k]fluoranthene	230	340	99	190	500	270	490	590	
Benzo[e]pyrene	380	710	180	310	640	400	760	860	
Benzo[a]pyrene	440	770	180	430	960	520	1200	1100	
Perylene	180	280	63	180	310	200	360	360	
Indeno[1,2,3,-c,d]pyrene	270	500	130	210	390	240	450	480	
Dibenzo[a,h]anthracene	59	100	30	44	99	54	110	120	
Benzo[g,h,i]perylene	300	630	150	200	330	230	370	460	
Total LMW PAH (7 compounds)	776	1363	301	674	1455	1001	1450	2647	3160
Total HMW PAH (6 compounds)	3679	6190	1330	3224	8459	4754	7710	9520	9600
Total PAH (13 compounds)	4455	7553	1631	3898	9914	5755	9160	12167	44792
C10B-Phenyl decanes	690	520	160	120	290	420	110	1100	
C11B-Phenyl undecanes	700	500	140	140	360	430	130	1200	
C12B-Phenyl dodecanes	370	330	85	84	150	240	88	540	
C13B-Phenyl tridecanes	230	870	120	220	220	310	150	380	
C14B-Phenyl tetradecanes	<5.6	<12	<2.8	<1.2	<1.4	<2.9	<1.2	<6.7	
TPH (µg·g^{-1}, dry weight)									
n-Nonane	<1.6	<2.2	<0.6	<0.2	<0.28	<0.39	<0.24	<1.7	
n-Decane	0.19	0.34	0.3	<0.01	0.01	0.06	0.01	<0.06	
n-Undecane	<0.19	<0.26	<0.07	<0.02	<0.03	<0.05	<0.03	<0.2	
n-Dodecane	<0.19	<0.26	0.07	<0.02	<0.03	<0.05	<0.03	0.31	
n-Tridecane	<0.26	<0.34	0.11	<0.03	<0.04	<0.06	<0.04	<0.27	
Isoprenoid RRT 1380	<0.31	<0.42	0.12	0.05	0.1	0.15	0.06	0.64	
n-Tetradecane	<0.4	<0.54	0.26	<0.05	<0.07	<0.09	<0.06	<0.42	
Isoprenoid RRT 1470	0.19	<0.1	0.19	0.06	0.23	0.19	0.05	0.94	
n-Pentadecane	<0.16	<0.22	0.45	0.05	0.08	0.09	0.05	0.31	
n-Hexadecane	0.12	0.22	0.51	0.05	0.1	0.1	<0.01	0.34	
Isoprenoid RRT 1650	0.29	<0.26	0.24	0.06	0.12	0.18	0.06	0.94	
n-Heptadecane	0.38	0.33	0.48	0.13	0.18	0.21	0.1	0.66	

Appendix A1
SURFACE SEDIMENT DATA - ISLAIS CREEK

October 1998

STATION	1C	1N	1S	2C	2N	2S	3C	3N	ERM
Sample Date	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	
Depth (ft)	0	0	0	0	0	0	0	0	
Replicate	1	1	1	1	1	1	1	1	
TPH (µg·g^{-1}, dry weight)									
Pristane	0.45	0.42	0.27	0.16	0.26	0.34	0.19	1.6	
n-Octadecane	<0.22	<0.3	0.37	0.06	0.08	0.11	<0.03	0.44	
Phytane	0.6	0.47	0.26	0.17	0.32	0.42	0.18	1.7	
n-Nonadecane	0.16	0.18	0.27	0.07	0.08	0.1	0.07	0.37	
n-Eicosane	<0.07	<0.09	0.24	0.08	0.12	0.1	<0.01	0.3	
n-Heneicosane	<0.16	<0.22	0.26	0.1	<0.03	<0.04	0.15	0.45	
n-Docosane	0.46	0.62	0.3	0.19	0.27	0.27	0.1	0.82	
n-Tricosane	0.64	0.85	0.22	0.22	0.37	0.39	0.21	1.4	
n-Tetracosane	<0.06	<0.08	0.18	0.15	<0.01	<0.01	<0.01	1.1	
n-Pentacosane	0.71	1.2	0.21	0.26	0.47	0.51	0.19	2.1	
n-Hexacosane	0.68	0.6	0.16	0.14	0.2	0.26	0.1	1.4	
n-Heptacosane	1.2	1.5	0.25	0.34	0.4	0.5	0.39	1.6	
n-Octacosane	<0.12	<0.16	<0.04	0.56	1.1	0.96	1.5	<0.13	
n-Nonacosane	3.7	5.1	0.93	0.95	1.6	1.7	1	5	
n-Triacontane	<0.26	<0.36	0.29	0.22	0.32	0.42	0.22	1.4	
n-Hentriacontane	3.8	3.6	0.7	0.9	1.5	1.5	1.1	13	
n-Dotriacontane	1.1	4.7	0.36	0.22	0.34	0.57	<0.01	2.2	
n-Tritriacontane	5	4.6	1	0.97	1.7	2.2	0.42	7.9	
n-Tetratriacontane	1.2	1.8	0.67	0.22	0.33	0.51	<0.02	2.2	
n-Pentatriacontane	0.73	1.3	0.53	0.17	0.28	0.42	0.19	1.4	
n-Hexatriacontane	0.63	1.2	0.37	0.11	0.24	0.26	0.17	1.2	
n-Heptatriacontane	0.6	0.91	0.38	0.12	0.18	0.29	0.11	0.94	
n-Octatriacontane	0.71	0.85	0.3	0.17	0.26	0.39	<0.02	0.99	
n-Nonatriacontane	0.38	0.69	0.15	<0.01	0.18	0.19	0.14	0.71	
n-Tetracontane	0.36	0.45	0.13	0.05	0.1	0.16	0.07	0.4	
Total Resolved Hydrocarbons	190	260	66	47	83	96	65	270	
Total Petroleum Hydrocarbons	2400	3800	860	430	740	1100	480	3400	
TPH >C8-C10	14	6.4	2.9	2	3.7	5.9	3	9.8	
TPH >C10-C12	17	21	4.7	2.4	4	7.7	2.4	25	
TPH >C12-C16	52	83	22	11	21	30	13	100	
TPH >C16-C21	180	250	64	46	77	100	56	300	
TPH >C21-C25	440	640	130	77	140	200	90	610	
TPH >C25-C30	710	1100	240	120	210	300	140	970	
TPH >C30-C35	540	880	200	98	160	240	100	730	
TPH >C35 +	460	810	200	78	120	190	76	610	
Pesticides & PCB (ng·g dry weight)									
Aldrin	<0.66	<0.36	<0.24	<0.32	<0.45	<0.62	<0.38	<0.69	
alpha-Chlordane	14	26	8.9	1.5	3	4.1	1.7	14	
gamma-Chlordane	12	25	9.8	<0.3	<0.42	3.4	1.5	12	
cis-Nonachlor	3.2	7	2.2	0.67	1.3	1.8	0.77	4.1	
trans-Nonachlor	9.7	21	15	0.98	2.1	2.8	0.81	8.9	
Heptachlor	<0.62	<0.33	0.64	<0.3	<0.42	<0.58	<0.35	<0.65	
Heptachlor Epoxide	<0.62	<0.33	<0.23	<0.3	<0.42	<0.58	<0.35	<0.65	

Appendix A1
SURFACE SEDIMENT DATA - ISLAIS CREEK

October 1998

STATION	1C	1N	1S	2C	2N	2S	3C	3N	ERM
Sample Date	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	
Depth (ft)	0	0	0	0	0	0	0	0	
Replicate	1	1	1	1	1	1	1	1	
Pesticides & PCB (ng/g dry weight)									
Total Chlordane (4 compounds)	38.9	79	35.9	3.15	6.4	12.1	4.78	39	
2,4'-DDT	<1	<0.56	<0.38	<0.5	<0.7	<0.97	<0.59	<1.1	
4,4'-DDT	3	5	1.8	1	2.9	2.1	<0.82	3.8	
2,4'-DDE	<1	<0.56	<0.38	<0.5	<0.7	<0.97	<0.59	<1.1	
4,4'-DDE	14	17	3.2	5.8	8	7.9	5.3	15	
2,4'-DDD	5.2	11	2.5	1.1	1.5	2	0.67	4.1	
4,4'-DDD	20	53	13	4.4	5.8	7.6	3.8	20	
Total DDT (6 compounds)	42.2	86	20.5	12.3	18.2	19.6	9.77	43.9	100
Dieldrin	19	34	11	2.7	4.2	6.9	3.2	20	8
Endrin	<0.62	<0.33	<0.23	<0.3	<0.42	<0.58	<0.35	<0.65	45
alpha-hexachlorocyclohexan									
beta-hexachlorocyclohexan									
delta-hexachlorocyclohexan									
Lindane	0.76	<0.24	<0.17	0.32	<0.31	0.44	0.46	<0.48	0.99
Mirex	<0.31	<0.17	<0.11	<0.15	<0.21	<0.29	<0.18	<0.32	
PCB 8	<0.43	3.1	<0.16	<0.21	<0.3	<0.41	<0.25	<0.45	
PCB 18	2.7	6.9	1.2	<0.44	0.69	<0.85	<0.52	2.6	
PCB 28	9.6	12	2.4	1.7	1.6	1.3	1.6	9.4	
PCB 44	5.4	10	2.6	0.48	0.84	1.3	0.57	5.6	
PCB 52	6.1	13	3.7	1.2	1.8	2.2	1.4	7.3	
PCB 66	11	24	9.6	1.8	2.2	5	2.4	13	
PCB 77	5.1	14	6	0.6	0.73	3.3	0.77	5.5	
PCB 101	18	36	22	2.6	3.1	8.8	3.5	18	
PCB 105	5	7.2	9.8	1.8	2.3	1.4	2.3	14	
PCB 118	14	22	9	2.7	3.8	5.2	3.4	15	
PCB 126	<0.76	<0.41	<0.28	<0.37	<0.52	<0.72	<0.44	<0.8	
PCB 128	5.2	8.6	3	1.2	1.6	3	2	6.1	
PCB 138	31	59	28	4.9	7.1	21	7.4	32	
PCB 153	32	80	56	4.5	5.5	20	5.4	28	
PCB 170	15	37	19	2.7	3.7	13	2.9	20	
PCB 180	18	49	25	3.4	3.5	17	3.9	25	
PCB 187	14	32	15	2.6	3.2	11	3.3	16	
PCB 195	2.4	8.3	4.6	0.54	0.67	2.1	0.88	4.8	
PCB 206	1.3	2.7	2.4	0.57	0.7	1	0.77	2.6	
PCB 209	0.56	1.8	0.24	0.28	<0.18	<0.25	<0.15	1	
Total PCB (18 compounds)	191.26	412.6	213.54	32.97	42.3	113.3	41.72	220.4	180
Total Aroclor 1016	<34	<18	<12	<16	<23	<32	<20	<36	
Total Aroclor 1221	<34	<18	<12	<16	<23	<32	<20	<36	
Total Aroclor 1232	<34	<18	<12	<16	<23	<32	<20	<36	
Total Aroclor 1242	<34	<18	<12	<16	<23	<32	<20	<36	
Total Aroclor 1248	<34	<18	<12	<16	<23	<32	<20	<36	
Total Aroclor 1254	290	540	180	42	65	100	48	310	
Total Aroclor 1260	270	520	270	71	83	230	89	410	

Appendix A1
SURFACE SEDIMENT DATA - ISLAIS CREEK
October 1998

STATION	3N	3N	3S	4C	4C	4C	4N	4S	
Sample Date	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	
Depth (ft)	0	0	0	0	0	0	0	0	ERM
Replicate	2	3	1	1	2	3	1	1	
Toxicity (% Survival)			61.5					70.5	
Total Organic Carbon (%)	3.6	3.5	1.6	1.6	1.4	1.6	1.3	1.8	
Grain Size (%)									
Gravel	0	0	0	0	0	0	0	0	
Sand	13.7	12.7	2.3	1.4	0.9	4.7	1.3	1.7	
Silt	75.8	78.2	38.3	36.1	27.6	19.8	25.2	39.7	
Clay	10.5	9.1	59.4	62.5	71.5	75.5	73.5	58.6	
Fines (Silt+Clay)	86.3	87.3	97.7	98.6	99.1	95.3	98.7	98.3	
Metals (µg·g', dry weight)									
Aluminum	41802	46400	60639	52102	58492	51061	54281	42748	
Arsenic	8.7	10.1	13.4	11.8	11.7	12.4	12.2	11.8	70
Cadmium	1.93	2.44	0.55	0.31	0.33	0.33	0.38	0.41	9.6
Chromium	138	165	131	115	119	115	123	102	370
Copper	135	154	71	58	63	65	64	62	270
Iron	40450	42466	50227	47584	47630	51041	52766	45142	
Lead	148	184	30	25	22	23	23	25	218
Mercury	0.82	0.84	0.28	0.24	0.23	0.22	0.24	0.26	0.7
Nickel	141	157	126	114	119	126	131	109	51.6
Selenium	0.73	0.94	0.43	0.47	0.4	0.45	0.42	0.35	
Silver	2.7	3.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	3.7
Zinc	345	401	153	137	138	138	144	135	410
PAH (ng·g', dry weight)									
Naphthalene	84	85	51	22	20	19	18	24	
C1-Naphthalenes	75	92	39	20	20	18	19	22	
C2-Naphthalenes	150	180	77	36	34	38	32	52	
C3-Naphthalenes	170	240	98	42	41	42	36	64	
C4-Naphthalenes	230	400	140	53	54	85	47	94	
Acenaphthylene	190	250	66	30	20	19	17	42	
Acenaphthene	42	62	59	15	15	14	15	20	
Biphenyl	35	46	19	13	11	12	12	15	
Dibenzofuran	73	82	64	29	25	24	24	39	
Fluorene	150	150	95	47	39	36	38	57	
C1-Fluorenes	78	100	52	26	20	20	18	31	
C2-Fluorenes	120	210	78	48	31	31	39	47	
C3-Fluorenes	340	470	110	54	46	44	39	67	
Anthracene	1400	1300	400	240	140	140	130	310	
Phenanthrene	560	600	280	110	90	94	89	160	
C1-Phenanthrenes/anthracenes	680	730	270	110	76	88	74	160	
C2-Phenanthrenes/anthracenes	630	820	230	85	71	88	64	150	
C3-Phenanthrenes/anthracenes	640	840	180	59	49	62	40	110	
C4-Phenanthrenes/anthracenes	1100	1600	300	130	100	99	82	200	
Dibenzothiophene	58	81	42	20	16	16	15	30	

Appendix A1
SURFACE SEDIMENT DATA - ISLAIS CREEK

October 1998

STATION	3N	3N	3S	4C	4C	4C	4N	4S	
Sample Date	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	ERM
Depth (ft)	0	0	0	0	0	0	0	0	
Replicate	2	3	1	1	2	3	1	1	
PAH (ng·g^{-1}, dry weight)									
C1-Dibenzothiophenes	54	76	22	12	9.9	9.5	8.5	17	
C2-Dibenzothiophenes	210	240	54	24	21	21	17	35	
C3-Dibenzothiophenes	420	440	60	20	23	26	17	36	
Fluoranthene	2400	3800	1100	470	330	360	310	870	
Pyrene	3000	3700	820	420	280	320	280	670	
C1-Fluoranthenes/pyrenes	2800	3400	930	300	200	210	170	560	
C2-Fluoranthenes/pyrenes	1500	1900	410	120	82	97	72	230	
C3-Fluoranthenes/pyrenes	820	970	180	59	47	56	38	100	
Benzo[a]anthracene	1400	1800	580	220	150	150	120	400	
Chrysene	2100	2700	830	300	200	180	160	510	
C1-Chrysenes	1000	1200	280	110	82	70	65	180	
C2-Chrysenes	640	750	130	57	48	42	37	83	
C3-Chrysenes	450	560	65	51	33	29	34	49	
C4-Chrysenes	370	420	55	23	25	26	20	40	
Benzo[b]fluoranthene	3100	4000	950	340	210	220	180	590	
Benzo[k]fluoranthene	1100	1300	280	91	78	75	65	200	
Benzo[e]pyrene	1400	1800	420	160	110	110	94	250	
Benzo[a]pyrene	1900	2400	600	230	150	150	130	370	
Perylene	570	700	210	120	87	96	81	160	
Indeno[1,2,3,-c,d]pyrene	830	1000	240	140	98	100	82	200	
Dibenzo[a,h]anthracene	210	260	59	21	14	15	12	38	
Benzo[g,h,i]perylene	880	960	200	130	97	110	82	200	
Total LMW PAH (7 compounds)	2501	2539	990	484	344	340	326	635	3160
Total HMW PAH (6 compounds)	11010	14660	3989	1661	1124	1175	1012	2858	9600
Total PAH (13 compounds)	13511	17199	4979	2145	1468	1515	1338	3493	44792
C10B-Phenyl decanes	1200	1300	120	84	110	61	69	81	
C11B-Phenyl undecanes	1300	1400	140	92	120	76	81	100	
C12B-Phenyl dodecanes	760	720	83	58	66	60	46	64	
C13B-Phenyl tridecanes	570	700	160	160	28	220	68	240	
C14B-Phenyl tetradecanes	<6.8	<7.3	<1.2	<0.39	<0.54	<1.2	<0.39	<1.3	
TPH (µg·g^{-1}, dry weight)									
n-Nonane	<3.1	<1.7	<0.22	<0.23	<0.31	<0.18	<0.22	<0.18	
n-Decane	<0.11	0.07	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
n-Undecane	<0.35	<0.2	<0.03	<0.03	<0.04	<0.02	<0.03	<0.02	
n-Dodecane	<0.35	<0.2	<0.03	<0.03	<0.04	<0.02	<0.03	<0.02	
n-Tridecane	<0.48	<0.26	<0.04	<0.04	<0.05	<0.03	<0.04	<0.03	
Isoprenoid RRT 1380	<0.57	<0.32	0.06	<0.04	<0.06	<0.03	<0.04	0.04	
n-Tetradecane	<0.74	<0.41	<0.05	<0.05	<0.08	<0.04	<0.05	<0.04	
Isoprenoid RRT 1470	0.32	0.45	0.05	0.05	0.05	0.04	0.05	0.06	
n-Pentadecane	<0.3	<0.17	0.05	0.04	0.05	0.03	0.03	0.04	
n-Hexadecane	<0.16	<0.09	0.05	0.05	0.05	0.04	0.04	0.05	
Isoprenoid RRT 1650	<0.36	<0.2	0.06	0.04	0.05	0.04	0.03	0.05	
n-Heptadecane	0.29	0.38	0.09	0.08	0.08	0.09	0.07	0.08	

Appendix A1
SURFACE SEDIMENT DATA - ISLAIS CREEK

October 1998

STATION	3N	3N	3S	4C	4C	4C	4N	4S	
Sample Date	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	ERM
Depth (ft)	0	0	0	0	0	0	0	0	
Replicate	2	3	1	1	2	3	1	1	
TPH (µg·g⁻¹, dry weight)									
Pristane	0.6	0.39	0.16	0.14	0.1	0.12	0.1	0.16	
n-Octadecane	<0.42	<0.23	0.06	0.05	0.06	0.04	0.05	0.05	
Phytane	0.73	0.82	0.2	0.14	0.13	0.14	0.13	0.16	
n-Nonadecane	0.28	<0.11	0.07	0.06	0.06	0.06	0.09	0.06	
n-Eicosane	0.32	<0.07	0.12	0.07	0.05	0.04	0.05	0.05	
n-Heneicosane	<0.3	<0.17	<0.02	0.07	0.08	0.07	0.07	0.07	
n-Docosane	<0.19	<0.1	0.09	0.06	0.06	0.09	0.05	0.15	
n-Tricosane	<0.14	<0.08	0.18	0.1	0.11	0.13	0.09	0.19	
n-Tetracosane	<0.11	<0.06	<0.01	0.04	<0.01	0.09	0.03	0.11	
n-Pentacosane	<0.36	<0.2	0.2	0.1	0.18	0.17	0.13	0.18	
n-Hexacosane	<0.19	<0.11	0.11	0.06	0.1	0.06	0.08	0.07	
n-Heptacosane	1.3	<0.11	0.39	0.24	0.33	0.34	0.27	0.3	
n-Octacosane	3.2	4	0.67	0.34	0.29	<0.01	0.23	<0.01	
n-Nonacosane	4.3	4.8	1.1	0.58	0.85	0.91	0.57	0.92	
n-Triacontane	1.3	<0.27	0.17	0.12	0.17	0.15	0.11	0.2	
n-Hentriacontane	6.1	6.4	1.2	0.65	0.95	0.98	0.68	0.88	
n-Dotriacontane	<0.18	2	0.3	0.19	0.29	0.12	0.18	0.19	
n-Tritriacontane	1.4	1.4	0.41	0.22	0.31	0.79	0.23	0.84	
n-Tetratriacontane	<0.2	<0.11	<0.01	<0.01	<0.02	0.09	<0.01	0.12	
n-Pentatriacontane	1.4	1.8	0.15	0.11	0.11	0.09	0.08	0.11	
n-Hexatriacontane	1.2	1.4	0.12	0.08	0.09	0.06	0.06	0.08	
n-Heptatriacontane	<0.23	0.72	0.08	0.07	0.06	0.07	0.05	0.08	
n-Octatriacontane	0.89	<0.12	0.1	0.08	0.05	0.09	<0.01	0.12	
n-Nonatriacontane	<0.2	<0.11	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	
n-Tetracontane	<0.21	<0.12	<0.01	0.04	0.03	0.03	0.02	<0.01	
Total Resolved Hydrocarbons	270	380	45	29	37	30	34	42	
Total Petroleum Hydrocarbons	3900	4400	390	200	270	210	190	300	
TPH >C8-C10	6.7	7.7	2.4	1.2	2.5	1.8	12	1.9	
TPH >C10-C12	18	22	2.3	1	1.2	1.4	1.2	1.8	
TPH >C12-C16	110	130	11	5.6	7	5.9	6.8	7.7	
TPH >C16-C21	390	450	45	27	28	24	21	35	
TPH >C21-C25	780	930	70	35	46	34	30	49	
TPH >C25-C30	1200	1300	110	53	73	55	46	77	
TPH >C30-C35	810	940	85	46	67	50	40	68	
TPH >C35 +	590	670	63	31	43	37	29	55	
Pesticides & PCB (ng·g dry weight)									
Aldrin	<0.49	<0.68	<0.36	<0.25	<0.35	<0.29	<0.25	<0.29	
alpha-Chlordane	14	17	1.4	0.76	1	0.8	0.77	0.91	
gamma-Chlordane	16	19	1.1	<0.24	0.76	<0.27	0.47	<0.27	
cis-Nonachlor	5.4	7.6	0.68	0.36	0.48	0.35	0.37	0.45	
trans-Nonachlor	11	15	0.9	0.42	0.74	0.5	0.51	0.54	
Heptachlor	<0.46	<0.64	<0.34	<0.24	<0.32	<0.27	<0.23	<0.27	
Heptachlor Epoxide	<0.46	<0.64	<0.34	<0.24	<0.32	<0.27	<0.23	<0.27	

Appendix A1
SURFACE SEDIMENT DATA - ISLAIS CREEK

October 1998

STATION	3N	3N	3S	4C	4C	4C	4N	4S	
Sample Date	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	ERM
Depth (ft)	0	0	0	0	0	0	0	0	
Replicate	2	3	1	1	2	3	1	1	
Pesticides & PCB (ng/g dry weight)									
Total Chlordane (4 compounds)	46.4	58.6	4.08	1.54	2.98	1.65	2.12	1.9	
2,4'-DDT	<0.76	<1.1	<0.56	<0.39	<0.54	<0.45	<0.39	<0.46	
4,4'-DDT	2.9	5.1	0.78	1.9	1.1	<0.64	0.79	1.8	
2,4'-DDE	<0.76	<1.1	<0.56	<0.39	<0.54	<0.45	<0.39	<0.46	
4,4'-DDE	25	30	6.5	5	7.2	6.7	6.7	5.1	
2,4'-DDD	6.2	24	0.93	0.91	1	0.96	0.79	0.92	
4,4'-DDD	34	49	4	3.2	3.6	2.9	3.1	3.1	
Total DDT (6 compounds)	68.1	108.1	12.21	11.01	12.9	10.56	11.38	10.92	100
Dieldrin	32	51	3.1	1.5	1.8	1.5	1.4	1.7	8
Endrin	<0.46	<0.64	<0.34	<0.24	<0.32	<0.27	<0.23	<0.27	45
alpha-hexachlorocyclohexan									
beta-hexachlorocyclohexan									
delta-hexachlorocyclohexan									
Lindane	0.45	0.89	<0.25	<0.17	<0.24	<0.2	<0.17	0.22	0.99
Mirex	<0.23	<0.32	<0.17	<0.12	<0.16	<0.14	<0.12	<0.14	
PCB 8	<0.32	<0.45	<0.24	<0.16	<0.23	<0.19	<0.16	<0.19	
PCB 18	3.5	11	<0.49	<0.35	<0.48	<0.4	<0.34	<0.4	
PCB 28	12	25	1.5	1.2	1.4	1.2	1.3	1.4	
PCB 44	7.7	19	0.59	0.36	0.4	0.37	0.32	0.31	
PCB 52	13	29	1.1	0.74	0.72	0.78	0.66	0.76	
PCB 66	21	42	2	1.2	1	0.92	0.85	1.3	
PCB 77	9	14	0.65	<0.19	<0.26	<0.22	<0.19	0.43	
PCB 101	28	52	2.8	1.6	1.6	1	0.9	2.2	
PCB 105	24	39	0.92	0.67	0.96	0.8	0.8	1.3	
PCB 118	25	48	2.7	1.8	1.7	1.4	1.1	2.1	
PCB 126	<0.57	<0.79	<0.41	<0.29	<0.4	<0.34	<0.29	<0.34	
PCB 128	9.8	14	1.3	0.65	0.52	0.46	0.42	0.94	
PCB 138	61	85	5.1	2.4	2.6	2	1.7	3.5	
PCB 153	50	70	4.2	2.3	2.9	2	1.8	3.2	
PCB 170	41	54	2.5	1.3	0.97	0.77	1.2	2.2	
PCB 180	55	72	3	1.7	1.8	1.3	1.2	3.1	
PCB 187	32	43	2.3	1.2	1.4	0.93	0.8	2.1	
PCB 195	7	9.4	0.47	0.22	0.26	0.22	0.18	0.43	
PCB 206	6.7	8.2	0.48	0.26	0.27	0.25	0.2	0.39	
PCB 209	2.2	1.9	<0.14	0.14	0.23	0.35	0.29	0.17	
Total PCB (18 compounds)	398.9	622.5	30.96	17.74	18.73	14.75	13.72	25.4	180
Total Aroclor 1016	<26	<35	<19	<16	<22	<15	<16	<15	
Total Aroclor 1221	<26	<35	<19	<16	<22	<15	<16	<15	
Total Aroclor 1232	<26	<35	<19	<16	<22	<15	<16	<15	
Total Aroclor 1242	<26	<35	<19	<16	<22	<15	<16	<15	
Total Aroclor 1248	<26	<35	<19	<16	<22	<15	<16	<15	
Total Aroclor 1254	510	850	46	20	24	19	18	26	
Total Aroclor 1260	720	940	65	32	33	26	27	60	

Appendix A1
SURFACE SEDIMENT DATA - ISLAIS CREEK

October 1998

STATION	5C	5N	5S	6C	6N	6S	PARADISE	ERM
Sample Date	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	
Depth (ft)	0	0	0	0	0	0	0	
Replicate	1	1	1	1	1	1	1	
Toxicity (% Survival)	82			70			65	
Total Organic Carbon (%)	1.7	1.7	1.3	1.5	1.3	1.2	1.2	
Grain Size (%)								
Gravel	0	0	0	0	0	3.7	0	
Sand	2.3	1.1	1.7	4.8	5.1	11.3	9.7	
Silt	36.1	37.1	37.2	39.8	43.8	38.4	39.4	
Clay	61.6	61.8	61.1	55.4	51.1	46.6	50.9	
Fines (Silt+Clay)	97.7	98.9	98.3	95.2	94.9	85	90.3	
Metals (µg·g', dry weight)								
Aluminum	39684	37532	40302	45664	35467	43687	43953	
Arsenic	10	12.1	10.9	9.2	11.9	9.5	10.1	70
Cadmium	0.35	0.36	0.28	0.3	0.27	0.28	0.28	9.6
Chromium	96	95	94	103	86	103	103	370
Copper	58	55	57	47	51	48	48	270
Iron	41857	43024	43053	39690	38473	38788	37331	
Lead	23	23	23	20	21	23	26	218
Mercury	0.34	0.25	0.25	0.23	0.29	0.24	0.35	0.7
Nickel	101	99	90	84	84	89	82	51.6
Selenium	0.41	0.38	0.38	0.23	0.37	0.2	0.29	
Silver	<0.5	<0.5	<0.5	<0.1	<0.1	<0.2	<0.5	3.7
Zinc	124	127	123	112	115	112	120	410
PAH (ng·g', dry weight)								
Naphthalene	27	26	35	23	30	25	21	
C1-Naphthalenes	21	21	29	17	16	14	11	
C2-Naphthalenes	47	46	72	35	38	30	20	
C3-Naphthalenes	61	61	79	50	42	26	19	
C4-Naphthalenes	81	83	120	51	64	20	15	
Acenaphthylene	35	37	68	26	35	30	19	
Acenaphthene	18	18	45	17	24	16	7	
Biphenyl	13	13	17	11	11	9.8	6.6	
Dibenzofuran	32	30	66	15	21	12	4.1	
Fluorene	48	47	110	31	43	27	10	
C1-Fluorenes	29	25	57	19	27	18	9.5	
C2-Fluorenes	47	36	76	20	30	18	13	
C3-Fluorenes	59	53	160	30	38	26	16	
Anthracene	260	270	520	110	160	100	37	
Phenanthrene	140	140	410	160	200	190	83	
C1-Phenanthrenes/anthracenes	140	150	320	110	140	100	51	
C2-Phenanthrenes/anthracenes	130	130	250	76	94	63	36	
C3-Phenanthrenes/anthracenes	88	85	150	45	54	36	22	
C4-Phenanthrenes/anthracenes	170	140	320	97	100	91	60	
Dibenzothiophene	23	22	48	15	19	14	6.4	

Appendix A1
SURFACE SEDIMENT DATA - ISLAIS CREEK

October 1998

	STATION	5C	5N	5S	6C	6N	6S	PARADISE	
	Sample Date	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	ERM
	Depth (ft)	0	0	0	0	0	0	0	
	Replicate	1	1	1	1	1	1	1	
PAH (ng·g^{-1}, dry weight)									
C1-Dibenzothiophenes		14	13	26	11	14	8.9	5.4	
C2-Dibenzothiophenes		32	26	48	19	23	16	9.9	
C3-Dibenzothiophenes		29	27	44	19	21	13	8.3	
Fluoranthene		660	660	1300	380	510	380	200	
Pyrene		520	520	890	410	520	410	260	
C1-Fluoranthenes/pyrenes		420	420	900	210	280	200	91	
C2-Fluoranthenes/pyrenes		180	180	380	90	110	90	51	
C3-Fluoranthenes/pyrenes		78	76	150	43	49	41	30	
Benzo[a]anthracene		300	300	580	170	230	170	96	
Chrysene		360	390	780	200	240	220	110	
C1-Chrysenes		130	130	260	76	92	84	42	
C2-Chrysenes		60	58	110	41	44	45	32	
C3-Chrysenes		34	34	56	27	29	29	28	
C4-Chrysenes		31	29	40	23	24	24	21	
Benzo[b]fluoranthene		460	460	810	300	400	290	210	
Benzo[k]fluoranthene		140	140	260	100	110	100	56	
Benzo[e]pyrene		210	220	360	160	200	170	120	
Benzo[a]pyrene		300	310	510	240	300	270	200	
Perylene		140	140	190	110	130	110	78	
Indeno[1,2,3,-c,d]pyrene		160	170	240	140	180	210	170	
Dibenzo[a,h]anthracene		27	27	47	19	25	25	18	
Benzo[g,h,i]perylene		160	160	220	150	190	220	190	
Total LMW PAH (7 compounds)		549	559	1217	384	508	402	188	3160
Total HMW PAH (6 compounds)		2167	2207	4107	1419	1825	1475	884	9600
Total PAH (13 compounds)		2716	2766	5324	1803	2333	1877	1072	44792
C10B-Phenyl decanes		73	51	69	28	28	22	26	
C11B-Phenyl undecanes		76	64	91	38	39	34	20	
C12B-Phenyl dodecanes		49	41	63	35	32	26	37	
C13B-Phenyl tridecanes		130	97	150	130	87	26	18	
C14B-Phenyl tetradecanes		<1.2	<1.2	<1.2	<1.2	<1.2	<0.29	<0.28	
TPH (µg·g^{-1}, dry weight)									
n-Nonane		<0.19	<0.19	<0.19	<0.18	<0.18	<0.17	<0.16	
n-Decane		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
n-Undecane		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
n-Dodecane		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
n-Tridecane		<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	
Isoprenoid RRT 1380		<0.04	<0.04	<0.04	<0.03	<0.03	<0.03	<0.03	
n-Tetradecane		<0.05	<0.05	<0.05	<0.04	<0.04	<0.04	<0.04	
Isoprenoid RRT 1470		0.03	0.03	0.03	0.02	0.02	0.03	0.01	
n-Pentadecane		0.04	0.04	0.04	0.03	0.03	0.02	<0.02	
n-Hexadecane		0.05	0.03	0.03	0.03	0.03	0.02	0.01	
Isoprenoid RRT 1650		0.03	0.03	0.04	0.03	0.03	<0.02	<0.02	
n-Heptadecane		0.07	0.08	0.07	0.05	0.05	0.03	0.02	

Appendix A1
SURFACE SEDIMENT DATA - ISLAIS CREEK

October 1998

	STATION	5C	5N	5S	6C	6N	6S	PARADISE	ERM
	Sample Date	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	
	Depth (ft)	0	0	0	0	0	0	0	
	Replicate	1	1	1	1	1	1	1	
TPH (µg·g^{-1}, dry weight)									
Pristane		0.13	0.14	0.14	0.11	0.12	0.05	0.03	
n-Octadecane		0.06	0.05	0.07	0.03	0.04	0.02	<0.02	
Phytane		0.12	0.13	0.17	0.1	0.1	0.06	0.04	
n-Nonadecane		0.05	0.06	0.06	0.05	0.05	0.03	0.02	
n-Eicosane		0.06	0.05	0.08	0.04	0.05	0.03	0.01	
n-Heneicosane		0.07	0.08	0.1	0.11	0.1	0.04	0.03	
n-Docosane		0.06	0.08	0.1	0.05	0.05	0.08	0.09	
n-Tricosane		0.11	0.12	0.14	0.09	0.1	0.09	0.09	
n-Tetracosane		<0.01	<0.01	<0.01	0.03	0.03	0.1	0.1	
n-Pentacosane		0.11	0.14	0.13	0.11	0.12	0.1	0.08	
n-Hexacosane		0.07	0.08	0.07	0.06	0.07	0.05	0.04	
n-Heptacosane		0.24	0.33	0.29	0.26	0.26	0.17	0.16	
n-Octacosane		0.42	0.44	0.62	0.31	0.32	<0.01	<0.01	
n-Nonacosane		0.55	0.88	0.69	0.64	0.62	0.39	0.37	
n-Triacontane		0.11	0.15	0.15	0.11	0.11	0.09	0.08	
n-Hentriacontane		0.69	0.93	0.84	0.66	0.64	0.53	0.43	
n-Dotriacontane		0.17	0.18	0.18	0.14	0.13	0.12	0.09	
n-Tritriacontane		0.33	0.32	0.37	0.28	0.23	0.31	0.16	
n-Tetratriacontane		<0.01	<0.01	0.12	<0.01	<0.01	0.05	0.05	
n-Pentatriacontane		0.09	0.13	0.1	0.08	0.07	0.03	<0.01	
n-Hexatriacontane		0.07	0.07	0.08	0.06	0.05	0.05	0.04	
n-Heptatriacontane		0.06	0.07	0.06	0.06	0.05	0.04	0.03	
n-Octatriacontane		<0.01	<0.01	<0.01	<0.01	<0.01	0.06	0.07	
n-Nonatriacontane		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
n-Tetracontane		0.03	<0.01	<0.01	0.03	0.02	0.02	0.02	
Total Resolved Hydrocarbons		31	35	39	23	24	19	15	
Total Petroleum Hydrocarbons		210	220	230	150	160	130	120	
TPH >C8-C10		3.3	4.8	2.5	1.5	2.4	1.5	1.4	
TPH >C10-C12		1.6	1.5	1.8	1.1	1.3	0.84	0.68	
TPH >C12-C16		6.2	5.9	6.7	4.1	4.5	3.4	2.6	
TPH >C16-C21		26	26	30	18	19	16	16	
TPH >C21-C25		35	37	40	24	25	22	21	
TPH >C25-C30		53	58	60	38	40	36	34	
TPH >C30-C35		46	52	52	36	37	32	28	
TPH >C35 +		35	39	39	27	29	22	21	
Pesticides & PCB (ng·g^{-1} dry weight)									
Aldrin		<0.3	<0.3	<0.31	<0.29	<0.28	<0.22	<0.21	
alpha-Chlordane		0.65	0.64	0.84	0.53	0.53	<0.21	<0.2	
gamma-Chlordane		<0.28	0.44	0.44	<0.27	<0.27	<0.21	<0.2	
cis-Nonachlor		0.41	0.46	0.48	0.3	0.31	0.22	0.3	
trans-Nonachlor		0.26	<0.2	0.34	0.24	0.2	0.22	<0.15	
Heptachlor		<0.28	<0.28	<0.29	<0.27	<0.27	<0.21	<0.2	
Heptachlor Epoxide		<0.28	<0.28	<0.29	<0.27	<0.27	<0.21	<0.2	

Appendix A1
SURFACE SEDIMENT DATA - ISLAIS CREEK

October 1998

STATION	5C	5N	5S	6C	6N	6S	PARADISE	ERM
Sample Date	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	
Depth (ft)	0	0	0	0	0	0	0	
Replicate	1	1	1	1	1	1	1	
Pesticides & PCB (ng/g dry weight)								
Total Chlordane (4 compounds)	1.32	1.54	2.1	1.07	1.04	0.44	0.3	
2,4'-DDT	<0.48	<0.46	<0.48	<0.45	<0.44	<0.35	<0.33	
4,4'-DDT	<0.67	<0.65	0.97	0.64	0.73	<0.49	<0.47	
2,4'-DDE	<0.48	<0.46	<0.48	<0.45	<0.44	<0.35	<0.33	
4,4'-DDE	4.2	4.1	4.3	3.5	3.3	3.1	2.2	
2,4'-DDD	0.79	0.72	0.86	0.66	0.72	0.6	0.9	
4,4'-DDD	3.5	3	3.5	2.7	2.6	2.8	4.2	
Total DDT (6 compounds)	8.49	7.82	9.63	7.5	7.35	6.5	7.3	100
Dieldrin	1.6	1.5	1.8	1.2	1.2	1.7	1.7	8
Endrin	<0.28	<0.28	<0.29	<0.27	<0.27	<0.21	<0.2	45
alpha-hexachlorocyclohexan								
beta-hexachlorocyclohexan								
delta-hexachlorocyclohexan								
Lindane	0.35	0.32	0.27	0.33	0.29	<0.15	<0.15	0.99
Mirex	<0.14	<0.14	<0.14	<0.13	<0.13	<0.1	<0.1	
PCB 8	<0.2	<0.2	<0.2	<0.19	<0.19	0.19	0.22	
PCB 18	<0.42	<0.41	<0.42	<0.39	<0.39	<0.31	<0.29	
PCB 28	1.3	1.3	1.4	1.2	1	<0.21	0.39	
PCB 44	0.3	0.26	0.39	0.27	0.24	0.46	0.38	
PCB 52	0.74	0.78	1.1	0.63	0.62	0.71	0.83	
PCB 66	1.2	1.2	1.4	0.94	0.94	1.6	1.5	
PCB 77	0.34	0.38	0.4	0.27	0.28	<0.17	<0.16	
PCB 101	1.4	1.6	1.7	0.96	1.1	1.8	1.7	
PCB 105	0.92	0.88	1.2	0.71	0.75	0.58	0.69	
PCB 118	1.7	1.7	2.3	1.4	1.4	1.4	1.9	
PCB 126	<0.35	<0.34	<0.36	<0.33	<0.33	<0.26	<0.25	
PCB 128	0.78	0.78	1.1	0.47	0.59	<0.11	<0.11	
PCB 138	2.9	3	3.6	2	2.1	2.9	2.8	
PCB 153	2.4	2.5	2.7	1.9	1.9	2.6	2.6	
PCB 170	1.3	1.3	1.3	0.99	0.81	1.2	0.78	
PCB 180	1.7	1.9	1.9	1.2	1.3	1.5	1.6	
PCB 187	1.3	1.3	1.5	0.97	0.9	1.3	1.3	
PCB 195	0.29	0.36	0.49	0.24	0.28	0.27	0.24	
PCB 206	0.34	0.34	0.54	0.27	0.25	0.23	0.28	
PCB 209	0.15	0.21	0.18	0.28	0.23	0.27	0.28	
Total PCB (18 compounds)	18.72	19.41	22.8	14.43	14.41	17.01	17.49	180
Total Aroclor 1016	<16	<16	<16	<15	<15	<14	<13	
Total Aroclor 1221	<16	<16	<16	<15	<15	<14	<13	
Total Aroclor 1232	<16	<16	<16	<15	<15	<14	<13	
Total Aroclor 1242	<16	<16	<16	<15	<15	<14	<13	
Total Aroclor 1248	<16	<16	<16	<15	<15	<14	<13	
Total Aroclor 1254	22	22	28	18	17	22	23	
Total Aroclor 1260	41	41	51	30	32	22	23	

Appendix A1
SURFACE SEDIMENT DATA - ISLAIS CREEK

October 1999

	STATION	1N	1S	2N	2S	3N	3S	
	Sample Date	10/12/99	10/12/99	10/12/99	10/12/99	10/12/99	10/12/99	ERM
	Depth (ft)	0	0	0	0	0	0	
	Replicate	1	1	1	1	1	1	
Toxicity (% Survival)		94	93	68	78	73	70	
Total Organic Carbon (%)		1.8	1.2	2.5	2.1	2.2	1.8	
Grain Size (%)								
Sand		61.9	3.7	1	1.6	5	0.6	
Fines (Silt+Clay)		38.1	96.3	99	98.4	95	99.4	
Metals (µg·g, dry weight)								
Aluminum		14227	12481	53766	43844	51036	50896	
Arsenic		4.18	1.94	10.78	8.25	8.42	11.44	70
Cadmium		2.42	0.94	0.71	0.72	1.33	0.62	9.6
Chromium		69.9	71.1	117.7	103.8	135.5	109.3	370
Copper		92.4	66.9	68.5	66.7	99.7	55.3	270
Iron		19376	17415	43692	37620	43149	40283	
Lead		402.8	227.4	39.5	41.5	86.4	31.6	218
Mercury		0.884	0.266	0.286	0.254	0.471	0.218	0.7
Nickel		71.7	57.5	97	90.9	123.3	82.8	51.6
Selenium		0.4	0.17	0.58	0.51	0.75	0.5	
Silver		1.27	0.76	0.92	0.76	1.91	0.66	3.7
Zinc		347.2	239.5	163.4	158.3	264.2	140	410
PAH (ng·g^{-1}, dry weight)								
Naphthalene		33	24	53	52	46	42	
C1-Naphthalenes		25	17	37	37	42	28	
C2-Naphthalenes		42	32	79	63	76	58	
C3-Naphthalenes		50	89	150	86	120	93	
C4-Naphthalenes		81	120	210	130	230	120	
Acenaphthylene		24	17	220	120	130	97	
Acenaphthene		14	7.8	46	22	26	37	
Biphenyl		8.7	5.5	19	20	23	16	
Fluorene		25	15	160	110	87	99	
C1-Fluorenes		21	27	130	69	82	68	
C2-Fluorenes		59	58	200	140	160	97	
C3-Fluorenes		140	96	290	200	280	160	
Anthracene		110	68	1200	660	710	560	
Phenanthrene		170	120	560	430	500	360	
C1-Phenanthrenes/anthracenes		140	120	760	470	540	340	
C2-Phenanthrenes/anthracenes		230	200	640	440	450	300	
C3-Phenanthrenes/anthracenes		290	180	410	290	370	220	
C4-Phenanthrenes/anthracenes		350	150	790	500	700	380	
Dibenzothiophene		20	17	66	44	59	42	
C1-Dibenzothiophenes		36	39	84	59	80	44	
C2-Dibenzothiophenes		120	88	150	120	160	84	
C3-Dibenzothiophenes		200	110	140	130	190	82	
Fluoranthene		700	430	5100	2300	3500	2000	
Pyrene		650	450	3100	1800	2600	1500	

Appendix A1
SURFACE SEDIMENT DATA - ISLAIS CREEK

October 1999

	STATION	1N	1S	2N	2S	3N	3S	
	Sample Date	10/12/99	10/12/99	10/12/99	10/12/99	10/12/99	10/12/99	ERM
	Depth (ft)	0	0	0	0	0	0	
	Replicate	1	1	1	1	1	1	
PAH (ng·g^{-1}, dry weight)								
C1-Fluoranthenes/pyrenes		390	270	3000	1400	1900	1100	
C2-Fluoranthenes/pyrenes		400	240	1400	810	1100	620	
C3-Fluoranthenes/pyrenes		400	230	710	450	570	320	
Benzo[a]anthracene		280	200	1900	800	1200	790	
Chrysene		360	240	3000	1200	1900	1100	
C1-Chrysenes		300	190	1200	630	870	470	
C2-Chrysenes		420	220	630	360	540	250	
C3-Chrysenes		570	240	360	300	440	190	
C4-Chrysenes		390	160	230	180	260	110	
Benzo[b]fluoranthene		430	350	3200	1400	2100	1200	
Benzo[k]fluoranthene		160	100	1100	480	760	390	
Benzo[e]pyrene		270	200	1400	680	1000	560	
Benzo[a]pyrene		270	220	2100	880	1400	790	
Perylene		100	72	660	320	440	290	
Indeno[1,2,3,-c,d]pyrene		170	140	830	410	620	350	
Dibenzo[a,h]anthracene		42	31	200	86	150	70	
Benzo[g,h,i]perylene		230	160	700	370	560	320	
Total LMW PAH (7 compounds)		401	268.8	2276	1431	1541	1223	3160
Total HMW PAH (6 compounds)		2302	1571	15400	7066	10750	6250	9600
Total PAH (13 compounds)		2703	1839.8	17676	8497	12291	7473	44792
Pesticides & PCB (ng·g dry weight)								
Aldrin		<0.61	<0.53	<1.1	<0.95	<0.75	<0.81	
alpha-Chlordane		8	5.8	2.6	4.9	7.6	2.6	
gamma-Chlordane		10	7.8	2.5	3.7	7.4	1.4	
cis-Nonachlor		3.9	3.7	1.6	2.2	3.1	0.82	
trans-Nonachlor		6.2	4.3	1.7	2.6	4.5	1	
Heptachlor		0.13	0.14	0.16	0.2	0.58	<0.76	
Heptachlor Epoxide		<0.57	<0.5	<1	<0.89	<0.7	<0.76	
Total Chlordane (4 compounds)		28.1	21.6	8.4	13.4	22.6	5.82	
2,4'-DDT		<0.95	<0.83	<1.7	<1.5	<1.2	<1.3	
4,4'-DDT		2.8	1.4	1.8	1.7	2.7	1.1	
2,4'-DDE		<0.95	<0.83	<1.7	<1.5	<1.2	<1.3	
4,4'-DDE		8	7.2	6.8	8.8	16	5.8	
2,4'-DDD		7	13	5.8	6.3	7.8	3.6	
4,4'-DDD		22	19	8.9	13	17	6.2	
Total DDT (6 compounds)		39.8	40.6	23.3	29.8	43.5	16.7	100
Dieldrin		4.1	<0.5	<1	3	4.6	2.1	8
Endrin		<0.57	<0.5	<1	<0.89	<0.7	<0.76	45
alpha-hexachlorocyclohexan		0.13	0.02	0.21	0.18	0.1	0.06	
beta-hexachlorocyclohexan		<0.25	<0.22	<0.44	<0.39	<0.3	<0.33	
delta-hexachlorocyclohexan		<0.4	<0.35	<0.72	<0.62	<0.49	<0.53	
Lindane		<0.42	0.17	0.45	<0.65	<0.52	<0.55	0.99
Mirex		<0.28	<0.25	<0.51	<0.45	<0.35	<0.38	

Appendix A1
SURFACE SEDIMENT DATA - ISLAIS CREEK

October 1999

STATION	1N	1S	2N	2S	3N	3S	ERM
Sample Date	10/12/99	10/12/99	10/12/99	10/12/99	10/12/99	10/12/99	
Depth (ft)	0	0	0	0	0	0	
Replicate	1	1	1	1	1	1	
Pesticides & PCB (ng/g dry weight)							
PCB 8	2.2	1	3.7	2.2	0.56	0.8	
PCB 18	2.4	1.7	2.2	1.6	7.1	3.9	
PCB 28	3	2.4	0.85	1.5	4.5	1.2	
PCB 44	4.7	3.8	2.3	2.6	3.9	1.7	
PCB 52	5.8	7.4	2	2.2	4.8	1.6	
PCB 66	16	19	5.7	6.4	12	4.7	
PCB 77	7.8	15	3.2	3.9	8.3	2.4	
PCB 101	17	28	5.2	6.2	14	3.9	
PCB 105	3.9	3.6	1.2	1.8	2.8	0.67	
PCB 118	11	12	5	5.2	11	3.5	
PCB 126	2.8	2.8	7.7	3	5.4	3.2	
PCB 128	5.2	4.7	4.7	2.4	5.8	2.4	
PCB 138	24	43	9.4	11	23	7.1	
PCB 153	32	90	12	14	30	9.3	
PCB 170	5.4	20	4.5	4.6	9.2	3	
PCB 180	20	41	6.7	8.9	27	4.3	
PCB 187	10	23	5	5.7	12	3.9	
PCB 195	1.3	3.6	1	1.1	2.4	0.81	
PCB 206	1.5	1.8	0.49	0.5	1.4	0.3	
PCB 209	1	0.38	1.3	1.2	1.5	0.45	
Total PCB (18 compounds)	166.4	306.38	73.24	79.1	172.96	53.53	180

Appendix A1
SURFACE SEDIMENT DATA - ISLAIS CREEK

October 1999

STATION	Island 1	Marconi Cove	North Site	Paradise	South Site	Tubbs Island	ERM
Sample Date	10/18/99	10/15/99	10/19/99	10/18/99	10/19/99	10/18/99	
Depth (ft)	0	0	0	0	0	0	
Replicate	1	1	1	1	1	1	
Toxicity (% Survival)	59	83	83	94	99	70	
Total Organic Carbon (%)	1.0	1.8	0.4	1.0	0.5	1.0	
Grain Size (%)							
Sand	0.8	0.3	69.3	4.5	36	3.5	
Fines (Silt+Clay)	99.2	99.7	30.7	95.5	64	96.5	
Metals (µg·g⁻¹, dry weight)							
Aluminum	52418	46020	23753	37480	30128	40110	
Arsenic	8.8	9.66	2.49	8.27	3.56	0.93	70
Cadmium	0.37	0.29	0.17	0.27	0.23	0.27	9.6
Chromium	106.7	149.1	83.2	94.1	82.2	94.2	370
Copper	50.9	41.6	13.7	42.6	20.3	50.8	270
Iron	40682	46162	23642	35596	25826	38562	
Lead	18.7	13.3	13.3	22.3	13.1	22.6	218
Mercury	0.234	0.175	0.086	0.225	0.159	0.24	0.7
Nickel	88.4	159.3	72	75.9	67.3	86	51.6
Selenium	0.13	0.33	<0.09	0.17	<0.09	0.22	
Silver	0.64	0.49	<0.45	0.67	0.47	0.55	3.7
Zinc	120	103.2	73.1	109.5	74.4	116.3	410
PAH (ng·g⁻¹, dry weight)							
Naphthalene	10	11	4.7	16	7.3	13	
C1-Naphthalenes	8.2	29	3.6	11	5.6	8.9	
C2-Naphthalenes	14	48	6.8	16	11	18	
C3-Naphthalenes	14	36	<2	14	9	16	
C4-Naphthalenes	<2.7	18	<2	14	<2.2	<2.9	
Acenaphthylene	6.1	1	2.2	8.9	7.6	8.3	
Acenaphthene	3.7	1.2	2.5	6.4	3.9	5.6	
Biphenyl	4.1	13	1.4	5.5	3	4.6	
Fluorene	5.8	7.3	3.6	8.1	8.5	7.7	
C1-Fluorenes	5.4	12	2.8	7.1	5.1	6.8	
C2-Fluorenes	9.9	26	<0.83	9.5	<0.89	12	
C3-Fluorenes	<1.1	18	<0.83	13	<0.89	<1.2	
Anthracene	13	4.6	5.1	21	13	17	
Phenanthrene	40	43	21	75	68	63	
C1-Phenanthrenes/anthracenes	29	51	13	40	36	45	
C2-Phenanthrenes/anthracenes	22	39	7.7	29	18	36	
C3-Phenanthrenes/anthracenes	17	18	4.3	19	8.5	25	
C4-Phenanthrenes/anthracenes	29	11	5.6	21	17	37	
Dibenzothiophene	3.8	2.5	1.6	5.6	4.7	5.4	
C1-Dibenzothiophenes	4.6	3.3	1.8	5.5	4.5	7.5	
C2-Dibenzothiophenes	7.2	4.2	<0.45	8.8	5.4	11	
C3-Dibenzothiophenes	7.9	3.3	<0.45	9	4.6	12	
Fluoranthene	110	20	41	210	120	170	
Pyrene	150	22	53	270	160	240	

Appendix A1
SURFACE SEDIMENT DATA - ISLAIS CREEK

October 1999

STATION	Island 1	Marconi Cove	North Site	Paradise	South Site	Tubbs Island	ERM
Sample Date	10/18/99	10/15/99	10/19/99	10/18/99	10/19/99	10/18/99	
Depth (ft)	0	0	0	0	0	0	
Replicate	1	1	1	1	1	1	
PAH (ng·g', dry weight)							
C1-Fluoranthenes/pyrenes	54	23	18	87	54	87	
C2-Fluoranthenes/pyrenes	32	23	8.5	39	22	46	
C3-Fluoranthenes/pyrenes	21	14	3.1	26	10	27	
Benzo[a]anthracene	48	9.8	18	95	54	70	
Chrysene	56	19	19	110	57	80	
C1-Chrysenes	24	12	6.1	32	19	35	
C2-Chrysenes	18	10	2.9	24	9	26	
C3-Chrysenes	12	7.1	<0.64	19	6.7	18	
C4-Chrysenes	9.5	4.8	<0.64	15	4.6	14	
Benzo[b]fluoranthene	95	20	33	180	84	140	
Benzo[k]fluoranthene	28	5.6	8.5	62	20	37	
Benzo[e]pyrene	62	14	20	110	49	93	
Benzo[a]pyrene	85	8.6	29	170	73	130	
Perylene	50	8.7	10	70	25	66	
Indeno[1,2,3,-c,d]pyrene	78	9	22	140	53	120	
Dibenzo[a,h]anthracene	8.4	2	2.5	14	6.5	14	
Benzo[g,h,i]perylene	85	11	26	140	60	130	
Total LMW PAH (7 compounds)	86.8	97.1	42.7	146.4	113.9	123.5	3160
Total HMW PAH (6 compounds)	457.4	81.4	162.5	869	470.5	704	9600
Total PAH (13 compounds)	544.2	178.5	205.2	1015.4	584.4	827.5	44792
Pesticides & PCB (ng·g dry weight)							
Aldrin	<0.4	<0.78	<0.29	<0.71	<0.32	<0.42	
alpha-Chlordane	0.12	<0.73	0.03	0.22	0.1	0.18	
gamma-Chlordane	<0.37	<0.73	<0.28	<0.66	<0.3	<0.39	
cis-Nonachlor	0.12	0.14	0.03	0.25	0.08	0.16	
trans-Nonachlor	0.07	<0.54	0.01	0.09	0.06	0.1	
Heptachlor	<0.37	<0.73	<0.28	0.07	0.01	<0.39	
Heptachlor Epoxide	<0.37	<0.73	<0.28	<0.66	<0.3	<0.39	
Total Chlordane (4 compounds)	0.31	0.14	0.07	0.56	0.24	0.44	
2,4'-DDT	<0.62	<1.2	<0.46	<1.1	<0.5	<0.66	
4,4'-DDT	0.27	0.21	<0.64	0.54	0.12	0.17	
2,4'-DDE	<0.62	<1.2	<0.46	<1.1	<0.5	<0.66	
4,4'-DDE	2	0.56	0.28	2	0.68	2.3	
2,4'-DDD	0.6	<0.73	<0.28	0.95	0.27	0.81	
4,4'-DDD	2.3	0.25	<0.64	3.2	0.76	2.4	
Total DDT (6 compounds)	5.17	1.02	0.28	6.69	1.83	5.68	100
Dieldrin	<0.37	<0.73	<0.28	2.4	<0.3	<0.39	8
Endrin	<0.37	<0.73	<0.28	<0.66	<0.3	<0.39	45
alpha-hexachlorocyclohexan	<0.32	0.04	<0.24	<0.58	<0.26	<0.34	
beta-hexachlorocyclohexan	<0.16	<0.32	<0.12	<0.29	<0.13	<0.17	
delta-hexachlorocyclohexan	<0.26	<0.51	<0.19	<0.47	<0.21	<0.28	
Lindane	<0.27	<0.54	<0.2	0.36	<0.22	<0.29	0.99
Mirex	<0.19	<0.36	<0.14	<0.33	<0.15	<0.2	

Appendix A1
SURFACE SEDIMENT DATA - ISLAIS CREEK

October 1999

STATION	Island 1	Marconi Cove	North Site	Paradise	South Site	Tubbs Island	ERM
Sample Date	10/18/99	10/15/99	10/19/99	10/18/99	10/19/99	10/18/99	
Depth (ft)	0	0	0	0	0	0	
Replicate	1	1	1	1	1	1	
Pesticides & PCB (ng/g dry weight)							
PCB 8	<0.26	0.7	<0.19	<0.47	0.16	<0.28	
PCB 18	0.14	<1.1	0.04	0.24	0.07	0.21	
PCB 28	0.22	<0.73	0.2	0.48	0.22	0.33	
PCB 44	0.67	1	0.35	1.3	0.53	0.88	
PCB 52	0.26	0.38	0.07	0.89	0.13	0.31	
PCB 66	0.86	1.5	0.36	2.6	0.52	1.1	
PCB 77	0.71	0.48	0.22	1.7	0.35	1	
PCB 101	0.48	0.42	0.19	1.4	0.27	0.69	
PCB 105	0.13	0.14	0.06	0.39	0.09	0.2	
PCB 118	0.5	0.48	0.2	1.2	0.42	0.75	
PCB 126	<0.46	<0.9	<0.34	<0.82	<0.37	<0.49	
PCB 128	0.12	0.16	0.04	<0.36	0.07	0.12	
PCB 138	0.8	0.51	0.26	2	0.45	1.3	
PCB 153	1.1	0.6	0.39	3	0.7	1.7	
PCB 170	0.21	<1.5	0.09	0.68	0.27	0.28	
PCB 180	0.43	0.14	0.12	1.4	0.25	0.75	
PCB 187	0.37	0.25	0.11	1.2	0.28	0.58	
PCB 195	0.17	0.35	0.03	0.34	0.06	0.18	
PCB 206	0.09	0.02	0.02	0.26	0.06	0.13	
PCB 209	0.16	0.17	0.04	0.27	0.08	0.28	
Total PCB (18 compounds)	6.71	6.82	2.57	17.65	4.63	9.79	180

Appendix A1
SURFACE SEDIMENT DATA - ISLAIS CREEK
April 2000

STATION	1N	1S	2N	2S	3N	3S	Island 1	North Site	Paradise	South Site	Tubbs	
Sample Date	4/19/00	4/19/00	4/19/00	4/19/00	4/19/00	4/19/00	4/20/00	4/21/00	4/20/00	4/21/00	4/20/00	ERM
Depth (ft)	0	0	0	0	0	0	0	0	0	0	0	
Replicate	1	1	1	1	1	1	1	1	1	1	1	
Toxicity (% Survival)	79	86	47	56	49	43	68	89	65	80	59	
Total Organic Carbon (%)	4.4	1.3	2.1	1.8	1.8	1.4	0.9	0.5	1.2	0.7	1.2	
Grain Size (%)												
Sand	28.1	86.8	2.9	1.8	0.9	3	2.1	73.7	3.5	41.5	5.2	
Fines (Silt+Clay)	71.9	13.2	97.1	98.2	99.1	97	97.9	26.3	96.5	58.5	94.8	
Metals (µg·g, dry weight)												
Aluminum	29575	12068	54544	53581	50148	49457	41994	28947	39697	19737	43335	
Arsenic	8.61	3.62	10	11	10	11	6.31	6.06	12	5.6	10	70
Cadmium	1.56	1.01	1.44	0.71	0.55	0.6	0.35	0.35	0.34	0.55	0.37	9.6
Chromium	99	83	124	124	118	117	94	81	99	70	100	370
Copper	116.7	109.1	83.2	74.9	67	69.7	45.1	28.2	47.6	16.3	52.1	270
Iron	34609	19103	49874	48373	47285	48876	40694	33263	42708	26814	44022	
Lead	224.9	370	60.2	46.8	33.8	36.8	17.9	15.4	21.3	11.8	20.1	218
Mercury	1.19	0.35	0.45	0.46	0.33	0.37	0.3	0.27	0.27	0.11	0.31	0.7
Nickel	94.8	66.8	110.4	103.6	97.9	98.2	84	73.9	85.9	75	90.3	51.6
Selenium	0.47	0.05	0.49	0.74	0.34	0.4	0.27	0.35	0.42	0.39	0.3	
Silver	1.66	0.64	1.18	0.92	0.68	1.16	<0.5	<0.5	<0.5	<0.5	<0.5	3.7
Zinc	398	269	231	190	162	172	112	91	118	76	125	410
PAH (ng·g^{-1}, dry weight)												
Naphthalene	74	26	82	45	44	140	12	5.2	18	13	13	
C1-Naphthalenes	66	27	59	41	41	130	6.1	3.3	9.2	6.3	6.9	
C2-Naphthalenes	120	47	250	96	100	190	11	5.4	15	12	12	
C3-Naphthalenes	170	56	380	120	140	200	12	4.3	14	12	11	
C4-Naphthalenes	220	61	430	120	170	190	9.7	2.7	11	9.2	8.4	
Acenaphthylene	74	16	260	69	110	120	8.1	2.9	10	11	9	
Acenaphthene	86	18	290	52	100	220	3.7	1.5	5.8	7.5	4.5	
Biphenyl	24	9	33	22	25	45	3.6	1.7	6.2	3.6	4	
Dibenzofuran												
Fluorene	150	27	380	120	160	320	6.7	3.2	9.6	10	7.9	
C1-Fluorenes	100	22	260	66	70	130	5.7	3.6	7.6	10	6.5	
C2-Fluorenes	260	41	380	94	110	160	8.7	6.4	11	12	8.9	
C3-Fluorenes	670	92	670	170	240	300	15	6.8	15	17	12	
Anthracene	3000	89	1900	490	940	1100	18	6.4	25	31	20	
Phenanthrene	640	200	1400	450	590	1000	56	24	73	100	71	
C1-Phenanthrenes/anthracenes	710	130	1500	410	520	760	35	16	42	59	42	
C2-Phenanthrenes/anthracenes	900	140	1400	400	450	670	27	12	32	38	30	
C3-Phenanthrenes/anthracenes	940	180	950	270	360	460	19	6.6	22	24	16	
C4-Phenanthrenes/anthracenes	1100	260	1600	490	630	860	32	9	38	43	29	
Dibenzothiophene	77	16	170	53	74	110	4.3	1.8	6	6.8	5.3	
C1-Dibenzothiophenes	120	25	180	46	58	81	4.7	2	6.1	7.2	5.7	
C2-Dibenzothiophenes	380	63	300	91	110	140	7.1	3	8.6	9.9	8.2	
C3-Dibenzothiophenes	640	110	330	130	130	190	7.2	2.9	11	14	8.7	
Fluoranthene	3000	470	7700	1600	2700	2800	150	50	190	210	160	
Pyrene	2400	500	4800	1300	2000	2100	200	67	250	270	210	

Appendix A1
SURFACE SEDIMENT DATA - ISLAIS CREEK

April 2000

STATION	1N	1S	2N	2S	3N	3S	Island 1	North Site	Paradise	South Site	Tubbs	
Sample Date	4/19/00	4/19/00	4/19/00	4/19/00	4/19/00	4/19/00	4/20/00	4/21/00	4/20/00	4/21/00	4/20/00	ERM
Depth (ft)	0	0	0	0	0	0	0	0	0	0	0	
Replicate	1	1	1	1	1	1	1	1	1	1	1	
PAH (ng·g⁻¹, dry weight)												
C1-Fluoranthenes/pyrenes	2600	370	6100	1400	2100	2700	71	23	83	110	73	
C2-Fluoranthenes/pyrenes	1700	350	2900	730	1000	1300	37	13	44	54	35	
C3-Fluoranthenes/pyrenes	1000	280	1100	350	470	570	22	6.8	28	26	18	
Benzo[a]anthracene	1300	240	2900	670	1400	1200	64	21	76	94	65	
Chrysene	1400	280	3800	920	2100	1700	79	24	88	130	75	
C1-Chrysenes	930	200	1600	400	660	660	27	9.2	33	45	28	
C2-Chrysenes	980	290	910	310	420	400	20	6.2	23	31	18	
C3-Chrysenes	650	250	580	200	240	240	17	4.6	19	21	14	
C4-Chrysenes	580	210	300	130	160	130	11	2.7	12	13	8.5	
Benzo[b]fluoranthene	1600	440	4400	1200	2000	2000	120	43	170	170	120	
Benzo[k]fluoranthene	510	120	1400	300	690	520	36	13	44	40	34	
Benzo[e]pyrene	810	230	2000	530	920	860	82	27	100	100	81	
Benzo[a]pyrene	990	260	2800	700	1400	1200	120	38	160	150	120	
Perylene	320	84	880	270	470	410	72	16	76	53	61	
Indeno[1,2,3,-c,d]pyrene	640	220	1500	480	800	690	100	33	130	120	93	
Dibenzo[a,h]anthracene	150	50	330	88	180	150	10	3.3	14	14	9.9	
Benzo[g,h,i]perylene	640	220	1000	400	590	540	120	37	150	130	110	
Total LMW PAH (7 compoun	4090	403	4371	1267	1985	3030	110.6	46.5	150.6	178.8	132.3	3160
Total HMW PAH (6 compoun	9240	1800	22330	5278	9780	9150	623	203.3	778	868	639.9	9600
Total PAH (13 compounds)	13330	2203	26701	6545	11765	12180	733.6	249.8	928.6	1047	772.2	44792
Pesticides & PCB (ng·g dry weight)												
Aldrin	<0.57	<0.31	<0.67	<0.58	<0.58	<0.58	<0.39	<0.32	<0.46	<0.36	<0.44	
alpha-Chlordane	12	5.6	5.2	2.4	1.5	1.7	<0.37	<0.3	<0.43	<0.34	<0.41	
gamma-Chlordane	20	8.6	11	5.4	4.3	6.8	<0.37	<0.3	<0.43	<0.34	<0.41	
cis-Nonachlor	5.9	3.5	2	1.2	0.9	1.1	<0.34	<0.28	<0.4	<0.32	<0.38	
trans-Nonachlor	8.9	3.9	2.4	1.7	1	1.1	<0.27	<0.22	<0.31	<0.25	<0.3	
Heptachlor	<0.53	<0.29	<0.63	<0.55	<0.55	<0.55	<0.37	<0.3	<0.43	<0.34	<0.41	
Heptachlor Epoxide	<0.53	<0.29	<0.63	<0.55	<0.55	<0.55	<0.37	<0.3	<0.43	<0.34	<0.41	
Total Chlordane (4 compou	46.8	21.6	20.6	10.7	7.7	10.7	<0.37	<0.3	<0.43	<0.34	<0.41	
2,4'-DDT	<0.88	<0.48	<1	<0.91	<0.91	<0.91	<0.61	<0.5	<0.71	<0.57	<0.68	
4,4'-DDT	<1.2	1.1	2.6	1.8	1.8	1.8	4.8	<0.7	<1	<0.8	<0.95	
2,4'-DDE	<0.88	<0.48	<1	<0.91	<0.91	<0.91	<0.61	<0.5	<0.71	<0.57	<0.68	
4,4'-DDE	16	5.4	9.1	6.2	5.7	6	2.5	0.52	2.1	1.4	1.9	
2,4'-DDD	18	12	9.3	4.2	4.4	4.6	0.7	<0.3	0.77	0.52	0.65	
4,4'-DDD	34	13	7	5.4	4	5	2.3	<0.7	2.3	1	1.8	
Total DDT (6 compounds)	68	31.5	28	17.6	15.9	17.4	10.3	0.52	5.17	2.92	4.35	100
Dieldrin	6.6	2.6	3.6	2.2	2	3.6	<0.37	<0.3	<0.43	<0.34	<0.41	8
Endrin	<0.53	<0.29	<0.63	<0.55	<0.55	<0.55	<0.37	<0.3	<0.43	<0.34	<0.41	45
alpha-hexachlorocyclohexan	<0.46	<0.25	<0.54	<0.47	<0.47	<0.47	<0.32	<0.26	<0.37	<0.3	<0.35	
beta-hexachlorocyclohexan	<0.23	<0.13	<0.27	<0.24	<0.24	<0.24	<0.16	<0.13	<0.18	<0.15	<0.18	
delta-hexachlorocyclohexan	<0.37	<0.2	<0.44	<0.38	<0.38	<0.38	<0.26	<0.21	<0.3	<0.24	<0.28	
Lindane	<0.39	<0.21	0.58	<0.4	0.52	0.53	<0.27	<0.22	<0.31	<0.25	<0.3	0.99
Mirex	<0.26	<0.14	<0.31	<0.27	<0.27	<0.27	<0.18	<0.15	<0.21	<0.17	<0.2	

Appendix A1
SURFACE SEDIMENT DATA - ISLAIS CREEK
April 2000

STATION	1N	1S	2N	2S	3N	3S	Island 1	North Site	Paradise	South Site	Tubbs	ERM
Sample Date	4/19/00	4/19/00	4/19/00	4/19/00	4/19/00	4/19/00	4/20/00	4/21/00	4/20/00	4/21/00	4/20/00	
Depth (ft)	0	0	0	0	0	0	0	0	0	0	0	
Replicate	1	1	1	1	1	1	1	1	1	1	1	
Pesticides & PCB (ng/g dry weight)												
PCB 8	<0.49	<0.27	<0.57	<0.5	<0.5	<0.5	<0.34	<0.27	<0.39	<0.31	<0.37	
PCB 18	6	0.81	<1.3	<1.1	1.2	<1.1	<0.75	<0.6	<0.87	<0.69	<0.83	
PCB 28	3.5	1.4	1.4	1.5	<0.68	1	<0.46	<0.37	<0.53	<0.42	<0.51	
PCB 44	7.9	2.6	1.7	1.5	1.4	1.4	<0.47	<0.38	<0.55	<0.44	<0.52	
PCB 52	9	5.4	2.3	1.6	1.5	1.8	<0.48	<0.39	<0.56	0.56	<0.53	
PCB 66	20	<0.31	1.3	0.94	0.9	1.2	<0.39	<0.32	1	1.1	0.49	
PCB 77	<0.88	<0.48	2.1	<0.91	1.4	1.3	<0.61	<0.5	<0.71	<0.57	<0.68	
PCB 101	30	25	7.6	4.8	4.1	4.5	0.62	<0.37	1	1.3	<0.51	
PCB 105	7.1	<0.38	1.4	1.4	1.1	1	<0.48	<0.39	<0.56	<0.44	<0.53	
PCB 118	20	8.8	5.4	3.6	3.2	3.3	0.55	<0.38	0.88	1.3	<0.52	
PCB 126	<0.69	<0.38	<0.82	<0.71	<0.71	4	<0.48	<0.39	<0.56	<0.44	<0.53	
PCB 128	8.5	3.8	5.3	4.8	4.4	6	<0.34	<0.27	<0.39	0.33	<0.37	
PCB 138	40	39	14	8.2	6.9	6.8	1	<0.48	<0.69	1.7	0.82	
PCB 153	57	72	13	8.7	7.2	7.6	0.81	<0.22	1.5	1.5	0.53	
PCB 170	16	20	5.6	2.8	2.9	2.9	<0.48	<0.39	0.84	<0.44	<0.53	
PCB 180	16	40	10	11	5.7	13	0.54	<0.31	2.4	0.62	<0.42	
PCB 187	20	22	6.6	4.4	4	3.5	0.41	<0.28	1.3	0.66	<0.38	
PCB 195	2.5	3.8	1	0.65	0.71	0.75	<0.43	<0.35	<0.5	<0.4	<0.47	
PCB 206	1.9	1.8	<0.85	<0.74	<0.74	<0.74	<0.5	<0.4	<0.58	<0.46	<0.55	
PCB 209	1.5	0.38	<0.78	1.1	<0.68	0.72	<0.46	<0.37	<0.53	<0.42	<0.51	
Total PCB (18 compounds)	266.9	246.8	76.6	56.99	45.21	55.47	3.93	<0.7	8.92	9.07	1.84	180

APPENDIX A2

Islais Creek
Subsurface Sediment Data

Appendix A2
SUBSURFACE SEDIMENT DATA - ISLAIS CREEK, October 1998

STATION	1C	1C	1C	1C	2N	2N	2N	2N	3S
Sample Date	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98
Depth (ft)	0-1	1-2	2-3	3-4	0-1	1-2	2-3	3-4	0-1
Replicate	1	1	1	1	1	1	1	1	1
Toxicity (% Survival)									
Total Organic Carbon (%)	4.7	4.2			2.1	2.7			1.6
Grain Size (%)									
Gravel	2.4	4.2			0	0			0
Sand	35.4	57.7			3.4	4.7			3
Silt	51.4	31			47.6	73			23.7
Clay	10.8	7.1			49	22.3			73.3
Fines (Silt+Clay)	62.2	38.1			96.6	95.3			97
Metals (µg·g', dry weight)									
Aluminum	34533	18008	18403	13224	48956	42804	31697	33969	44664
Arsenic	6.5	5.6	4.19	5.04	9.4	6.8	8.61	8.67	11.4
Cadmium	1.43	1.74	24.94	1.83	0.62	0.95	1.3	1.7	0.53
Chromium	109	85	82.6	71.2	117	115	102.9	115.3	111
Copper	119	117	163.9	152.2	75	94	102.8	117	72
Iron	37207	28927	25104	23133	47266	45884	37304	38867	45660
Lead	232	356	355.7	383.1	48	103	127.6	186.5	42
Mercury	0.78	0.82	1.295	1.026	0.33	0.61	0.579	0.909	0.32
Nickel	93	73	64.5	71.6	113	109	93.9	101.3	111
Selenium	0.42	0.37	1.55	0.59	0.39	0.44	0.67	0.62	0.41
Silver	1.7	2.9	4.29	2.92	0.6	1.4	2.4	3.04	0.7
Zinc	402	546	567.8	574.9	180	270	586.7	329.9	169
PAH (ng·g', dry weight)									
Naphthalene	81	300	440	520	40	44	100	100	34
C1-Naphthalenes	76	400	720	830	38	50	120	86	30
C2-Naphthalenes	190	880	1500	1700	100	180	370	120	79
C3-Naphthalenes	370	1200	2200	2300	130	240	540	110	74
C4-Naphthalenes	550	1100	1500	1700	180	350	710	240	89
Acenaphthylene	48	130	52	43	190	110	410	450	63
Acenaphthene	68	120	150	130	96	150	400	68	45
Biphenyl	24	61	80	100	19	26	60	40	15
Dibenzofuran	66	95			72	110			42
Fluorene	140	220	310	280	140	250	710	210	68
C1-Fluorenes	160	340	540	540	94	130	430	230	38
C2-Fluorenes	380	710	1100	1100	150	260	710	590	50
C3-Fluorenes	630	840	1400	1300	230	360	1000	1200	85
Anthracene	330	490	500	430	880	830	3300	2200	290
Phenanthrene	470	980	1400	1300	270	550	2000	670	220
C1-Phenanthrenes/anthracenes	460	1100	1900	1800	490	620	2200	1300	190
C2-Phenanthrenes/anthracenes	900	1600	2300	2400	470	680	2000	1600	180
C3-Phenanthrenes/anthracenes	960	1800	1600	1700	360	490	1400	1500	130
C4-Phenanthrenes/anthracenes	910	4000	940	1000	880	660	2300	2200	310
Dibenzothiophene	100	120	200	210	63	88	210	55	30
C1-Dibenzothiophenes	140	200	460	480	45	72	300	160	21
C2-Dibenzothiophenes	480	650	800	890	150	240	580	560	58
C3-Dibenzothiophenes	580	710	950	940	140	200	560	690	68

Appendix A2
SUBSURFACE SEDIMENT DATA - ISLAIS CREEK, October 1998

STATION	1C	1C	1C	1C	2N	2N	2N	2N	3S
Sample Date	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98
Depth (ft)	0-1	1-2	2-3	3-4	0-1	1-2	2-3	3-4	0-1
Replicate	1	1	1	1	1	1	1	1	1
PAH (ng·g^{-1}, dry weight)									
Fluoranthene	1500	1900	2300	2000	3300	3300	18000	17000	630
Pyrene	1300	1600	2100	1900	2200	1700	10000	10000	720
C1-Fluoranthenes/pyrenes	1000	1400	1900	1800	2300	1800	8700	9500	570
C2-Fluoranthenes/pyrenes	820	1300	1600	1500	990	700	3900	4300	300
C3-Fluoranthenes/pyrenes	590	760	1400	1200	400	340	1800	2000	140
Benzo[a]anthracene	650	880	820	800	1200	1200	5300	5900	340
Chrysene	740	1300	1200	1100	1700	1400	6600	8800	480
C1-Chrysenes	590	840	1000	960	820	690	3000	3500	240
C2-Chrysenes	560	960	1300	1100	380	360	1600	1800	150
C3-Chrysenes	500	880	1300	1200	270	250	890	1000	97
C4-Chrysenes	400	750	930	790	140	200	670	760	68
Benzo[b]fluoranthene	910	1300	1200	1200	1800	1400	6400	9000	610
Benzo[k]fluoranthene	270	450	360	370	570	430	2200	2400	180
Benzo[e]pyrene	580	820	790	730	840	740	3000	3500	290
Benzo[a]pyrene	610	830	770	730	1200	1000	4400	4900	400
Perylene	210	290	300	250	380	320	1300	1400	150
Indeno[1,2,3,-c,d]pyrene	450	620	520	520	500	520	1700	2000	200
Dibenzo[a,h]anthracene	85	130	120	120	120	110	460	520	38
Benzo[g,h,i]perylene	460	730	730	700	400	410	1500	1800	170
Total LMW PAH (7 compounds)	1213	2640	3572	3533	1654	1984	7040	3784	750
Total HMW PAH (6 compounds)	4885	6640	7310	6650	9720	8710	44760	47120	2608
Total PAH (13 compounds)	6098	9280	10882	10183	11374	10694	51800	50904	3358
C10B-Phenyl decanes	710	1100			430	370			250
C11B-Phenyl undecanes	720	1100			400	420			250
C12B-Phenyl dodecanes	320	540			220	240			140
C13B-Phenyl tridecanes	420	530			86	180			45
C14B-Phenyl tetradecanes	<4	<12			<1.4	<0.87			<0.33
TPH (µg·g^{-1}, dry weight)									
n-Nonane	<3.8	<3.2			<0.79	<1.5			<0.19
n-Decane	0.61	1.6			0.03	0.07			0.03
n-Undecane	<0.44	1.3			<0.09	<0.17			<0.02
n-Dodecane	<0.44	1.3			<0.09	<0.17			0.03
n-Tridecane	<0.6	0.75			<0.12	<0.23			<0.03
Isoprenoid RRT 1380	<0.72	1			<0.15	0.28			0.11
n-Tetradecane	<0.93	2			<0.19	<0.36			0.06
Isoprenoid RRT 1470	0.48	1.6			0.09	0.33			0.17
n-Pentadecane	<0.38	0.75			<0.08	<0.15			0.05
n-Hexadecane	<0.2	0.74			<0.04	0.16			0.07
Isoprenoid RRT 1650	<0.46	1.6			0.15	0.33			0.15
n-Heptadecane	0.28	0.93			0.12	0.24			0.11
Pristane	0.62	2.2			0.26	0.66			0.25
n-Octadecane	<0.53	0.94			0.11	0.22			0.07
Phytane	0.88	2.4			0.28	0.69			0.27
n-Nonadecane	0.31	0.86			0.09	0.18			0.08

Appendix A2
SUBSURFACE SEDIMENT DATA - ISLAIS CREEK, October 1998

STATION	1C	1C	1C	1C	2N	2N	2N	2N	3S
Sample Date	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98
Depth (ft)	0-1	1-2	2-3	3-4	0-1	1-2	2-3	3-4	0-1
Replicate	1	1	1	1	1	1	1	1	1
TPH (µg·g⁻¹, dry weight)									
n-Eicosane	0.9	2.5			0.16	0.16			0.1
n-Heneicosane	0.65	1.7			0.28	<0.14			<0.02
n-Docosane	0.4	1.4			0.22	0.2			0.12
n-Tricosane	<0.18	1.8			0.39	0.32			0.19
n-Tetracosane	<0.14	2.2			<0.03	<0.05			<0.01
n-Pentacosane	1.3	4			<0.09	<0.17			<0.02
n-Hexacosane	<0.24	2.5			<0.05	<0.09			<0.01
n-Heptacosane	2	3.9			0.6	0.58			0.35
n-Octacosane	1.7	3.3			1.7	1.7			0.68
n-Nonacosane	5.9	12			1.6	2			1.3
n-Triacontane	<0.61	2.8			0.35	<0.24			<0.03
n-Hentriacontane	7	14			2	3			1.6
n-Dotriacontane	<0.22	4.6			0.4	1.1			0.51
n-Tritriacontane	1.8	3.4			0.52	0.8			0.33
n-Tetratriacontane	1.7	6.6			<0.05	0.76			0.24
n-Pentatriacontane	1.8	4.3			0.49	0.98			0.27
n-Hexatriacontane	1.6	3.1			0.41	0.79			0.26
n-Heptatriacontane	<0.29	2.2			0.24	0.56			0.17
n-Octatriacontane	0.86	2			0.26	0.54			0.2
n-Nonatriacontane	0.82	1.5			0.19	0.42			0.1
n-Tetracontane	0.52	1.2			0.16	0.36			0.1
Total Resolved Hydrocarbons	270	570			100	160			63
Total Petroleum Hydrocarbons	3700	5500			1100	2100			720
TPH >C8-C10	10	18			3.6	5			2.7
TPH >C10-C12	30	49			6.6	14			4.2
TPH >C12-C16	94	140			28	56			20
TPH >C16-C21	270	400			100	180			69
TPH >C21-C25	690	1000			210	430			140
TPH >C25-C30	1100	1700			320	630			210
TPH >C30-C35	840	1300			230	440			160
TPH >C35 +	640	900			170	320			110
Pesticides & PCB (ng·g dry weight)									
Aldrin	<0.26	<0.22	<1	<0.8	<0.26	<0.2	<1.1	<0.9	<0.26
alpha-Chlordane	22	25	25	28	3.9	7.1	8.4	13	2.5
gamma-Chlordane	23	27	35	38	3.8	<0.18	8.3	18	<0.24
cis-Nonachlor	<0.22	6.8	12	12	1.4	2.4	4.9	7.8	0.87
trans-Nonachlor	16	17	19	20	2.1	4.5	5.8	9.3	1.6
Heptachlor	<0.24	<0.2	<0.95	<0.75	<0.24	<0.18	<1	<0.85	<0.24
Heptachlor Epoxide	<0.24	<0.2	<0.95	<0.75	<0.24	<0.18	<1	<0.85	<0.24
Total Chlordane (4 compounds)	61	75.8	91	98	11.2	14	27.4	48.1	4.97
2,4'-DDT	<0.4	<0.34	<1.6	<1.2	<0.41	<0.31	<1.8	<1.4	<0.4
4,4'-DDT	110	<0.47	2.3	3.2	1.6	<0.43	2	1.8	1.5
2,4'-DDE	<0.4	<0.34	<1.6	<1.2	<0.41	<0.31	<1.8	<1.4	<0.4
4,4'-DDE	19	19	21	24	8.6	<0.31	12	16	6.3

Appendix A2
SUBSURFACE SEDIMENT DATA - ISLAIS CREEK, October 1998

STATION	1C	1C	1C	1C	2N	2N	2N	2N	3S
Sample Date	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98
Depth (ft)	0-1	1-2	2-3	3-4	0-1	1-2	2-3	3-4	0-1
Replicate	1	1	1	1	1	1	1	1	1
Pesticides & PCB (ng/g dry weight)									
2,4'-DDD	<0.24	<0.2	49	37	<0.24	4	18	21	1.1
4,4'-DDD	52	110	61	59	9.4	17	22	29	6
Total DDT (6 compounds)	181	129	133.3	123.2	19.6	21	54	67.8	14.9
Dieldrin	30	35	14	15	5.5	9.1	7.2	8.2	4.1
Endrin	<0.24	<0.2	2.2	1.8	<0.24	<0.18	<1	<0.85	<0.24
alpha-hexachlorocyclohexan			0.21	0.16			0.2	0.27	
beta-hexachlorocyclohexan			<0.41	<0.32			<0.46	<0.37	
delta-hexachlorocyclohexan			<0.67	<0.53			<0.74	<0.59	
Lindane	<0.18	<0.15	1.7	0.48	<0.18	<0.13	0.46	0.85	<0.18
Mirex	<0.12	<0.1	<0.48	1.9	<0.12	<0.09	<0.53	<0.42	<0.12
PCB 8	<0.17	<0.14	3.1	4.6	<0.17	<0.13	3.6	7.1	<0.17
PCB 18	5.2	7.2	11	6.6	0.78	<0.27	9.9	13	0.52
PCB 28	10	16	7.3	5.9	2.5	5.4	3.6	4	0.9
PCB 44	8.8	12	9.6	11	1.8	2.8	4.8	5.9	1
PCB 52	9	8.6	13	18	2.2	3.3	5.3	8.2	1.6
PCB 66	<0.13	23	41	36	<0.13	<0.1	12	23	<0.13
PCB 77	<0.19	<0.16	32	39	<0.2	<0.15	8.9	19	<0.19
PCB 101	37	21	56	61	3.6	6	15	30	3.6
PCB 105	7.2	8.3	6.7	3.8	1.6	3.2	3.8	3.6	1.4
PCB 118	17	16	26	23	4.6	6.4	13	18	3.2
PCB 126	<0.3	<0.25	<1.2	15	<0.3	<0.23	16	17	<0.3
PCB 128	6.4	6.6	13	9.1	2.1	3	9.6	13	<0.13
PCB 138	52	89	86	73	9.4	13	25	58	7.8
PCB 153	65	48	140	160	6.9	12	32	74	7.8
PCB 170	33	23	37	34	3.2	5.8	12	32	4.4
PCB 180	49	37	83	69	5.1	9.7	22	58	5.9
PCB 187	31	21	48	41	4	6.2	12	30	4.3
PCB 195	6.7	4.3	9.2	9.5	0.58	1.5	2.6	5.7	0.79
PCB 206	2.5	2.2	5.8	11	1.1	1.2	1.6	3	0.72
PCB 209	2.2	2.6	4.1	1.4	0.21	0.61	2.3	1.5	0.24
Total PCB (18 compounds)	342	345.8	599.8	577.9	49.67	80.11	190.1	388	44.17
Total Aroclor 1016	<16	<14			<16	<12			<16
Total Aroclor 1221	<16	<14			<16	<12			<16
Total Aroclor 1232	<16	<14			<16	<12			<16
Total Aroclor 1242	<16	<14			<16	<12			<16
Total Aroclor 1248	<16	<14			<16	<12			<16
Total Aroclor 1254	420	450			83	140			56
Total Aroclor 1260	520	520			98	160			87

Appendix A2
SUBSURFACE SEDIMENT DATA - ISLAIS CREEK, October 1998

STATION	3S	3S	3S	4S	4S	5C	5C	6C	6C
Sample Date	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98
Depth (ft)	1-2	2-3	3-4	0-1	1-2	0-1	1-2	0-1	1-2
Replicate	1	1	1	1	1	1	1	1	1
Toxicity (% Survival)									
Total Organic Carbon (%)	2.1			1.6	1.8	1.4	1.4	1.6	1.7
Grain Size (%)									
Gravel	0			0	0	0	0	0	0
Sand	3.6			1.4	1.1	0.4	1	1.9	2.1
Silt	83.7			23.3	28.6	26.6	30.1	27.1	23.1
Clay	12.7			75.3	70.3	73	68.9	71	74.8
Fines (Silt+Clay)	96.4			98.6	98.9	99.6	99	98.1	97.9
Metals (µg·g, dry weight)									
Aluminum	49206	31222	23091	51109	37371	38738	42440	48587	49571
Arsenic	9.1	9.6	8.94	12.2	12.5	11.1	12.7	11.2	10.4
Cadmium	0.76	0.79	0.78	0.33	0.41	0.3	0.35	0.28	0.23
Chromium	126	97.3	93.7	117	102	101	104	111	112
Copper	81	74.7	74.1	64	68	57	61	54	53
Iron	44025	38825	37920	47533	45110	46361	46914	46892	43280
Lead	70	62.9	65.2	28	31	21	26	21	21
Mercury	0.54	0.483	0.528	0.25	0.32	0.17	0.23	0.18	0.18
Nickel	101	89.7	86.4	110	103	111	108	106	101
Selenium	0.43	0.74	0.74	0.35	0.3	0.39	0.41	0.45	0.4
Silver	2.1	2.47	4.04	<0.5	<0.5	<0.5	<0.5	<0.5	0
Zinc	217	189.9	200.4	142	148	132	141	128	125
PAH (ng·g^{1}, dry weight)									
Naphthalene	43	54	66	31	30	16	28	20	25
C1-Naphthalenes	31	29	32	33	32	16	26	18	18
C2-Naphthalenes	54	44	52	60	52	30	47	40	33
C3-Naphthalenes	45	35	68	61	49	34	52	33	34
C4-Naphthalenes	57	33	180	70	60	40	61	46	45
Acenaphthylene	130	93	90	40	38	9	27	13	20
Acenaphthene	19	19	24	45	41	17	26	12	14
Biphenyl	15	17	21	16	14	9.3	13	11	11
Dibenzofuran	20			42	31	20	29	12	15
Fluorene	38	38	59	68	52	29	48	23	28
C1-Fluorenes	30	28	58	30	25	19	27	17	19
C2-Fluorenes	45	<4.2	170	43	33	20	31	24	20
C3-Fluorenes	120	100	340	60	48	27	49	27	32
Anthracene	390	300	470	240	180	62	160	49	86
Phenanthrene	200	190	200	220	210	78	160	82	120
C1-Phenanthrenes/anthracenes	220	180	280	150	140	57	120	58	82
C2-Phenanthrenes/anthracenes	260	190	360	120	120	49	95	50	60
C3-Phenanthrenes/anthracenes	230	190	380	81	78	29	65	33	39
C4-Phenanthrenes/anthracenes	500	330	600	170	160	43	140	63	76
Dibenzothiophene	19	18	29	26	20	12	20	10	14
C1-Dibenzothiophenes	19	21	62	16	14	7.1	14	7.8	10
C2-Dibenzothiophenes	73	57	180	34	37	13	31	17	20
C3-Dibenzothiophenes	110	98	210	34	38	15	29	16	18

Appendix A2
SUBSURFACE SEDIMENT DATA - ISLAIS CREEK, October 1998

STATION	3S	3S	3S	4S	4S	5C	5C	6C	6C
Sample Date	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98
Depth (ft)	1-2	2-3	3-4	0-1	1-2	0-1	1-2	0-1	1-2
Replicate	1	1	1	1	1	1	1	1	1
PAH (ng·g^{-1}, dry weight)									
Fluoranthene	490	590	2800	660	500	200	500	190	300
Pyrene	1800	2000	2300	540	490	180	440	220	340
C1-Fluoranthenes/pyrenes	1000	980	1500	380	330	93	290	90	150
C2-Fluoranthenes/pyrenes	550	740	880	170	150	46	140	54	71
C3-Fluoranthenes/pyrenes	310	430	450	76	70	27	62	28	34
Benzo[a]anthracene	450	400	920	280	270	64	220	76	130
Chrysene	760	700	1100	400	340	79	280	89	160
C1-Chrysenes	580	530	610	140	130	34	110	39	62
C2-Chrysenes	340	370	340	77	76	23	64	26	37
C3-Chrysenes	200	250	220	41	46	18	44	21	23
C4-Chrysenes	150	150	160	36	34	14	35	18	23
Benzo[b]fluoranthene	1300	1500	1500	420	390	100	320	140	210
Benzo[k]fluoranthene	500	550	420	130	120	28	100	38	62
Benzo[e]pyrene	670	720	690	200	190	58	160	84	120
Benzo[a]pyrene	940	1000	940	290	280	77	230	120	180
Perylene	330	390	400	140	150	63	140	89	100
Indeno[1,2,3,-c,d]pyrene	460	520	470	150	160	60	160	98	150
Dibenzo[a,h]anthracene	86	95	84	28	26	7.1	23	11	17
Benzo[g,h,i]perylene	430	530	460	140	150	68	170	110	160
Total LMW PAH (7 compounds)	851	723	941	677	583	227	475	217	311
Total HMW PAH (6 compounds)	4526	4785	8144	2198	1906	607.1	1693	706	1127
Total PAH (13 compounds)	5377	5508	9085	2875	2489	834.1	2168	923	1438
C10B-Phenyl decanes	440			160	140	39	120	26	36
C11B-Phenyl undecanes	480			170	140	54	160	45	47
C12B-Phenyl dodecanes	290			81	86	37	78	38	31
C13B-Phenyl tridecanes	94			110	34	140	58	310	25
C14B-Phenyl tetradecanes	<2.5			<0.32	<0.32	<0.33	<0.31	25	15
TPH (µg·g^{-1}, dry weight)									
n-Nonane	<1.4			<0.19	<0.18	<0.19	<0.18	<0.16	<0.16
n-Decane	<0.05			0.02	0.03	<0.01	0.01	<0.01	<0.01
n-Undecane	<0.16			<0.02	0.14	<0.02	<0.02	<0.02	<0.02
n-Dodecane	<0.16			0.04	0.05	<0.02	0.03	<0.02	<0.02
n-Tridecane	<0.22			0.05	0.06	<0.03	0.03	<0.03	<0.03
Isoprenoid RRT 1380	<0.27			0.07	0.07	<0.04	0.05	<0.03	<0.03
n-Tetradecane	<0.35			0.08	0.11	<0.05	0.05	<0.04	<0.04
Isoprenoid RRT 1470	0.08			0.09	0.09	0.05	0.09	0.04	0.04
n-Pentadecane	<0.14			0.1	0.13	0.03	0.08	0.03	0.03
n-Hexadecane	0.08			0.13	0.15	0.04	0.09	0.03	0.03
Isoprenoid RRT 1650	<0.17			0.1	0.11	0.04	0.09	0.03	0.04
n-Heptadecane	0.19			0.17	0.27	0.08	0.16	0.06	0.06
Pristane	0.26			0.2	0.2	0.12	0.16	0.15	0.1
n-Octadecane	<0.2			0.14	0.18	0.04	0.12	0.04	0.04
Phytane	0.32			0.22	0.22	0.14	0.19	0.14	0.13
n-Nonadecane	0.1			0.13	0.15	0.05	0.12	0.05	0.05

Appendix A2
SUBSURFACE SEDIMENT DATA - ISLAIS CREEK, October 1998

STATION	3S	3S	3S	4S	4S	5C	5C	6C	6C
Sample Date	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98
Depth (ft)	1-2	2-3	3-4	0-1	1-2	0-1	1-2	0-1	1-2
Replicate	1	1	1	1	1	1	1	1	1
TPH (µg·g⁻¹, dry weight)									
n-Eicosane	<0.06			0.12	0.16	0.06	0.1	0.04	0.04
n-Heneicosane	<0.14			0.17	0.21	0.08	0.12	0.07	0.08
n-Docosane	<0.09			0.11	0.16	0.1	0.14	0.09	0.09
n-Tricosane	<0.07			0.19	0.21	0.14	0.2	0.13	0.13
n-Tetracosane	<0.05			0.11	0.13	0.08	0.16	0.07	0.09
n-Pentacosane	<0.17			0.28	0.32	0.19	0.29	0.18	0.17
n-Hexacosane	<0.09			0.18	0.21	0.07	0.14	0.07	0.07
n-Heptacosane	<0.09			0.46	0.48	0.38	0.41	0.35	0.32
n-Octacosane	1.4			0.49	0.57	0.11	0.2	0.12	0.08
n-Nonacosane	1.9			1.1	1.3	1.1	1.1	0.91	0.88
n-Triacontane	<0.23			0.3	0.32	0.18	0.32	0.23	0.18
n-Hentriacontane	2.2			1.4	1.7	1.4	0.94	1.8	1.2
n-Dotriacontane	<0.08			0.56	0.51	0.16	0.23	0.23	0.14
n-Tritriacontane	0.34			0.41	0.53	0.93	1.2	0.97	0.69
n-Tetratriacontane	<0.1			<0.01	<0.01	0.09	0.17	0.08	0.09
n-Pentatriacontane	0.51			0.19	0.19	0.09	0.14	0.05	0.08
n-Hexatriacontane	0.5			0.13	0.15	0.07	0.1	0.06	0.06
n-Heptatriacontane	0.37			0.11	0.1	0.05	0.11	0.07	0.04
n-Octatriacontane	0.36			0.1	0.12	0.09	0.12	0.09	0.09
n-Nonatriacontane	0.36			<0.01	0.09	<0.01	<0.01	<0.01	<0.01
n-Tetracontane	0.25			0.03	0.05	0.02	0.04	0.01	0.02
Total Resolved Hydrocarbons	100			47	56	30	42	39	27
Total Petroleum Hydrocarbons	1500			360	420	180	330	180	190
TPH >C8-C10	4			1.7	2.3	1.7	1.9	1.5	1.6
TPH >C10-C12	8.4			2.4	2.8	1.5	2.1	1.4	1.2
TPH >C12-C16	42			11	12	5.1	9.4	4.6	4.9
TPH >C16-C21	150			39	43	20	35	22	21
TPH >C21-C25	320			66	77	27	57	27	30
TPH >C25-C30	460			100	120	45	91	43	49
TPH >C30-C35	310			88	100	46	76	52	46
TPH >C35 +	240			55	62	30	54	33	33
Pesticides & PCB (ng·g⁻¹ dry weight)									
Aldrin	<0.24	<0.74	<0.72	<0.25	<0.24	<0.26	<0.24	<0.22	<0.21
alpha-Chlordane	3.7	2.9	6.1	1.2	1.2	0.29	0.64	0.23	0.29
gamma-Chlordane	<0.22	3.4	3.6	<0.23	<0.23	<0.24	<0.22	<0.2	<0.2
cis-Nonachlor	1.6	2	2.2	0.44	0.44	0.28	0.44	0.24	0.3
trans-Nonachlor	2.4	1.7	1.6	0.7	0.58	0.27	0.49	0.23	0.34
Heptachlor	<0.22	<0.69	0.31	<0.23	<0.23	<0.24	<0.22	<0.2	<0.2
Heptachlor Epoxide	<0.22	<0.69	<0.68	<0.23	<0.23	<0.24	<0.22	<0.2	<0.2
Total Chlordane (4 compounds)	7.7	10	13.5	2.34	2.22	0.84	1.57	0.7	0.93
2,4'-DDT	<0.37	<1.2	<1.1	<0.39	<0.38	<0.4	<0.37	<0.34	<0.33
4,4'-DDT	<0.52	0.61	0.52	<0.55	<0.53	0.82	0.65	0.67	0.49
2,4'-DDE	<0.37	<1.2	<1.1	<0.39	<0.38	<0.4	<0.37	<0.34	<0.33
4,4'-DDE	7.4	7.7	11	6	5.7	6.7	6.2	5.1	5.1

Appendix A2
SUBSURFACE SEDIMENT DATA - ISLAIS CREEK, October 1998

STATION	3S	3S	3S	4S	4S	5C	5C	6C	6C
Sample Date	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98	10/27/98
Depth (ft)	1-2	2-3	3-4	0-1	1-2	0-1	1-2	0-1	1-2
Replicate	1	1	1	1	1	1	1	1	1
Pesticides & PCB (ng/g dry weight)									
2,4'-DDD	1.8	4.6	6	0.84	0.98	1.1	1.2	0.84	0.87
4,4'-DDD	10	9.6	8.4	4	4.9	3.5	4.8	3.2	3.9
Total DDT (6 compounds)	19.2	22.51	25.92	10.84	11.58	12.12	12.85	9.81	10.36
Dieldrin	8.2	1.8	3.1	2.4	2.7	1.2	1.8	1.1	1.3
Endrin	<0.22	<0.69	<0.68	<0.23	<0.23	<0.24	<0.22	<0.2	<0.2
alpha-hexachlorocyclohexan		0.09	<0.59						
beta-hexachlorocyclohexan		<0.3	<0.29						
delta-hexachlorocyclohexan		<0.48	<0.48						
Lindane	<0.16	0.32	<0.5	<0.17	<0.17	<0.18	<0.16	<0.15	<0.15
Mirex	<0.11	<0.35	<0.34	<0.12	<0.11	<0.12	<0.11	<0.1	<0.1
PCB 8	<0.16	2	0.68	<0.16	<0.16	<0.17	<0.16	<0.14	<0.14
PCB 18	1.1	4.9	7.9	<0.34	<0.34	<0.35	<0.32	<0.3	<0.29
PCB 28	1.8	2.6	2	0.45	0.57	<0.24	0.57	0.28	0.25
PCB 44	2.3	3.5	3.1	0.46	0.64	<0.12	0.42	0.28	<0.1
PCB 52	3.3	3.6	4.4	0.88	0.73	0.42	0.68	0.57	0.44
PCB 66	<0.12	10	10	<0.12	1.6	0.65	<0.12	0.66	<0.11
PCB 77	<0.18	7.6	9.5	<0.19	<0.18	<0.19	<0.18	0.2	<0.16
PCB 101	7.6	10	10	1.6	2	0.78	1.5	0.87	0.96
PCB 105	2.9	2.5	2	0.67	0.82	0.35	0.6	0.65	0.46
PCB 118	6.8	7.2	7	1.6	1.9	1.2	1.6	0.96	1.2
PCB 126	<0.28	4.2	3.8	<0.29	<0.28	<0.3	<0.27	<0.25	<0.25
PCB 128	2.9	3.7	3.4	0.7	0.9	<0.13	0.76	<0.11	0.58
PCB 138	15	20	17	3.6	4	1.3	2.7	1.2	1.6
PCB 153	12	27	23	3.1	3.4	1.6	3	1.6	2
PCB 170	8	11	7.2	1.2	1.3	<0.5	1.2	0.46	0.68
PCB 180	12	20	14	2.2	2.7	0.76	1.8	0.88	1.1
PCB 187	7.5	12	9.3	1.5	1.8	0.62	1.4	0.65	0.85
PCB 195	1.4	2.6	1.8	0.39	0.41	<0.1	<0.1	<0.09	<0.09
PCB 206	1.6	2.6	0.96	0.34	0.45	0.18	0.31	0.18	0.22
PCB 209	0.63	1.4	0.79	0.14	0.37	0.47	0.4	0.39	0.44
Total PCB (18 compounds)	86.83	146.6	124.53	18.83	23.59	8.33	16.94	9.63	10.78
Total Aroclor 1016	<15			<16	<15	<16	<15	<14	<13
Total Aroclor 1221	<15			<16	<15	<16	<15	<14	<13
Total Aroclor 1232	<15			<16	<15	<16	<15	<14	<13
Total Aroclor 1242	<15			<16	<15	<16	<15	<14	<13
Total Aroclor 1248	<15			<16	<15	<16	<15	<14	<13
Total Aroclor 1254	120			28	32	<16	25	15	20
Total Aroclor 1260	150			35	35	18	33	18	25

APPENDIX A3

Islais Creek
Clam Tissue Bioaccumulation Data

Appendix A3
CLAM TISSUE BIOACCUMULATION DATA - ISLAIS CREEK, April 2000

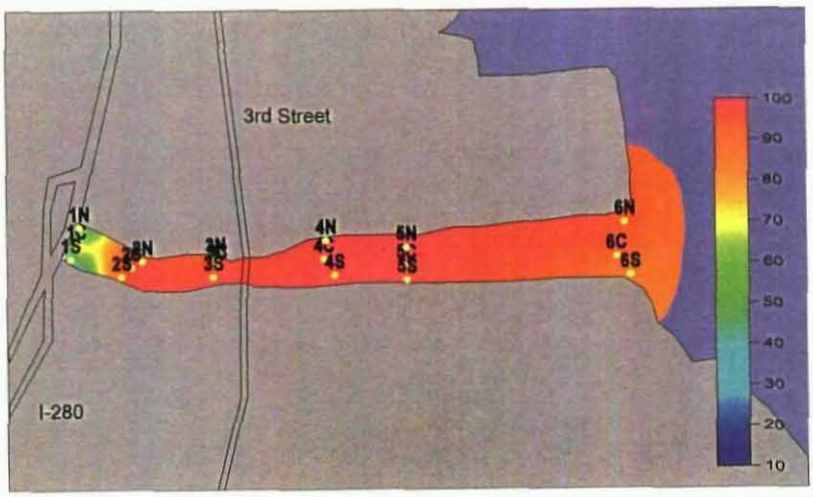
STATION	1N	1S	2N	2S	3N	3S	Island 1	North Site	Paradise	South Site	Tubbs
Sample Date	4/19/00	4/19/00	4/19/00	4/19/00	4/19/00	4/19/00	4/20/00	4/21/00	4/20/00	4/21/00	4/20/00
Replicate	1	1	1	1	1	1	1	1	1	1	1
Metals (µg/g, dry weight)											
Mercury	0.625	0.093	0.161	0.182	0.207	0.146	0.185	0.183	0.194	0.217	0.242
Pesticides & PCB (ng/g dry weight)											
Aldrin	<0.97	<0.59	<0.62	<0.72	<0.64	<0.95	<0.67	<0.68	<0.68	<0.52	<0.7
alpha-Chlordane	9.9	10	2.5	3	1.8	2.4	0.9	1.2	0.91	0.7	0.93
gamma-Chlordane	8.5	10	0.73	0.84	0.75	1.1	0.78	0.8	0.8	0.61	0.82
cis-Nonachlor	4.1	3.4	1	1.6	2.2	1.3	0.9	1	1.1	0.71	0.93
trans-Nonachlor	5.4	5.9	2.5	1.9	1.4	0.95	0.67	0.84	0.74	0.52	0.7
Heptachlor	<1.3	<0.78	<0.83	<0.96	<0.86	<1.3	<0.9	<0.91	<0.91	<0.7	<0.93
Heptachlor Epoxide	<1.1	<0.69	<0.73	<0.84	<0.75	<1.1	<0.78	<0.8	<0.8	<0.61	<0.82
Total Chlordane (4 compounds)	27.9	29.3	6	6.5	5.4	2.4	<0.7	3.04	1.84	0.71	<0.7
2,4'-DDT	1.8	1.1	1.1	1.3	1.2	1.7	1.2	1.2	1.2	0.96	1.3
4,4'-DDT	2	8	1.3	1.5	1.3	2	1.4	1.4	1.4	1.1	1.4
2,4'-DDE	1.6	0.98	1	1.2	1.1	1.6	1.1	1.1	1.1	0.87	1.2
4,4'-DDE	9	7.6	8.9	10	9.3	15	7.6	8.5	8.2	0.87	6.9
2,4'-DDD	8.8	17	0.94	3.8	5.5	1.4	1	1	1.2	0.79	1
4,4'-DDD	15	20	4.7	5.3	4.6	6.3	4.6	4	4.7	2.2	3.6
Total DDT (6 compounds)	32.8	52.6	13.6	19.1	19.4	21.3	12.2	12.5	14.1	2.2	10.5
Dieldrin	6.6	8.2	1.4	3.1	2	1.6	1	2.4	1.3	0.84	1.2
Endrin	<1.1	<0.69	<0.73	<0.84	<0.75	<1.1	<0.78	<0.8	<0.8	<0.61	<0.82
alpha-hexachlorocyclohexan	<0.97	<0.59	<0.62	<0.72	<0.64	<0.95	<0.67	<0.68	<0.68	<0.52	<0.7
beta-hexachlorocyclohexan	<0.97	<0.59	<0.62	<0.72	<0.64	<0.95	<0.67	<0.68	<0.68	<0.52	<0.7
delta-hexachlorocyclohexan	<0.97	<0.59	<0.62	<0.72	<0.64	<0.95	<0.67	<0.68	<0.68	<0.52	<0.7
Lindane	<1.1	<0.69	<0.73	<0.84	<0.75	<1.1	<0.78	<0.8	<0.8	<0.61	<0.82
Mirex	<0.65	<0.39	<0.42	<0.48	<0.43	<0.63	<0.45	<0.46	<0.46	<0.35	<0.47
PCB 8	2.9	1.8	1.8	2.1	1.9	2.8	2	2	2	1.6	2.1
PCB 18	3	1.8	1.9	2.2	2	3	2.1	2.1	2.1	1.7	2.2
PCB 28	4.9	4.9	8.3	2.1	2.5	16	12	1.6	1.4	4.1	1.1
PCB 44	2.2	4	1.4	1.6	1.5	2.2	1.5	1.6	1.6	1.2	1.6
PCB 52	7.9	12	3.2	1.6	3.2	3.6	1.5	1.5	1.5	1.2	1.6
PCB 66	3.1	1	4.7	1.5	5.9	5.6	1.4	1.9	1.2	1.7	1.2
PCB 77	<3.6	<2.2	<2.3	<2.7	<2.4	<3.5	<2.5	<2.5	<2.5	<1.9	<2.6
PCB 101	21	48	6.2	5.8	5.6	8.2	1.3	2.1	2.5	2	0.9
PCB 105	2.8	13	0.77	1.3	0.75	1.1	0.78	1.5	1.2	0.61	0.81
PCB 118	8.5	13	5.8	4.9	4.6	6.2	1.7	2.6	1.8	1.8	1.3
PCB 126	<3	<1.8	<1.9	<2.2	<2	<3	<2.1	<2.1	<2.1	<1.6	<2.2
PCB 128	2.2	3.4	1.7	1.6	1.5	2.2	1.6	1.6	1.6	1.2	1.6
PCB 138	17	35	7.1	6.2	6	11	2.6	5.3	4.2	4	2.3
PCB 153	27	68	14	8.6	5.7	19	5	7.8	6.5	7	5.4
PCB 170	2.6	8	1.3	1.2	1.1	2.6	1.1	1.1	1.1	0.86	1.2
PCB 180	8.2	16	0.8	0.92	0.83	4.2	0.87	1.9	2.6	1.8	0.9
PCB 187	6.4	17	2.9	2.4	3	3.8	1.3	3.2	3.2	1.9	1.3
PCB 195	1.8	2.2	1.2	1.3	5.4	1.8	1.2	2.3	1.3	0.97	1.3
PCB 206	1.5	3.5	0.61	2.8	12	0.93	0.66	4.5	10	0.52	1.6
PCB 209	3.3	2	2.1	2.4	4.4	3.2	2.3	2.3	3.3	1.8	2.4
Total PCB (18 compounds)	110.9	248	55.97	35.6	58.3	81.3	24.87	34.7	36.7	27.2	10.5

APPENDIX A4

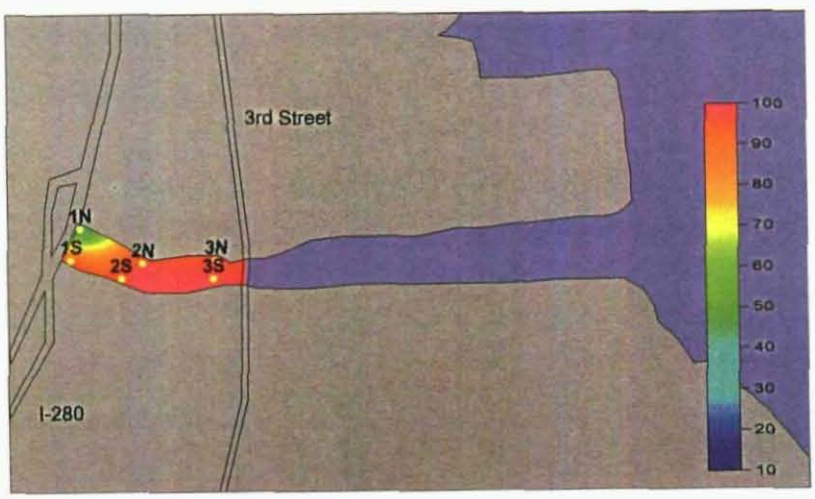
Islais Creek
Surface Sediment Distributions

Appendix A4
SURFACE SEDIMENT DISTRIBUTIONS - ISLAIS CREEK

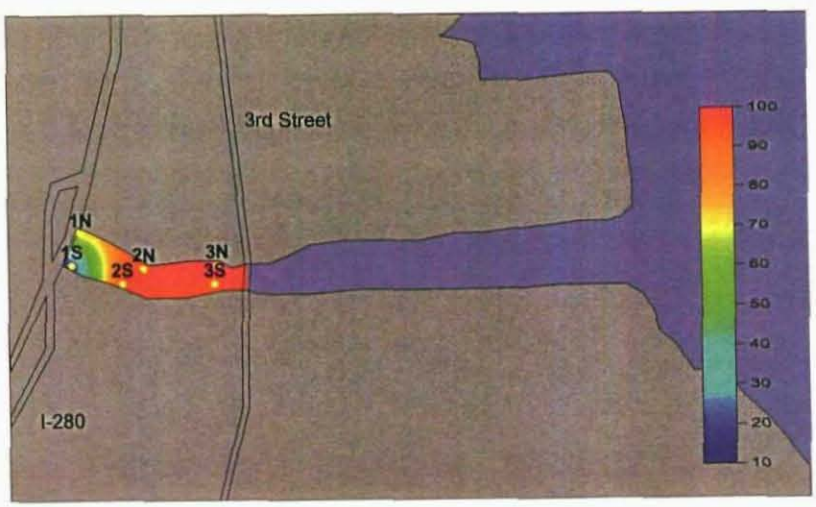
Percent Fines, October 1998



Percent Fines, October 1999

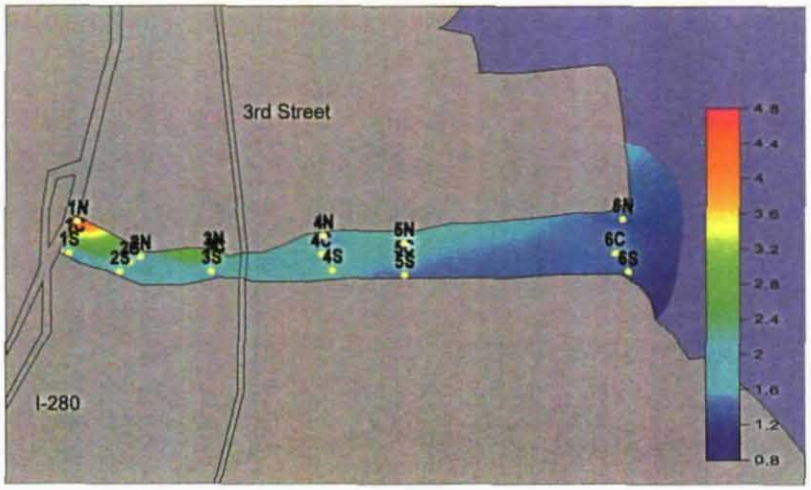


Percent Fines, April 2000

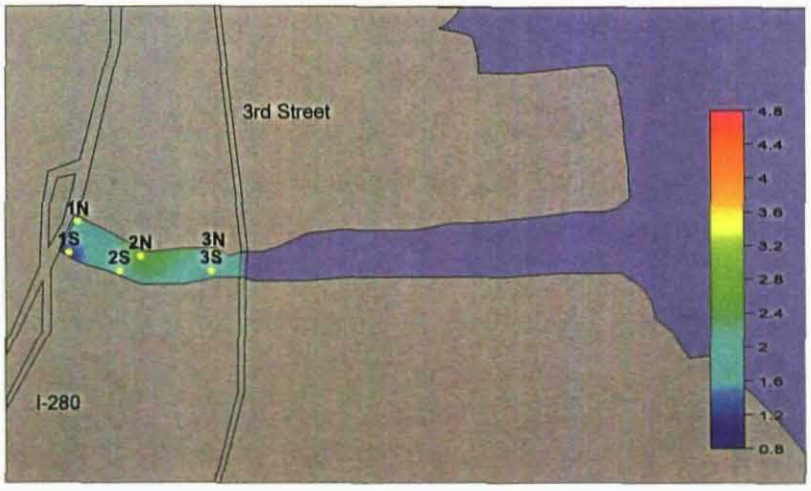


Appendix A4
SURFACE SEDIMENT DISTRIBUTIONS - ISLAIS CREEK

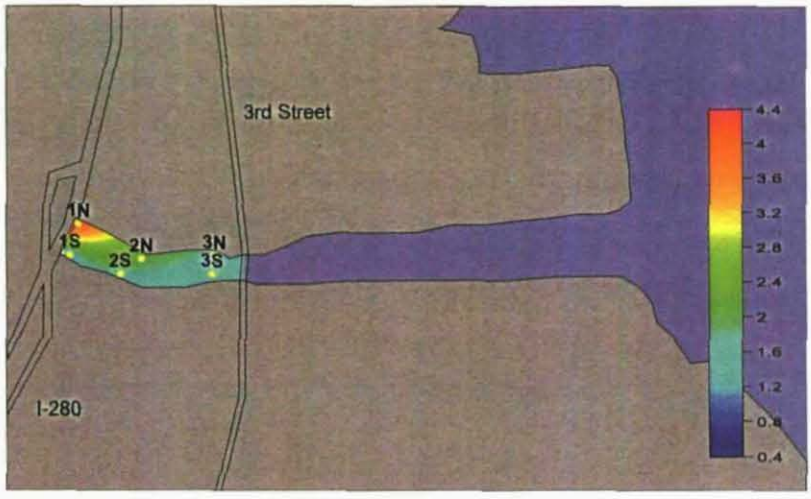
Percent Total Organic Carbon, October 1998



Percent Total Organic Carbon, October 1999

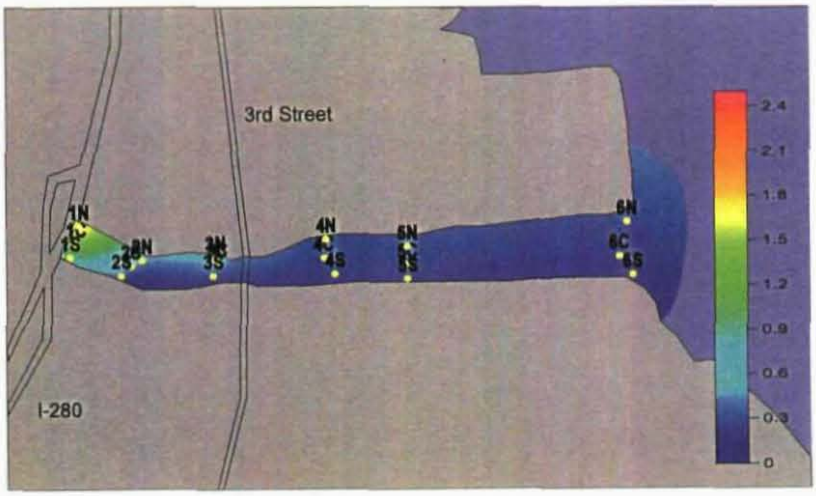


Percent Total Organic Carbon, April 2000

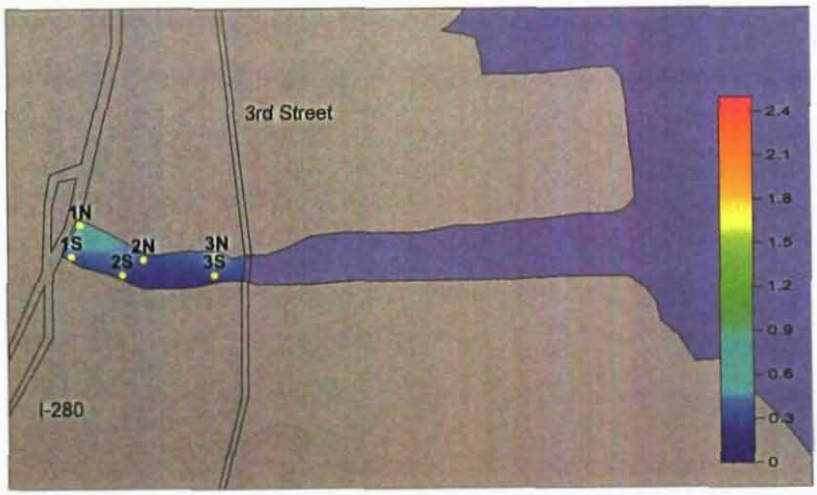


Appendix A4
SURFACE SEDIMENT DISTRIBUTIONS - ISLAIS CREEK

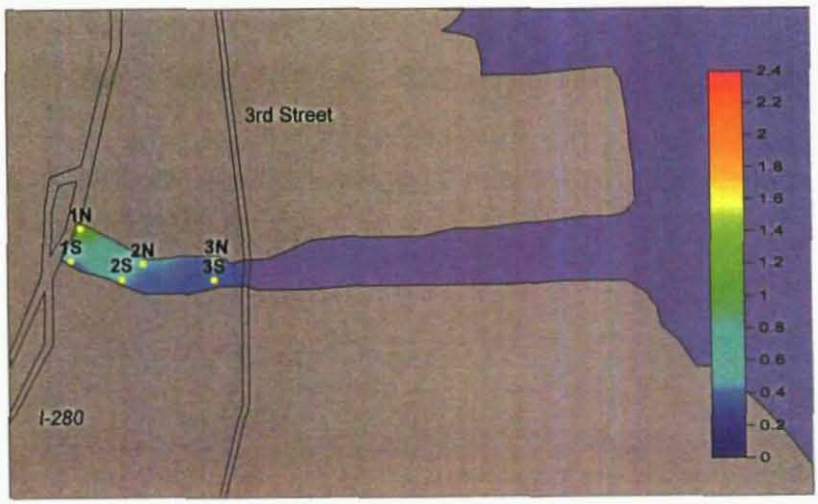
Mercury (ppm), October 1998



Mercury (ppm), October 1999

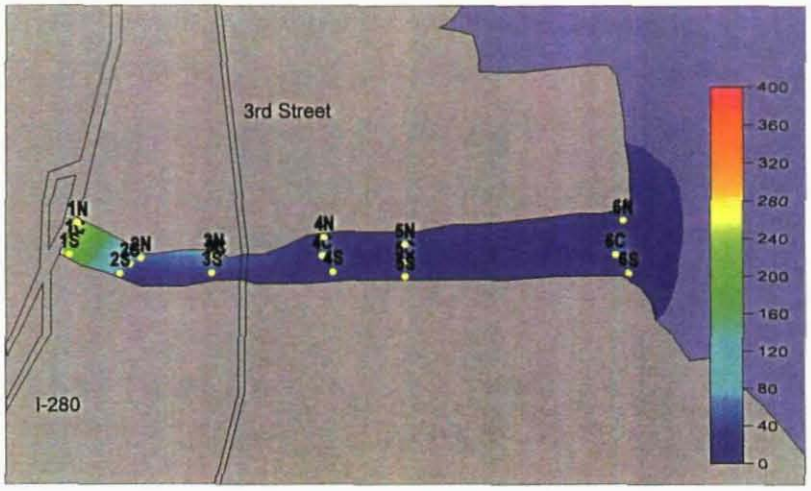


Mercury (ppm), April 2000

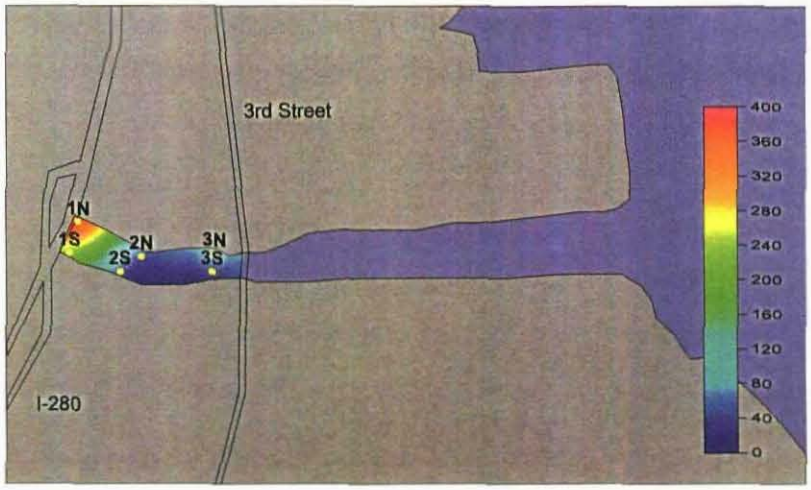


Appendix A4
SURFACE SEDIMENT DISTRIBUTIONS - ISLAIS CREEK

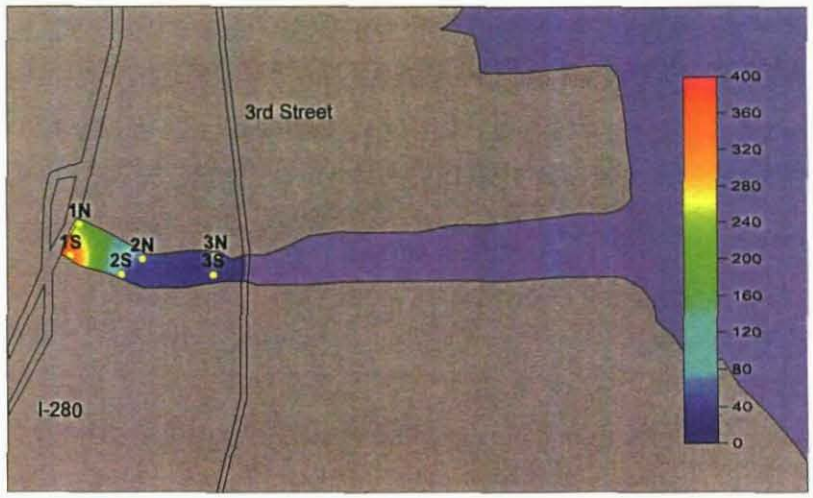
Lead (ppm), October 1998



Lead (ppm), October 1999

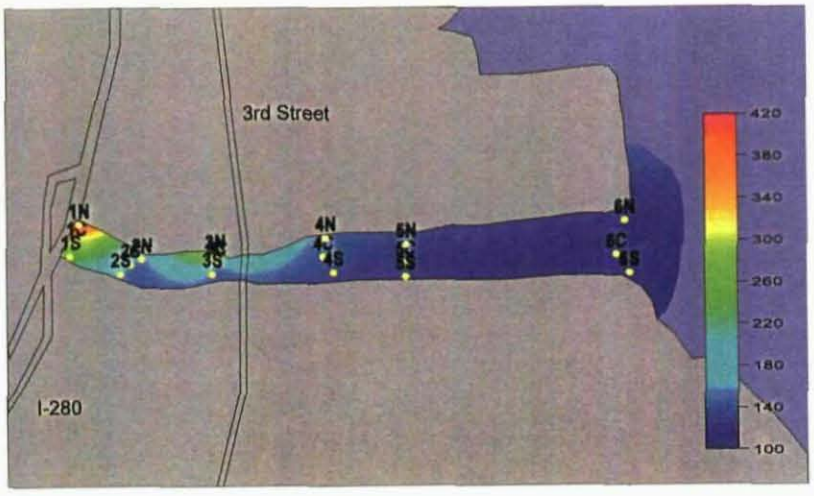


Lead (ppm), April 2000

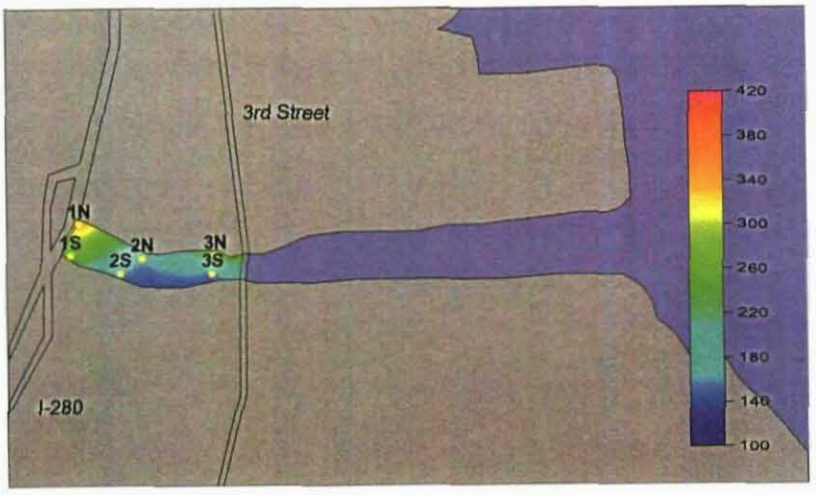


Appendix A4
SURFACE SEDIMENT DISTRIBUTIONS - ISLAIS CREEK

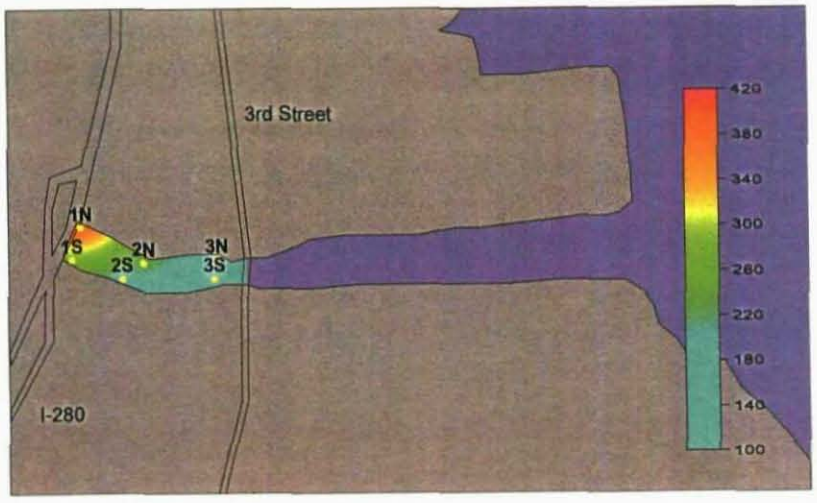
Zinc (ppm), October 1998



Zinc (ppm), October 1999

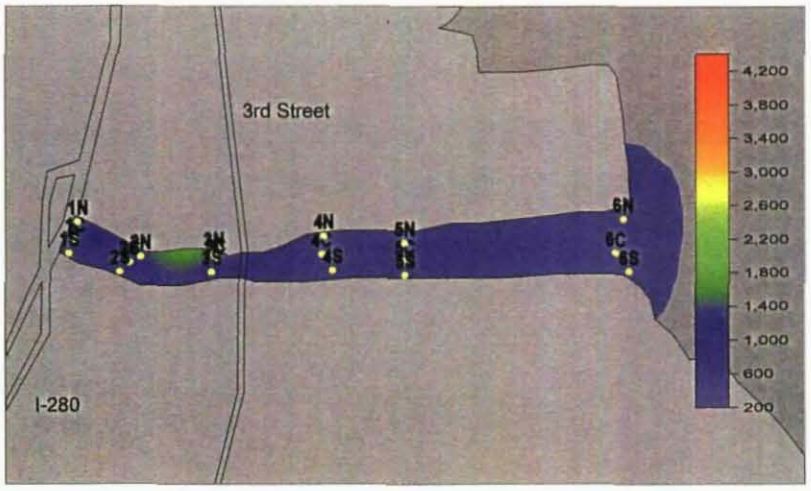


Zinc (ppm), April 2000

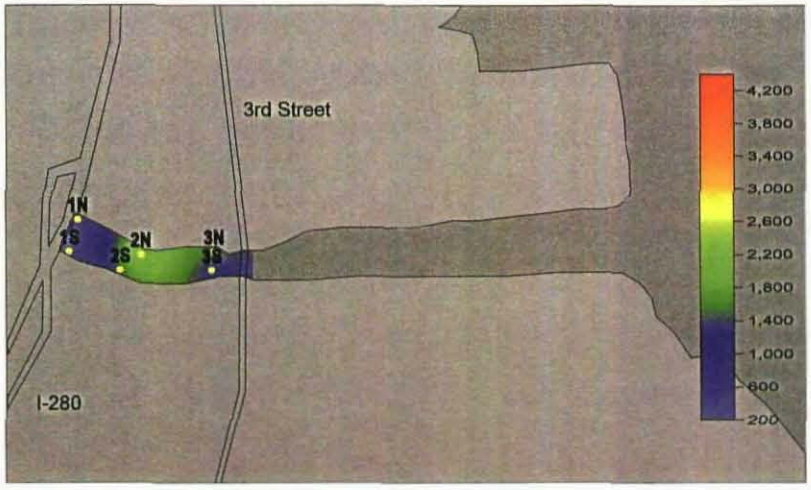


Appendix A4
SURFACE SEDIMENT DISTRIBUTIONS - ISLAIS CREEK

Low Molecular Weight PAH (ppb), October 1998



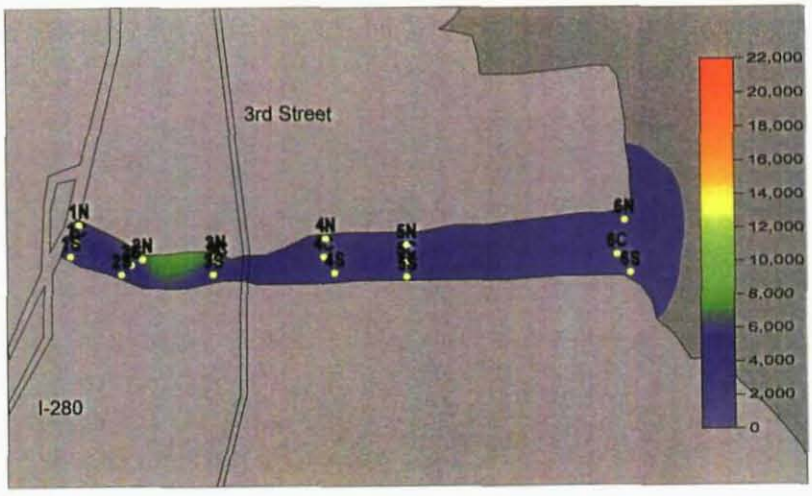
Low Molecular Weight PAH (ppb), October 1999



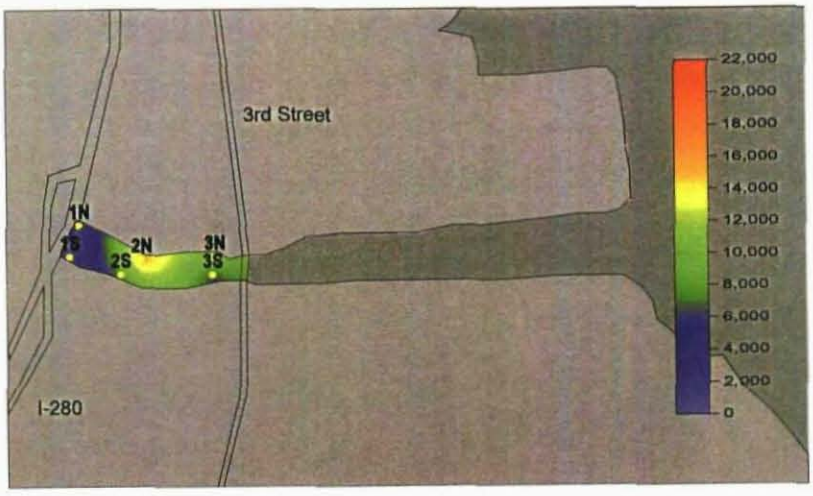
Low Molecular Weight PAH (ppb), April 2000

Appendix A4
SURFACE SEDIMENT DISTRIBUTIONS - ISLAIS CREEK

High Molecular Weight PAH (ppb), October 1998



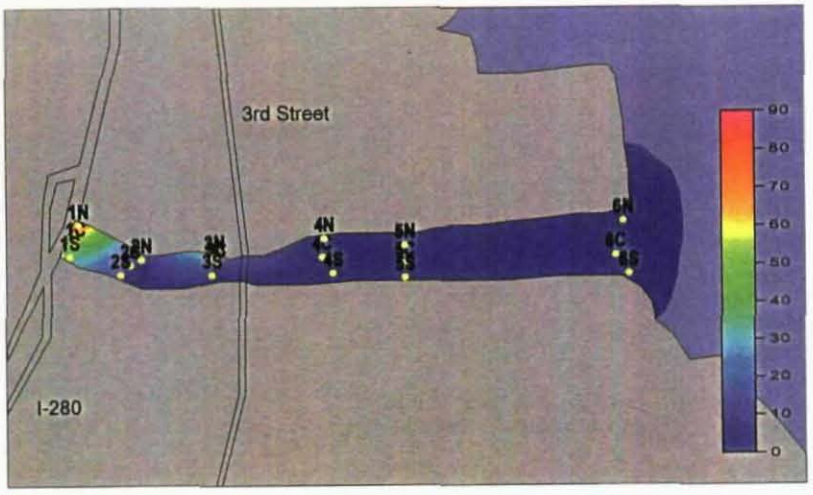
High Molecular Weight PAH (ppb), October 1999



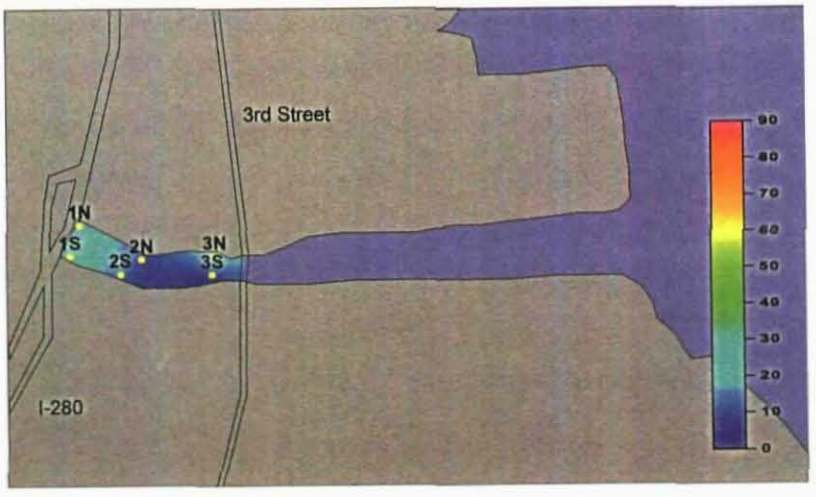
High Molecular Weight PAH (ppb), April 2000

Appendix A4
SURFACE SEDIMENT DISTRIBUTIONS - ISLAIS CREEK

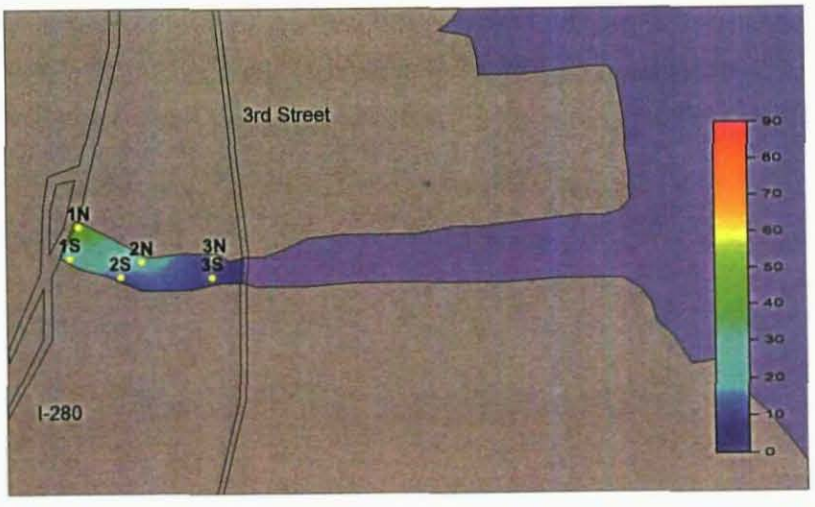
Total Chlordane (ppb), October 1998



Total Chlordane (ppb), October 1999

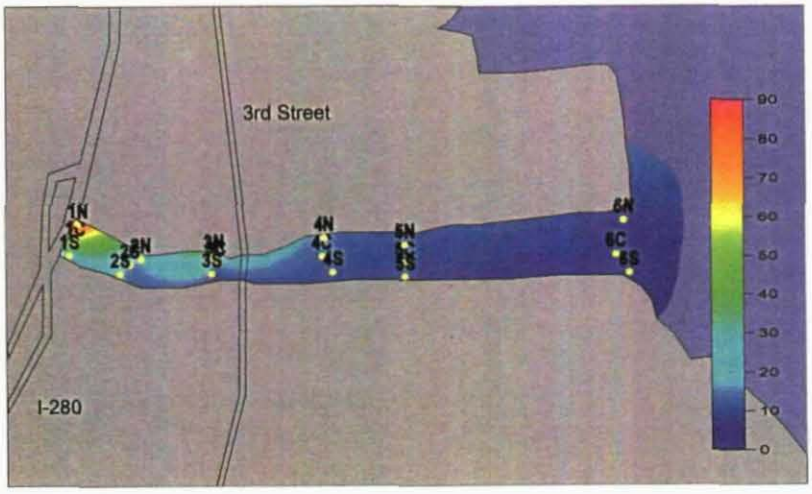


Total Chlordane (ppb), April 2000

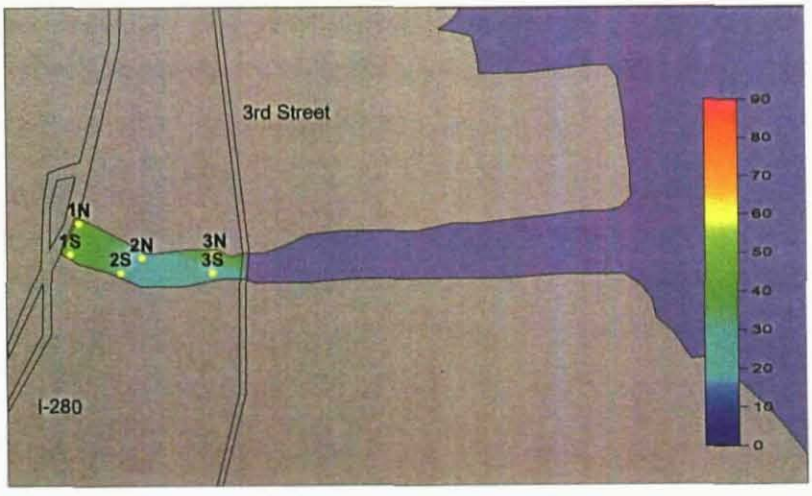


Appendix A4
SURFACE SEDIMENT DISTRIBUTIONS - ISLAIS CREEK

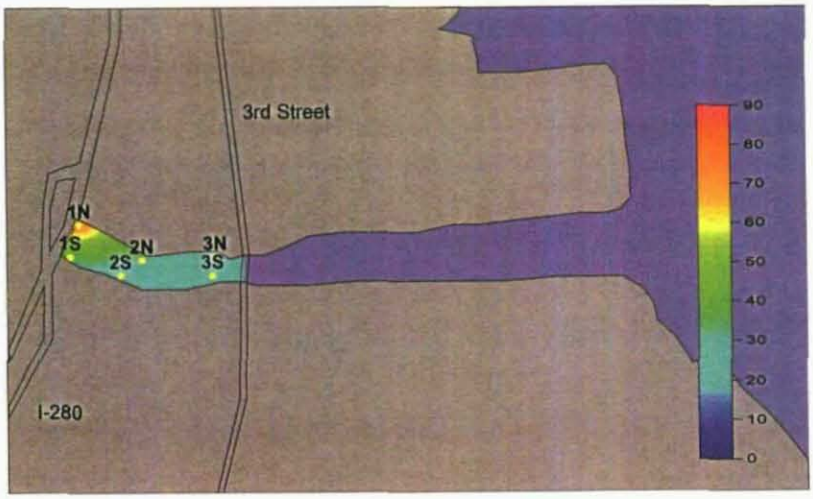
Total DDT (ppb), October 1998



Total DDT (ppb), October 1999

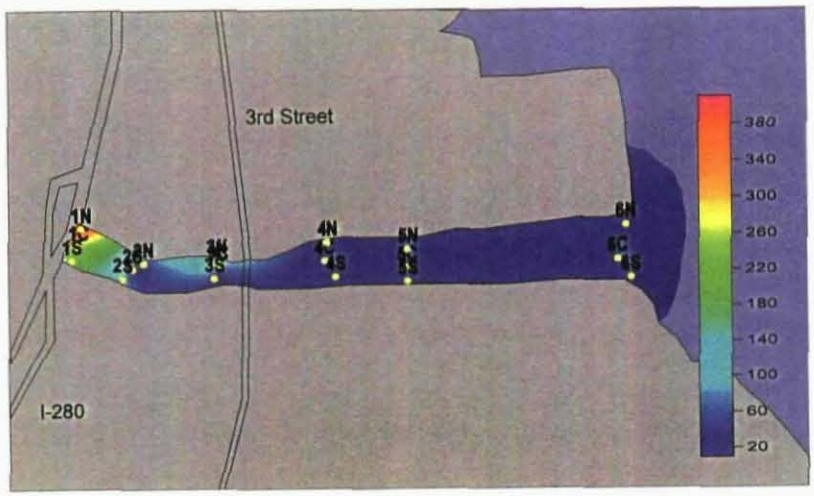


Total DDT (ppb), April 2000

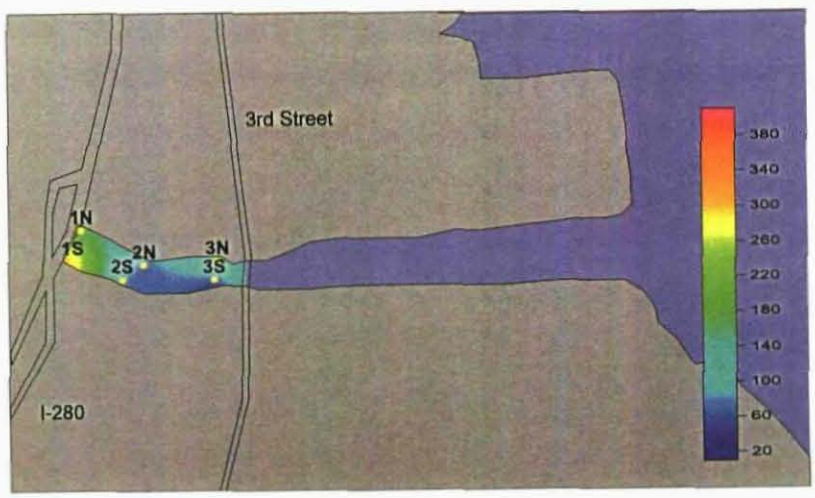


Appendix A4
SURFACE SEDIMENT DISTRIBUTIONS - ISLAIS CREEK

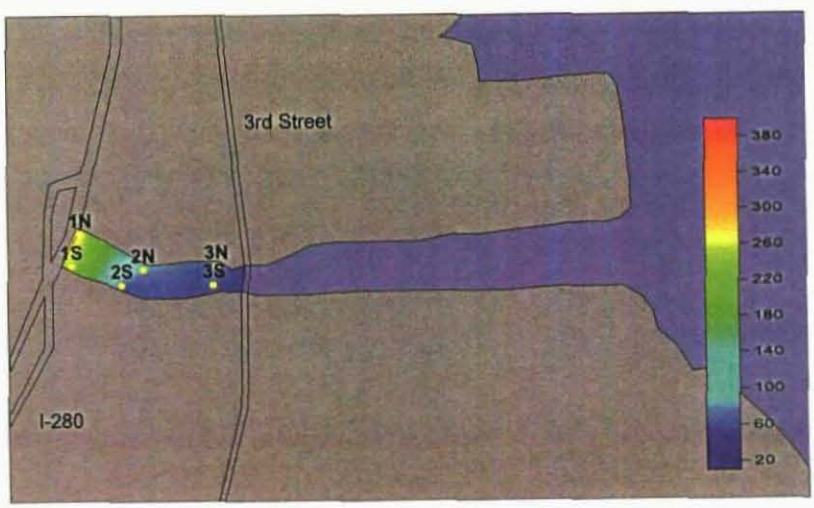
Total PCBs (18 compounds, ppb), October 1998



Total PCBs (18 compounds, ppb), October 1999



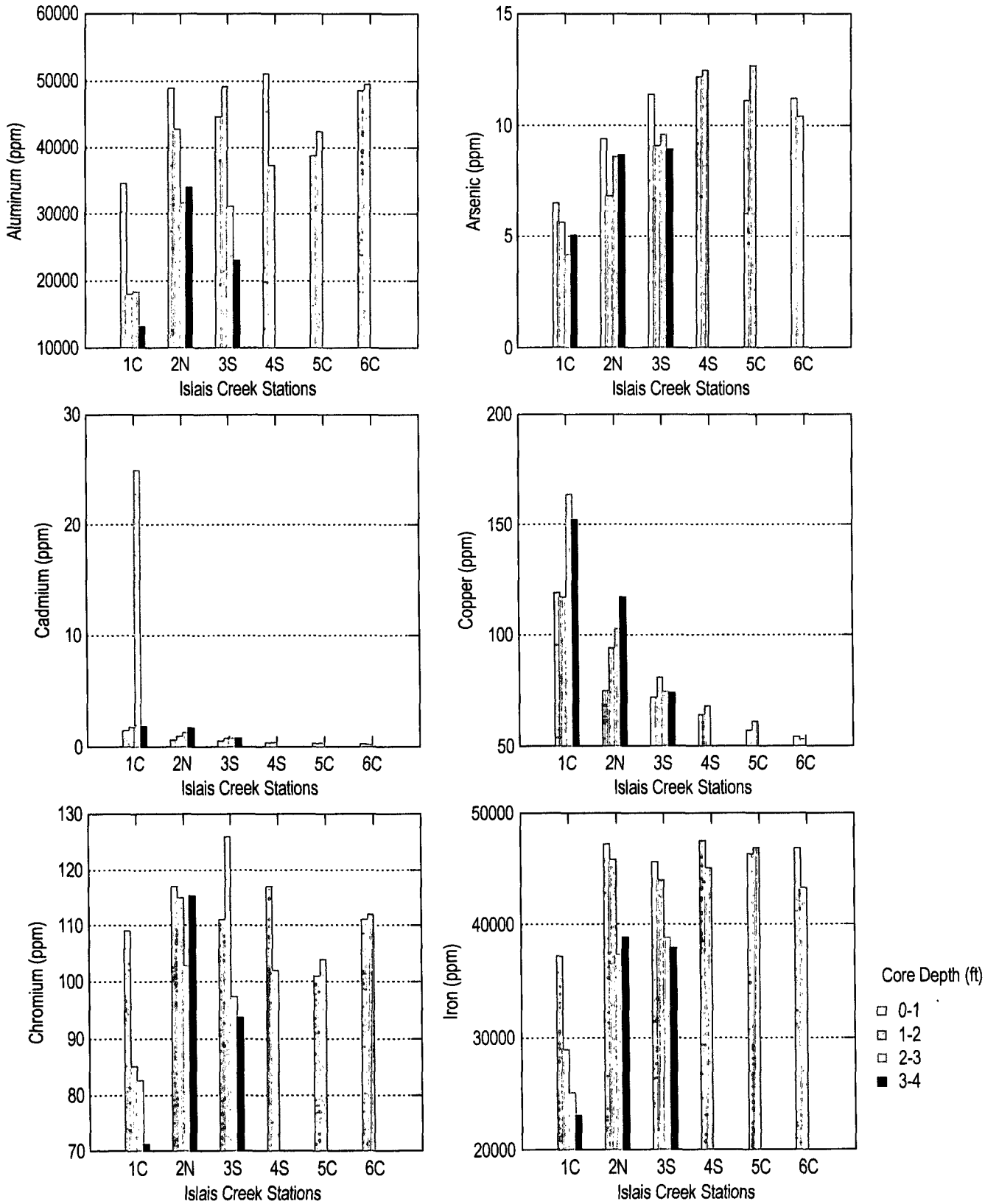
Total PCBs (18 compounds, ppb), April 2000



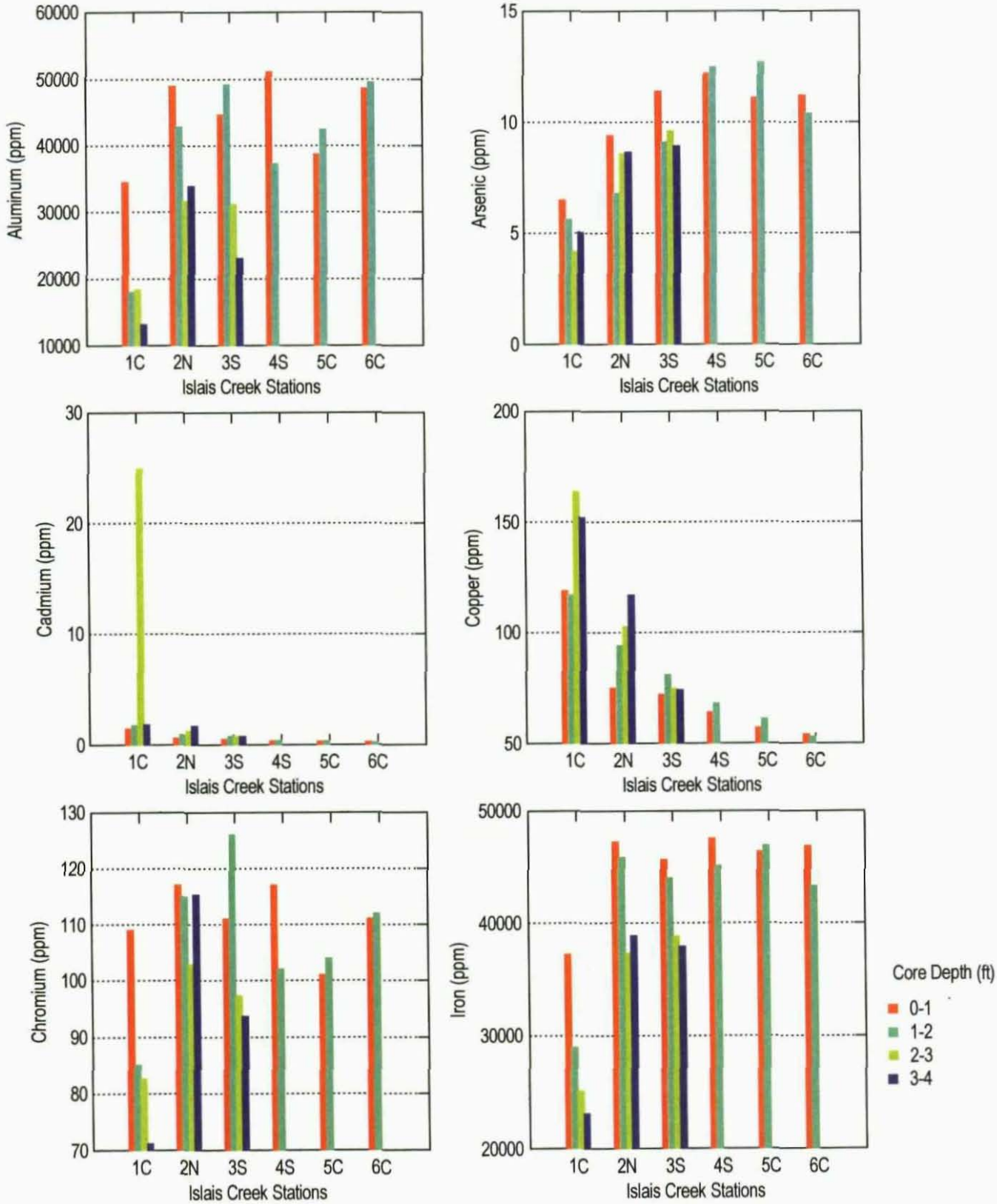
APPENDIX A5

Islais Creek
Subsurface Sediment Plots

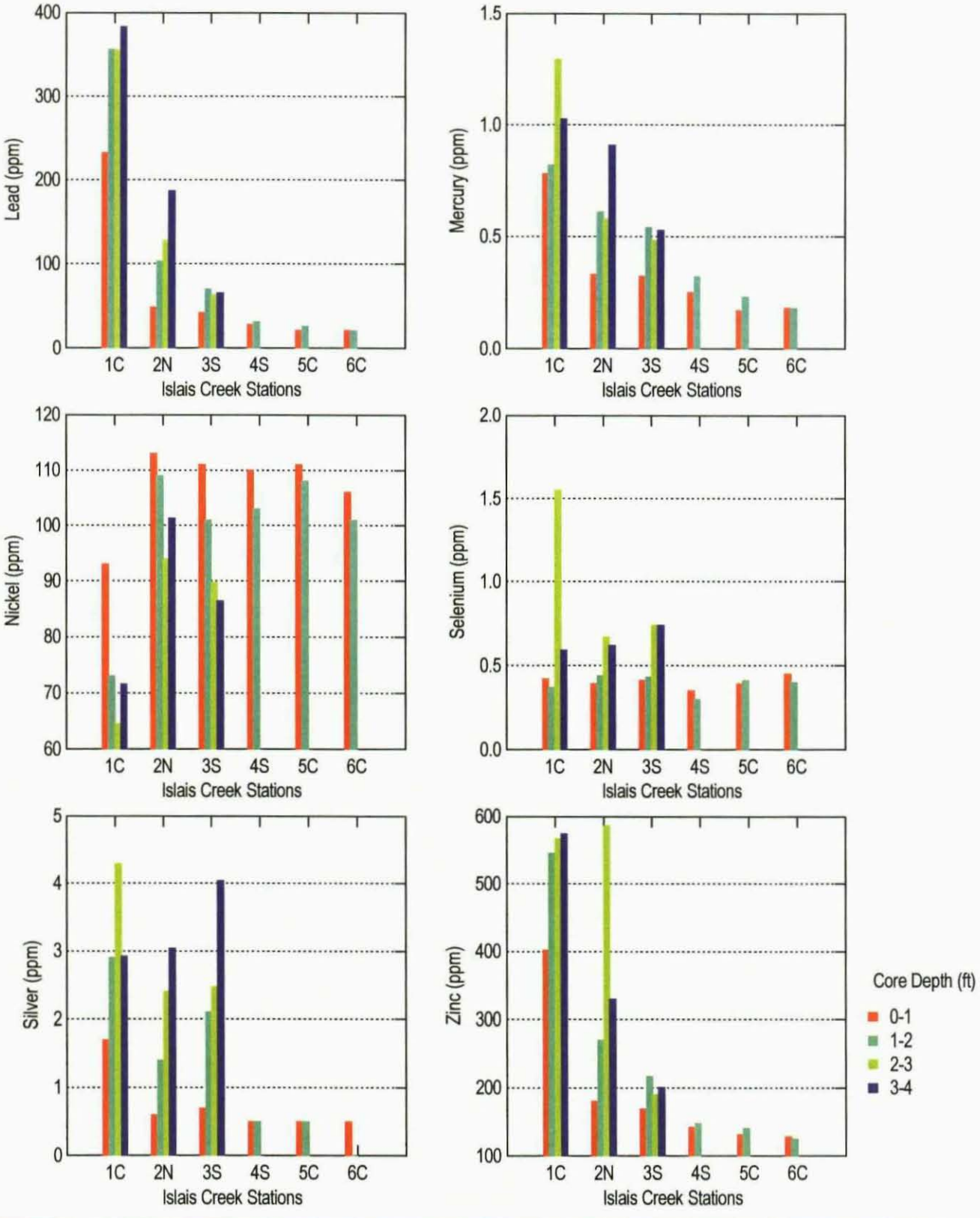
Appendix A5
SUBSURFACE SEDIMENT DISTRIBUTIONS - ISLAIS CREEK (October 1998)



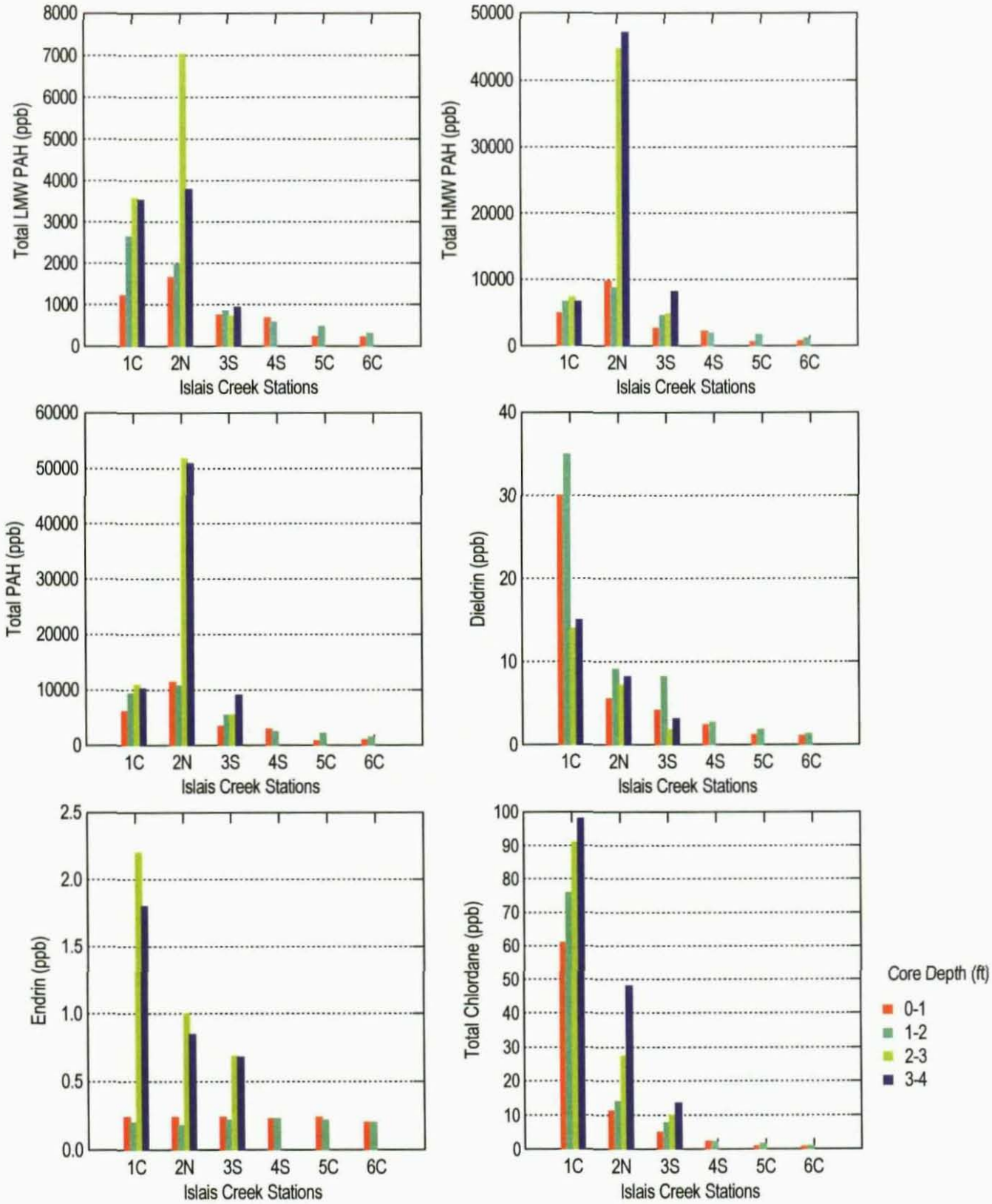
Appendix A5
SUBSURFACE SEDIMENT DISTRIBUTIONS - ISLAIS CREEK (October 1998)



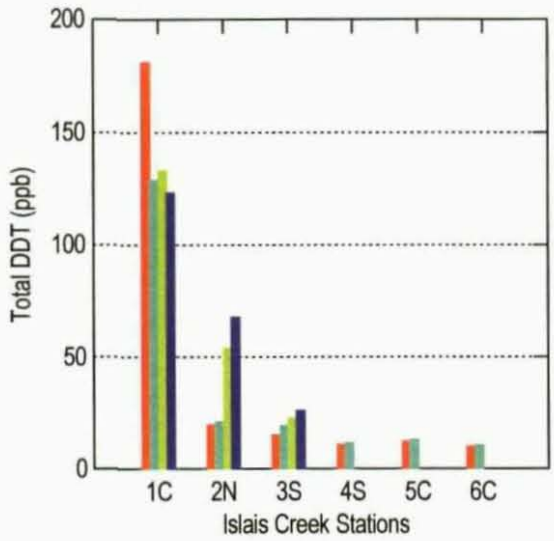
Appendix A5
SUBSURFACE SEDIMENT DISTRIBUTIONS - ISLAIS CREEK (October 1998)

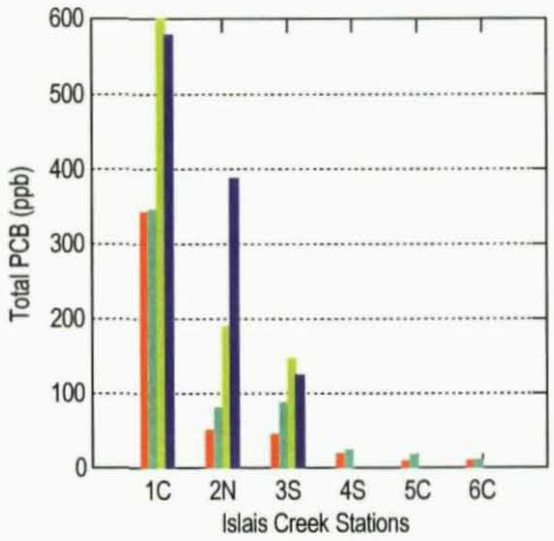


Appendix A5
SUBSURFACE SEDIMENT DISTRIBUTIONS - ISLAIS CREEK (October 1998)



Appendix A5
SUBSURFACE SEDIMENT DISTRIBUTIONS - ISLAIS CREEK (October 1998)





APPENDIX B1

Mission Creek
Surface Sediment Data

Appendix B1
SURFACE SEDIMENT DATA - MISSION CREEK

October 1998

STATION	1N	1N	1S	2N	2S	3N	3S	4N	ERM
Sample Date	10/20/98	11/23/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	
Depth (ft)	0	1	0	0	0	0	0	0	
Replicate	1	1	1	1	1	1	1	1	
Toxicity (% Survival)	85				74	85			
Total Organic Carbon (%)	2.9	2.5	2.5	4.5	4.2	4.4	3.4	3.0	
Grain Size (%)									
Gravel	2.2	11.1	3.8	2.4	3.1	0	0	0	
Sand	70	73.4	72.2	73.5	62.9	7.9	18	6	
Silt	20.1	11.8	16	18	26.6	38.7	71.5	78.9	
Clay	7.7	3.7	8	6.1	7.4	53.4	10.5	15.1	
Fines (Silt+Clay)	27.8	15.5	24	24.1	34	92.1	82	94	
Metals (µg·g⁻¹, dry weight)									
Aluminum	15931	15195	19468	16511	17987	39905	44756	50138	
Arsenic	8.2	4.8	9	9.1	10.1	10.6	10.8	12.6	70
Cadmium	1.89	2.69	1.58	1.52	1.8	1.97	1.64	1	9.6
Chromium	93	81	104	82	84	109	107	113	370
Copper	124	99	107	130	161	157	150	106	270
Iron	25471	20218	25578	24292	26656	42630	42605	45697	
Lead	419	372	300	377	428	251	229	128	218
Mercury	1.5	0.99	1.35	1.05	3.76	1.04	1.04	0.74	0.7
Nickel	67	55	74	57	69	104	101	99	51.6
Selenium	0.18	0.19	0.16	0.17	0.19	0.43	0.44	0.33	
Silver	5.6	2.8	2.1	3.1	5.9	3.5	2.5	1.5	3.7
Zinc	475	392	408	452	496	427	397	267	410
PAH (ng·g⁻¹, dry weight)									
Naphthalene	210	110	120	160	130	85	78	100	
C1-Naphthalenes	310	200	140	210	160	110	98	98	
C2-Naphthalenes	480	380	280	310	400	300	220	130	
C3-Naphthalenes	460	360	290	360	450	300	270	160	
C4-Naphthalenes	550	460	300	440	440	400	380	180	
Acenaphthylene	64	54	82	110	100	120	73	130	
Acenaphthene	280	250	260	130	120	89	81	54	
Biphenyl	59	50	35	38	41	42	31	32	
Dibenzofuran	190	160	160	100	100	100	75	86	
Fluorene	260	220	260	160	160	180	120	160	
C1-Fluorenes	150	120	110	120	110	120	99	75	
C2-Fluorenes	320	220	160	240	230	230	220	110	
C3-Fluorenes	790	670	400	460	520	420	380	250	
Anthracene	430	440	460	740	370	820	430	1200	
Phenanthrene	1800	1700	1700	1000	1000	710	580	670	
C1-Phenanthrenes/anthracenes	750	700	590	660	570	750	530	590	
C2-Phenanthrenes/anthracenes	780	660	530	710	760	760	610	500	
C3-Phenanthrenes/anthracenes	1000	850	530	690	770	650	620	370	
C4-Phenanthrenes/anthracenes	1600	1200	830	1000	1200	1000	690	860	
Dibenzothiophene	130	120	100	81	96	94	74	53	

Appendix B1
SURFACE SEDIMENT DATA - MISSION CREEK

October 1998

STATION	1N	1N	1S	2N	2S	3N	3S	4N	ERM
Sample Date	10/20/98	11/23/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	
Depth (ft)	0	1	0	0	0	0	0	0	
Replicate	1	1	1	1	1	1	1	1	
PAH (ng·g^{-1}, dry weight)									
C1-Dibenzothiophenes	96	93	69	78	94	86	70	40	
C2-Dibenzothiophenes	320	280	180	250	320	270	240	100	
C3-Dibenzothiophenes	510	470	250	350	440	360	340	130	
Fluoranthene	2600	2200	2200	2200	2300	2400	2100	2400	
Pyrene	2600	2200	2200	2300	2200	1900	1600	2300	
C1-Fluoranthenes/pyrenes	1200	1200	1000	1400	1200	1600	1100	2600	
C2-Fluoranthenes/pyrenes	1300	1200	780	1000	1100	1200	910	1200	
C3-Fluoranthenes/pyrenes	700	830	460	590	630	610	500	550	
Benzo[a]anthracene	1100	850	980	990	920	1000	760	1700	
Chrysene	1400	1100	1200	1200	1200	1500	1100	2900	
C1-Chrysenes	890	690	590	770	760	880	670	1300	
C2-Chrysenes	830	680	540	710	790	730	650	720	
C3-Chrysenes	750	560	490	620	660	680	590	410	
C4-Chrysenes	610	500	390	480	660	600	480	380	
Benzo[b]fluoranthene	1400	1000	1300	1400	1400	1600	1200	3400	
Benzo[k]fluoranthene	460	430	430	490	380	550	420	1200	
Benzo[e]pyrene	780	670	740	810	770	910	740	1700	
Benzo[a]pyrene	970	890	970	980	890	1000	810	2300	
Perylene	300	260	300	320	310	380	290	670	
Indeno[1,2,3,-c,d]pyrene	670	550	680	640	660	720	570	1300	
Dibenzo[a,h]anthracene	150	130	150	140	140	150	130	320	
Benzo[g,h,i]perylene	730	510	710	740	740	790	660	1200	
Total LMW PAH (7 compounds)	3354	2974	3022	2510	2040	2114	1460	2412	3160
Total HMW PAH (6 compounds)	8820	7370	7700	7810	7650	7950	6500	11920	9600
Total PAH (13 compounds)	12174	10344	10722	10320	9690	10064	7960	14332	44792
C10B-Phenyl decanes	270	250	240	260	430	540	470	200	
C11B-Phenyl undecanes	270	230	250	220	500	520	510	220	
C12B-Phenyl dodecanes	120	<4.6	110	93	150	180	160	77	
C13B-Phenyl tridecanes	190	220	300	180	780	400	260	130	
C14B-Phenyl tetradecanes	<4.8	<4.6	<4.6	<9	<11	<7.5	<6.5	<3.4	
TPH (µg·g^{-1}, dry weight)									
n-Nonane	<2.8	<2.7	<2.6	<2	<3.1	<5.1	<3.1	<2.4	
n-Decane	<0.1	0.52	<0.09	0.22	0.36	<0.19	<0.12	<0.09	
n-Undecane	<0.32	<0.31	<0.3	<0.23	<0.35	<0.59	<0.36	<0.27	
n-Dodecane	<0.32	<0.31	<0.3	<0.23	<0.35	<0.59	<0.36	<0.27	
n-Tridecane	<0.43	<0.42	<0.4	<0.31	<0.48	<0.79	<0.49	<0.37	
Isoprenoid RRT 1380	<0.52	<0.5	<0.48	0.38	0.58	<0.96	<0.59	<0.45	
n-Tetradecane	<0.67	<0.65	<0.62	<0.49	<0.74	<1.2	<0.76	<0.57	
Isoprenoid RRT 1470	0.64	0.47	0.36	0.44	0.64	0.52	0.51	0.16	
n-Pentadecane	<0.28	<0.27	<0.26	<0.2	<0.3	<0.51	<0.31	<0.24	
n-Hexadecane	<0.14	0.2	0.29	0.21	0.36	<0.26	0.21	0.2	
Isoprenoid RRT 1650	<0.33	<0.32	<0.3	0.24	0.44	<0.6	0.37	<0.28	
n-Heptadecane	0.33	0.25	0.32	0.31	0.44	0.66	0.6	0.36	

Appendix B1
SURFACE SEDIMENT DATA - MISSION CREEK

October 1998

STATION	1N	1N	1S	2N	2S	3N	3S	4N	
Sample Date	10/20/98	11/23/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	ERM
Depth (ft)	0	1	0	0	0	0	0	0	
Replicate	1	1	1	1	1	1	1	1	
TPH (µg·g^{-1}, dry weight)									
Pristane	0.88	0.41	0.38	0.42	0.61	0.86	0.7	<0.35	
n-Octadecane	<0.38	<0.37	<0.35	<0.28	<0.42	<0.7	<0.43	<0.33	
Phytane	0.43	0.24	0.37	0.39	0.66	1.1	0.88	0.38	
n-Nonadecane	0.2	<0.18	0.32	0.21	0.24	0.34	0.26	0.24	
n-Eicosane	0.12	0.43	0.13	<0.09	<0.13	<0.22	0.51	0.36	
n-Heneicosane	<0.27	0.69	0.29	0.3	0.38	<0.5	0.49	0.35	
n-Docosane	0.77	0.32	0.48	0.75	1	0.95	0.71	0.66	
n-Tricosane	0.64	0.41	0.53	0.56	1	1.1	1	0.8	
n-Tetracosane	<0.1	<0.1	0.3	0.42	0.5	0.91	0.71	0.39	
n-Pentacosane	0.48	<0.32	0.61	1.1	1.2	2	1.9	0.72	
n-Hexacosane	<0.17	<0.17	0.39	0.72	0.85	1.3	1.2	0.51	
n-Heptacosane	0.71	0.39	0.79	1.2	1.8	2.2	2.1	0.64	
n-Octacosane	<0.2	<0.2	<0.19	<0.15	<0.22	1.3	1.5	<0.17	
n-Nonacosane	2.4	<1.2	2	3.4	6.2	5.8	6.4	1.9	
n-Triacontane	<0.44	<0.43	<0.41	<0.32	1.4	2.3	1.8	0.55	
n-Hentriacontane	1.9	1.1	0.95	2.3	4.7	4.2	3.7	1.7	
n-Dotriacontane	3.1	<0.16	1.1	2.8	3	6.1	3.7	0.68	
n-Tritriacontane	3.4	2.4	3.5	4.7	8.2	8.6	7.9	2.4	
n-Tetratriacontane	1.4	0.82	1	1.5	2	2.6	2.4	1	
n-Pentatriacontane	<0.17	1.4	0.57	0.85	1.4	1.9	1.8	0.42	
n-Hexatriacontane	0.61	0.46	0.41	1.1	1.2	1.8	1.5	0.82	
n-Heptatriacontane	0.55	0.21	0.46	0.98	0.92	1.3	1.1	0.55	
n-Octatriacontane	0.74	0.28	0.41	0.83	0.88	1.4	1.2	0.62	
n-Nonatriacontane	0.47	0.19	0.28	0.64	0.77	0.94	0.9	0.41	
n-Tetracontane	0.33	<0.18	0.28	0.52	0.5	0.74	0.69	0.36	
Total Resolved Hydrocarbons	210	180	140	210	300	310	270	140	
Total Petroleum Hydrocarbons	2700	2200	2000	2800	3600	4100	3800	1700	
TPH >C8-C10	9.1	13	5.3	12	13	12	13	5	
TPH >C10-C12	30	24	15	20	34	26	22	8.2	
TPH >C12-C16	110	91	64	84	150	93	86	37	
TPH >C16-C21	250	210	150	210	280	290	260	130	
TPH >C21-C25	450	370	290	430	550	680	630	290	
TPH >C25-C30	750	610	530	780	990	1200	1100	500	
TPH >C30-C35	610	490	450	650	830	970	890	390	
TPH >C35 +	530	410	450	620	780	830	790	320	
Pesticides & PCB (ng·g dry weight)									
Aldrin	<0.18	<0.18	<0.17	<0.27	<0.41	<0.85	<0.52	<0.4	
alpha-Chlordane	28	30	32	31	41	21	17	8.7	
gamma-Chlordane	22	36	19	30	34	18	15	7.2	
cis-Nonachlor	8.3	8.2	4.4	6.7	7.2	4.6	4.1	2.6	
trans-Nonachlor	23	20	12	18	18	9.2	7.6	4.5	
Heptachlor	<0.17	<0.17	<0.16	<0.25	<0.38	<0.8	<0.49	<0.37	
Heptachlor Epoxide	<0.17	<0.17	<0.16	<0.25	<0.38	<0.8	<0.49	<0.37	

Appendix B1
SURFACE SEDIMENT DATA - MISSION CREEK

October 1998

STATION	1N	1N	1S	2N	2S	3N	3S	4N	
Sample Date	10/20/98	11/23/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	ERM
Depth (ft)	0	1	0	0	0	0	0	0	
Replicate	1	1	1	1	1	1	1	1	
Pesticides & PCB (ng/g dry weight)									
Total Chlordane (4 compounds)	81.3	94.2	67.4	85.7	100.8	52.8	43.7	23	
2,4'-DDT	<0.29	<0.28	<0.27	<0.42	<0.64	<1.3	<0.82	<0.62	
4,4'-DDT	5.4	<0.39	6.8	7.5	11	4.4	11	3.6	
2,4'-DDE	<0.29	<0.28	<0.27	<0.42	<0.64	<1.3	<0.82	<0.62	
4,4'-DDE	14	12	10	13	19	13	12	9	
2,4'-DDD	10	8.9	7.6	9.1	12	7.5	6	3.3	
4,4'-DDD	38	62	27	30	75	41	40	19	
Total DDT (6 compounds)	67.4	82.9	51.4	59.6	117	65.9	69	34.9	100
Dieldrin	37	36	60	35	57	29	26	13	8
Endrin	<0.17	<0.17	<0.16	<0.25	<0.38	<0.8	<0.49	<0.37	45
alpha-hexachlorocyclohexan									
beta-hexachlorocyclohexan									
delta-hexachlorocyclohexan									
Lindane	<0.13	<0.12	<0.12	<0.18	<0.28	<0.58	<0.36	<0.27	0.99
Mirex	<0.09	<0.08	<0.08	<0.13	<0.19	<0.4	<0.24	<0.18	
PCB 8	4.4	5.3	2.9	3.2	3.9	<0.56	<0.34	<0.26	
PCB 18	7.2	8.8	3.8	4.3	6	3.3	2.7	1.6	
PCB 28	15	17	8.4	9.6	13	13	6.7	4.8	
PCB 44	15	13	14	10	17	9.1	7.6	4.4	
PCB 52	26	22	29	18	32	12	12	6.9	
PCB 66	30	28	43	24	40	20	16	9.6	
PCB 77	12	<0.13	12	8.3	12	7.3	6.1	3.8	
PCB 101	43	29	63	30	47	27	21	11	
PCB 105	25	13	38	23	38	23	12	11	
PCB 118	35	30	58	30	48	27	24	13	
PCB 126	<0.21	<0.21	<0.2	<0.31	<0.47	<0.98	<0.6	<0.46	
PCB 128	10	8.7	20	9.5	14	8.6	7.6	5.4	
PCB 138	52	90	76	44	63	42	34	22	
PCB 153	64	39	60	50	52	36	29	17	
PCB 170	24	25	26	23	28	24	18	10	
PCB 180	30	34	26	28	35	27	21	14	
PCB 187	32	18	22	23	23	18	13	9	
PCB 195	3.5	3.8	4.7	3.2	3.1	2.9	1.9	1.5	
PCB 206	4.3	3.5	1.7	2.8	3.2	2.1	2	2.1	
PCB 209	0.91	2.1	<0.07	<0.11	<0.16	<0.34	2.3	<0.16	
Total PCB (18 compounds)	421.3	390.2	496.3	335.6	466.8	295	230.8	143.3	180
Total Aroclor 1016	<11	<11	<11	<17	<26	<53	<33	<25	
Total Aroclor 1221	<11	<11	<11	<17	<26	<53	<33	<25	
Total Aroclor 1232	<11	<11	<11	<17	<26	<53	<33	<25	
Total Aroclor 1242	<11	<11	<11	<17	<26	<53	<33	<25	
Total Aroclor 1248	<11	<11	<11	<17	<26	<53	<33	<25	
Total Aroclor 1254	670	600	860	580	800	480	440	220	
Total Aroclor 1260	490	290	430	400	540	490	420	220	

Appendix B1
SURFACE SEDIMENT DATA - MISSION CREEK
October 1998

STATION	4N	4N	4S	5N	5S	6C	6N	6S	PARADISE	
Sample Date	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	ERM
Depth (ft)	0	0	0	0	0	0	0	0	0	
Replicate	2	3	1	1	1	1	1	1	1	
Toxicity (% Survival)			78.5	77			82		65	
Total Organic Carbon (%)	2.9	2.6	3.2	1.5	1.8	1.4	1.3	1.3	1.2	
Grain Size (%)										
Gravel	0	0	0	0	0	0	0	0	0	
Sand	4.7	7.6	8.1	1.8	2.2	5.3	9.4	6.3	9.7	
Silt	66.8	57.7	76	40.3	50	37.7	43.9	46.5	39.4	
Clay	28.5	34.7	15.9	57.9	47.8	57	46.7	47.2	50.9	
Fines (Silt+Clay)	95.3	92.4	91.9	98.2	97.8	94.7	90.6	93.7	90.3	
Metals (µg·g', dry weight)										
Aluminum	53199	49539	53402	46766	47249	44238	44614	41095	43953	
Arsenic	12.6	11.9	15.5	12.5	12.9	11.6	9.1	11.5	10.1	70
Cadmium	0.95	1.03	1.28	0.4	0.47	0.26	0.27	0.26	0.28	9.6
Chromium	117	114	124	107	109	107	100	98	103	370
Copper	104	107	117	69	83	48	47	49	48	270
Iron	43840	43288	45147	45144	45184	41219	38088	39720	37331	
Lead	134	153	182	43	55	22	19	22	26	218
Mercury	0.64	0.73	0.83	0.35	0.39	0.22	0.21	0.22	0.35	0.7
Nickel	96	100	98	97	101	92	84	85	82	51.6
Selenium	0.38	0.33	0.35	0.28	0.31	0.27	0.26	0.28	0.29	
Silver	1.4	1.8	3	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	3.7
Zinc	263	268	299	153	170	122	112	118	120	410
PAH (ng·g', dry weight)										
Naphthalene	80	76	120	36	37	29	28	31	21	
C1-Naphthalenes	71	78	130	29	30	24	21	21	11	
C2-Naphthalenes	120	120	180	50	50	41	40	42	20	
C3-Naphthalenes	140	94	180	52	56	40	40	46	19	
C4-Naphthalenes	170	130	220	58	82	33	32	42	15	
Acenaphthylene	140	160	120	43	50	35	50	47	19	
Acenaphthene	53	40	120	28	20	21	19	31	7	
Biphenyl	32	28	36	16	16	14	13	14	6.6	
Dibenzofuran	83	61	95	38	34	21	17	27	4.1	
Fluorene	190	130	160	54	43	42	46	52	10	
C1-Fluorenes	86	67	93	33	29	26	30	35	9.5	
C2-Fluorenes	110	88	110	42	73	28	34	34	13	
C3-Fluorenes	260	190	370	65	88	38	39	48	16	
Anthracene	1400	1000	800	290	230	130	170	220	37	
Phenanthrene	830	580	1000	210	190	160	240	230	83	
C1-Phenanthrenes/anthracenes	660	510	790	170	160	110	160	180	51	
C2-Phenanthrenes/anthracenes	520	440	750	130	140	77	90	120	36	
C3-Phenanthrenes/anthracenes	380	340	620	94	110	42	52	65	22	
C4-Phenanthrenes/anthracenes	1100	920	1300	240	290	90	110	140	60	
Dibenzothiophene	58	37	79	23	24	20	22	25	6.4	

Appendix B1
SURFACE SEDIMENT DATA - MISSION CREEK

October 1998

STATION	4N	4N	4S	5N	5S	6C	6N	6S	PARADISE	ERM
Sample Date	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	
Depth (ft)	0	0	0	0	0	0	0	0	0	
Replicate	2	3	1	1	1	1	1	1	1	
PAH (ng·g^{-1}, dry weight)										
C1-Dibenzothiophenes	40	32	69	15	16	12	16	18	5.4	
C2-Dibenzothiophenes	100	82	200	37	48	23	24	30	9.9	
C3-Dibenzothiophenes	150	120	270	36	52	19	20	25	8.3	
Fluoranthene	2500	1500	2900	610	760	430	450	560	200	
Pyrene	2400	2300	3300	550	790	390	470	530	260	
C1-Fluoranthenes/pyrenes	2800	2400	2700	520	550	220	280	350	91	
C2-Fluoranthenes/pyrenes	1400	1400	1400	260	280	91	110	130	51	
C3-Fluoranthenes/pyrenes	580	640	940	120	150	43	45	61	30	
Benzo[a]anthracene	1800	1400	2200	380	380	170	240	280	96	
Chrysene	3200	2500	2700	610	500	200	290	370	110	
C1-Chrysenes	1400	1300	1500	240	250	74	100	140	42	
C2-Chrysenes	760	770	1200	150	180	44	53	68	32	
C3-Chrysenes	410	450	800	94	130	32	38	56	28	
C4-Chrysenes	380	330	550	61	92	26	25	36	21	
Benzo[b]fluoranthene	3400	3500	3200	780	650	290	360	420	210	
Benzo[k]fluoranthene	1200	1200	1100	250	220	96	100	130	56	
Benzo[e]pyrene	1700	1800	1800	340	350	160	200	240	120	
Benzo[a]pyrene	2300	2500	2300	460	440	240	300	350	200	
Perylene	660	680	680	180	180	120	120	140	78	
Indeno[1,2,3,-c,d]pyrene	1300	1400	1400	280	280	170	200	230	170	
Dibenzo[a,h]anthracene	320	330	300	59	49	21	27	31	18	
Benzo[g,h,i]perylene	1200	1200	1100	260	280	170	200	230	190	
Total LMW PAH (7 compounds)	2764	2064	2450	690	600	441	574	632	188	3160
Total HMW PAH (6 compounds)	12520	10530	13700	2669	2919	1451	1777	2121	884	9600
Total PAH (13 compounds)	15284	12594	16150	3359	3519	1892	2351	2753	1072	44792
C10B-Phenyl decanes	210	150	220	45	90	28	20	18	26	
C11B-Phenyl undecanes	150	140	180	52	97	32	23	25	20	
C12B-Phenyl dodecanes	80	62	180	31	58	26	20	22	37	
C13B-Phenyl tridecanes	100	82	160	140	66	150	88	85	18	
C14B-Phenyl tetradecanes	<3.2	<3.1	<1.2	<0.31	<0.63	<0.35	<0.34	<0.29	<0.28	
TPH (µg·g^{-1}, dry weight)										
n-Nonane	<1.8	<2.1	<2	<0.21	<0.36	<0.2	<0.19	<0.2	<0.16	
n-Decane	<0.07	<0.08	0.08	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
n-Undecane	<0.21	<0.24	<0.23	<0.03	<0.04	<0.02	<0.02	<0.02	<0.02	
n-Dodecane	<0.21	<0.24	<0.23	<0.03	<0.04	<0.02	<0.02	<0.02	<0.02	
n-Tridecane	<0.28	<0.33	<0.31	<0.03	<0.06	<0.03	<0.03	<0.03	<0.03	
Isoprenoid RRT 1380	<0.34	<0.4	<0.38	0.04	<0.07	<0.04	<0.04	<0.04	<0.03	
n-Tetradecane	<0.44	<0.51	<0.49	<0.05	<0.09	<0.05	<0.05	<0.05	<0.04	
Isoprenoid RRT 1470	0.13	0.1	0.16	0.05	0.08	0.02	0.02	0.02	0.01	
n-Pentadecane	<0.18	<0.21	<0.2	0.04	0.05	0.03	0.03	0.03	<0.02	
n-Hexadecane	0.1	<0.11	0.14	0.05	0.06	0.04	0.04	0.03	0.01	
Isoprenoid RRT 1650	<0.21	<0.25	<0.24	0.04	0.05	0.03	0.03	0.03	<0.02	
n-Heptadecane	0.22	0.23	0.21	0.1	0.12	0.04	0.04	0.07	0.02	

Appendix B1
SURFACE SEDIMENT DATA - MISSION CREEK

October 1998

STATION	4N	4N	4S	5N	5S	6C	6N	6S	PARADISE	ERM
Sample Date	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	
Depth (ft)	0	0	0	0	0	0	0	0	0	
Replicate	2	3	1	1	1	1	1	1	1	
TPH (µg·g^{-1}, dry weight)										
Pristane	<0.27	<0.32	<0.3	0.16	0.16	0.14	0.11	0.12	0.03	
n-Octadecane	<0.25	<0.29	<0.28	0.06	0.08	0.05	0.04	0.06	<0.02	
Phytane	0.21	0.19	0.32	0.16	0.18	0.11	0.11	0.1	0.04	
n-Nonadecane	<0.12	<0.14	<0.13	0.05	0.08	0.05	0.04	0.04	0.02	
n-Eicosane	0.2	0.19	<0.09	0.08	0.1	0.06	0.06	0.06	0.01	
n-Heneicosane	<0.18	<0.21	0.46	0.1	0.37	0.07	0.05	0.06	0.03	
n-Docosane	0.46	0.41	0.22	0.07	0.09	0.04	0.04	0.05	0.09	
n-Tricosane	0.53	0.62	0.46	0.16	0.18	0.09	0.09	0.1	0.09	
n-Tetracosane	<0.07	<0.08	<0.08	<0.01	0.07	0.04	0.03	0.03	0.1	
n-Pentacosane	0.46	0.48	<0.24	0.16	0.22	0.11	0.11	0.12	0.08	
n-Hexacosane	<0.11	<0.13	<0.13	0.12	0.15	0.07	0.08	0.07	0.04	
n-Heptacosane	0.42	0.57	0.6	0.35	0.56	0.23	0.25	0.26	0.16	
n-Octacosane	<0.13	2.6	2.9	0.67	0.83	0.35	0.39	0.46	<0.01	
n-Nonacosane	1.4	1.3	1.9	0.74	1.5	0.48	0.45	0.47	0.37	
n-Triacontane	<0.29	0.43	<0.32	0.2	0.3	0.1	0.09	0.1	0.08	
n-Hentriacontane	1.3	1.6	3.2	0.98	1.6	0.48	0.51	0.49	0.43	
n-Dotriacontane	0.45	0.48	<0.12	0.18	<0.02	0.14	0.13	0.14	0.09	
n-Tritriacontane	1.9	1.9	0.58	0.38	0.48	0.22	0.23	0.26	0.16	
n-Tetratriacontane	0.58	0.61	<0.14	0.09	<0.03	<0.01	<0.01	<0.01	0.05	
n-Pentatriacontane	<0.11	0.98	0.6	0.15	0.24	0.07	0.07	<0.01	<0.01	
n-Hexatriacontane	0.51	0.58	0.56	0.14	0.22	0.06	0.05	0.06	0.04	
n-Heptatriacontane	0.34	0.38	0.4	0.1	0.16	0.05	0.05	0.05	0.03	
n-Octatriacontane	0.35	0.33	0.3	<0.01	0.14	<0.01	<0.01	0.04	0.07	
n-Nonatriacontane	0.24	0.24	0.35	<0.01	0.16	0.07	0.05	0.09	<0.01	
n-Tetracontane	0.24	0.2	0.22	0.05	0.09	0.02	0.02	0.03	0.02	
Total Resolved Hydrocarbons	120	130	170	40	56	23	27	25	15	
Total Petroleum Hydrocarbons	1400	1700	2000	350	580	140	130	150	120	
TPH >C8-C10	4.4	6.7	3.6	1.6	3	1.1	6	1.5	1.4	
TPH >C10-C12	6.7	8.5	6.8	1.3	2.5	0.8	0.77	0.85	0.68	
TPH >C12-C16	31	40	48	8	13	3.7	3.7	3.9	2.6	
TPH >C16-C21	120	140	190	38	52	18	18	20	16	
TPH >C21-C25	240	280	340	60	98	22	21	24	21	
TPH >C25-C30	420	490	590	100	170	34	33	37	34	
TPH >C30-C35	320	380	450	84	140	33	30	35	28	
TPH >C35 +	270	330	330	60	100	24	22	26	21	
Pesticides & PCB (ng·g dry weight)										
Aldrin	<0.3	<0.35	<0.27	<0.24	<0.49	<0.23	<0.22	<0.23	<0.21	
alpha-Chlordane	7.5	12	14	1.6	2.6	0.48	0.52	0.58	<0.2	
gamma-Chlordane	6.3	9.9	13	1.1	1.8	<0.21	<0.2	0.22	<0.2	
cis-Nonachlor	2.3	3.2	3.5	0.59	0.92	0.25	0.28	0.35	0.3	
trans-Nonachlor	3.2	5.6	7.2	0.86	1.3	<0.16	0.21	<0.16	<0.15	
Heptachlor	<0.28	<0.33	<0.25	<0.22	<0.46	<0.21	<0.2	<0.21	<0.2	
Heptachlor Epoxide	<0.28	<0.33	<0.25	<0.22	<0.46	<0.21	<0.2	<0.21	<0.2	

Appendix B1
SURFACE SEDIMENT DATA - MISSION CREEK

October 1998

STATION	4N	4N	4S	5N	5S	6C	6N	6S	PARADISE	
Sample Date	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	10/20/98	ERM
Depth (ft)	0	0	0	0	0	0	0	0	0	
Replicate	2	3	1	1	1	1	1	1	1	
Pesticides & PCB (ng/g dry weight)										
Total Chlordane (4 compounds)	19.3	30.7	37.3	4.15	6.63	0.73	1.01	1.15	0.3	
2,4'-DDT	<0.47	<0.55	<0.42	<0.37	<0.76	<0.35	<0.34	<0.35	<0.33	
4,4'-DDT	3.1	5.6	2.2	1	2.3	<0.5	0.82	0.75	<0.47	
2,4'-DDE	<0.47	<0.55	<0.42	<0.37	<0.76	<0.35	<0.34	<0.35	<0.33	
4,4'-DDE	7.3	8.6	11	5	5.8	3.7	3.9	3.5	2.2	
2,4'-DDD	2.9	3.9	5.2	1.4	1.8	0.65	0.8	0.84	0.9	
4,4'-DDD	16	23	33	5.6	7.7	2.8	3	4.8	4.2	
Total DDT (6 compounds)	29.3	41.1	51.4	13	17.6	7.15	8.52	9.89	7.3	100
Dieldrin	11	17	18	3.1	4.7	1.2	1.3	1.6	1.7	8
Endrin	<0.28	<0.33	<0.25	<0.22	<0.46	<0.21	<0.2	<0.21	<0.2	45
alpha-hexachlorocyclohexan										
beta-hexachlorocyclohexan										
delta-hexachlorocyclohexan										
Lindane	<0.21	<0.24	<0.18	<0.16	<0.34	<0.16	<0.15	<0.16	<0.15	0.99
Mirex	<0.14	<0.16	<0.13	<0.11	<0.23	<0.11	<0.1	<0.11	<0.1	
PCB 8	<0.2	2.1	2	<0.16	<0.32	<0.15	<0.14	<0.15	0.22	
PCB 18	1.3	2.8	2.2	<0.32	<0.67	<0.31	<0.3	<0.31	<0.29	
PCB 28	4	5.9	6	1.7	1.8	1.1	1	1.2	0.39	
PCB 44	3.6	5.3	4.7	0.63	1.1	0.24	0.23	0.3	0.38	
PCB 52	5	9.5	8.6	1.2	2	0.59	0.59	0.66	0.83	
PCB 66	8	13	13	<0.12	<0.24	0.95	1	1.2	1.5	
PCB 77	3.1	5.7	<0.2	<0.18	<0.36	<0.17	<0.16	<0.17	<0.16	
PCB 101	9.2	16	15	3	4.3	0.96	1	2.2	1.7	
PCB 105	8.4	13	14	1.4	2.4	0.59	0.75	0.89	0.69	
PCB 118	10	16	15	3.6	5.2	1.4	1.6	1.7	1.9	
PCB 126	<0.35	<0.41	<0.31	<0.27	<0.56	<0.26	<0.25	<0.26	<0.25	
PCB 128	4.5	6	6.6	1.4	2.2	<0.11	0.52	<0.11	<0.11	
PCB 138	18	24	30	5.7	7.8	1.9	1.9	2.4	2.8	
PCB 153	14	20	25	4.7	6.4	1.7	1.7	2.2	2.6	
PCB 170	9.4	13	17	3.1	3	1.2	0.97	1.4	0.78	
PCB 180	13	18	25	3.8	4.2	1	1	1.5	1.6	
PCB 187	7.8	10	13	2.5	3.3	0.82	0.9	1.2	1.3	
PCB 195	1.2	2	3.1	0.5	0.72	0.16	0.2	0.24	0.24	
PCB 206	1.9	1.8	2.1	0.54	0.68	0.26	0.35	0.34	0.28	
PCB 209	<0.12	<0.14	<0.11	0.29	0.55	0.15	0.26	0.19	0.28	
Total PCB (18 compounds)	119.3	178.4	202.3	34.06	45.65	13.02	13.97	17.62	17.49	180
Total Aroclor 1016	<19	<22	<17	<15	<30	<14	<14	<14	<13	
Total Aroclor 1221	<19	<22	<17	<15	<30	<14	<14	<14	<13	
Total Aroclor 1232	<19	<22	<17	<15	<30	<14	<14	<14	<13	
Total Aroclor 1242	<19	<22	<17	<15	<30	<14	<14	<14	<13	
Total Aroclor 1248	<19	<22	<17	<15	<30	<14	<14	<14	<13	
Total Aroclor 1254	170	300	350	35	68	14	18	18	23	
Total Aroclor 1260	240	270	710	63	63	24	32	38	23	

Appendix B1
SURFACE SEDIMENT DATA - MISSION CREEK
October 1999

STATION	1N	1S	2N	2S	3N	3S	4N	ERM
Sample Date	10/13/99	10/13/99	10/13/99	10/13/99	10/13/99	10/13/99	10/13/99	
Depth (ft)	0	0	0	0	0	0	0	
Replicate	1	1	1	1	1	1	1	
Toxicity (% Survival)	90	87	70	82	82	80	81	
Total Organic Carbon (%)	1.5	1.8	3.2	0.8	2.9	1.7	1.4	
Grain Size (%)								
Gravel								
Sand	52.5	36.4	7.9	53.6	5.3	1	2.4	
Silt								
Clay								
Fines (Silt+Clay)	47.5	63.6	92.1	46.4	94.7	99	97.6	
Metals (µg·g⁻¹, dry weight)								
Aluminum	17353	24340	20055	16496	48705	49662	51606	
Arsenic	7.39	9.6	7.24	5.5	12.64	11.75	17.72	70
Cadmium	1.83	2.51	2.94	1.45	1.98	1.84	1.13	9.6
Chromium	101.8	106.1	97.9	89.4	122.2	116.1	116	370
Copper	131	115.7	158	89.6	150.3	142.6	133.7	270
Iron	26605	28749	25019	20121	39879	41865	42595	
Lead	429.8	378.9	858.3	273.8	223.2	215.3	133.9	218
Mercury	0.868	0.985	5.37	0.718	0.953	0.861	0.833	0.7
Nickel	86.5	83.2	69.5	50.6	93.5	96.5	91.7	51.6
Selenium	0.35	0.46	0.39	0.32	0.88	0.73	0.51	
Silver	2.88	4.46	6.29	2.6	3.23	2.98	1.44	3.7
Zinc	381.2	447	678.6	318.7	386	388.8	260.9	410
PAH (ng·g⁻¹, dry weight)								
Naphthalene	320	91	220	37	81	64	100	
C1-Naphthalenes	440	130	410	46	68	59	66	
C2-Naphthalenes	700	260	820	77	140	120	290	
C3-Naphthalenes	660	260	860	66	180	150	2500	
C4-Naphthalenes	430	260	1100	69	190	180	4600	
Acenaphthylene	42	38	55	16	57	40	73	
Acenaphthene	1200	110	130	34	71	60	140	
Biphenyl	110	32	58	17	26	26	28	
Fluorene	990	120	180	42	110	94	280	
C1-Fluorenes	290	69	280	22	66	51	960	
C2-Fluorenes	290	200	1100	66	190	150	1800	
C3-Fluorenes	890	510	1600	170	310	280	1400	
Anthracene	1000	260	420	110	500	320	710	
Phenanthrene	7500	1100	1000	370	570	480	1200	
C1-Phenanthrenes/anthracenes	2000	470	790	160	440	330	1500	
C2-Phenanthrenes/anthracenes	1000	550	1800	190	590	430	1200	
C3-Phenanthrenes/anthracenes	710	760	2100	230	550	500	600	
C4-Phenanthrenes/anthracenes	970	750	1800	200	570	490	470	
Dibenzothiophene	410	79	130	31	76	63	340	
C1-Dibenzothiophenes	190	72	270	27	82	61	1100	
C2-Dibenzothiophenes	240	240	890	84	200	180	1200	
C3-Dibenzothiophenes	340	400	1000	140	280	290	650	

Appendix B1
SURFACE SEDIMENT DATA - MISSION CREEK

October 1999

STATION	1N	1S	2N	2S	3N	3S	4N	ERM
Sample Date	10/13/99	10/13/99	10/13/99	10/13/99	10/13/99	10/13/99	10/13/99	
Depth (ft)	0	0	0	0	0	0	0	
Replicate	1	1	1	1	1	1	1	
PAH (ng·g^{-1}, dry weight)								
Fluoranthene	7200	2300	3200	920	2600	1900	2700	
Pyrene	7600	2300	3200	890	2200	1700	3100	
C1-Fluoranthenes/pyrenes	2500	1200	2200	500	1700	1200	2700	
C2-Fluoranthenes/pyrenes	2200	1100	2200	420	1100	870	1400	
C3-Fluoranthenes/pyrenes	1300	810	1500	260	660	590	630	
Benzo[a]anthracene	2400	850	1400	410	1100	750	1600	
Chrysene	2900	1100	1600	460	1300	900	2400	
C1-Chrysenes	1700	740	1500	290	850	620	1100	
C2-Chrysenes	1400	780	1900	320	720	610	630	
C3-Chrysenes	1100	760	1400	260	530	560	380	
C4-Chrysenes	810	500	1100	170	360	360	250	
Benzo[b]fluoranthene	3200	1400	2000	570	1600	1200	3400	
Benzo[k]fluoranthene	1100	320	460	180	500	370	1000	
Benzo[e]pyrene	1600	730	1100	330	890	660	1700	
Benzo[a]pyrene	2500	850	1200	390	1000	760	2200	
Perylene	620	280	390	120	330	260	640	
Indeno[1,2,3,-c,d]pyrene	1400	640	920	290	670	540	1300	
Dibenzo[a,h]anthracene	360	150	240	70	160	130	340	
Benzo[g,h,i]perylene	1300	670	1000	300	700	610	1200	
Total LMW PAH (7 compounds)	11492	1849	2415	655	1457	1117	2569	3160
Total HMW PAH (6 compounds)	22960	7550	10840	3140	8360	6140	12340	9600
Total PAH (13 compounds)	34452	9399	13255	3795	9817	7257	14909	44792
Pesticides & PCB (ng·g dry weight)								
Aldrin	<0.44	<0.77	<0.65	<0.48	<0.85	<0.84	<1.7	
alpha-Chlordane	33	28	110	12	15	12	6.6	
gamma-Chlordane	40	40	160	15	18	15	7.8	
cis-Nonachlor	9.8	11	36	4.6	8.2	4.7	3.1	
trans-Nonachlor	18	20	76	7.9	9.4	8	4.2	
Heptachlor	<0.41	<0.73	<0.61	<0.45	<0.8	0.17	<1.6	
Heptachlor Epoxide	<0.41	<0.73	<0.61	<0.45	<0.8	<0.78	<1.6	
Total Chlordane (4 compounds)	100.8	99	382	39.5	50.6	39.7	21.7	
2,4'-DDT	<0.68	3.7	<1	<0.75	<1.3	<1.3	<2.6	
4,4'-DDT	7.3	17	6	3	7.4	20	3.9	
2,4'-DDE	<0.68	<1.2	<1	<0.75	<1.3	<1.3	<2.6	
4,4'-DDE	5	15	53	7	13	13	8.4	
2,4'-DDD	23	21	38	6.8	11	9	9.9	
4,4'-DDD	74	62	130	26	37	30	18	
Total DDT (6 compounds)	109.3	118.7	227	42.8	68.4	72	40.2	100
Dieldrin	17	<0.73	38	<0.45	<0.8	6	4.3	8
Endrin	<0.41	<0.73	<0.61	<0.45	<0.8	<0.78	<1.6	45
alpha-hexachlorocyclohexan	0.19	0.09	0.5	0.05	0.14	0.09	0.11	
beta-hexachlorocyclohexan	<0.18	<0.31	<0.26	<0.2	<0.35	<0.34	<0.68	
delta-hexachlorocyclohexan	<0.28	<0.51	<0.43	<0.32	<0.56	<0.55	<1.1	

Appendix B1
SURFACE SEDIMENT DATA - MISSION CREEK

October 1999

STATION	1N	1S	2N	2S	3N	3S	4N	ERM
Sample Date	10/13/99	10/13/99	10/13/99	10/13/99	10/13/99	10/13/99	10/13/99	
Depth (ft)	0	0	0	0	0	0	0	
Replicate	1	1	1	1	1	1	1	
Pesticides & PCB (ng/g dry weight)								
Lindane	0.12	0.56	<0.45	<0.33	0.35	0.33	0.31	0.99
Mirex	<0.2	<0.36	<0.3	<0.22	<0.4	<0.39	<0.78	
PCB 8	7.2	4.8	18	2.2	3.1	2.8	4.3	
PCB 18	7.5	5.7	15	1.5	2.3	1.6	1.2	
PCB 28	8.2	7.5	24	2.6	3.6	3	2.2	
PCB 44	16	20	42	7.5	9.4	6.1	5.2	
PCB 52	20	35	40	12	13	8.3	6.1	
PCB 66	34	55	69	20	23	19	14	
PCB 77	33	28	71	11	22	10	9.2	
PCB 101	38	64	80	22	49	22	15	
PCB 105	10	10	30	6.9	23	7.9	4.2	
PCB 118	31	52	69	19	57	20	14	
PCB 126	15	<0.9	<0.75	<0.56	<0.98	<0.97	<1.9	
PCB 128	13	17	25	6.9	25	9.4	8.1	
PCB 138	47	70	110	26	85	32	25	
PCB 153	82	130	160	33	90	38	32	
PCB 170	20	19	48	8.1	21	9.7	9	
PCB 180	34	42	81	17	47	21	18	
PCB 187	22	34	45	10	21	12	12	
PCB 195	4	3.6	6.7	1.2	2.8	1.8	2.1	
PCB 206	2.2	3.3	6.3	1	2.2	1.7	1.1	
PCB 209	4.5	0.42	0.87	0.48	1.6	1.3	1.3	
Total PCB (18 compounds)	400.6	573.32	869.87	197.38	479	217.6	174.8	180

Appendix B1
SURFACE SEDIMENT DATA - MISSION CREEK

October 1999

STATION	4S	Island 1	Marconi Cove	North Site	Paradise	South Site	Tubbs Island	
Sample Date	10/13/99	10/18/99	10/15/99	10/19/99	10/18/99	10/19/99	10/18/99	ERM
Depth (ft)	0	0	0	0	0	0	0	
Replicate	1	1	1	1	1	1	1	
Toxicity (% Survival)	80	59	83	83	94	99	70	
Total Organic Carbon (%)	1.4	1.0	1.8	0.4	1.0	0.5	1.0	
Grain Size (%)								
Gravel								
Sand	2.9	0.8	0.3	69.3	4.5	36	3.5	
Silt								
Clay								
Fines (Silt+Clay)	97.1	99.2	99.7	30.7	95.5	64	96.5	
Metals (µg·g', dry weight)								
Aluminum	39374	52418	46020	23753	37480	30128	40110	
Arsenic	14.12	8.8	9.66	2.49	8.27	3.56	0.93	70
Cadmium	1.39	0.37	0.29	0.17	0.27	0.23	0.27	9.6
Chromium	104.6	106.7	149.1	83.2	94.1	82.2	94.2	370
Copper	118.7	50.9	41.6	13.7	42.6	20.3	50.8	270
Iron	40806	40682	46162	23642	35596	25826	38562	
Lead	153.2	18.7	13.3	13.3	22.3	13.1	22.6	218
Mercury	0.723	0.234	0.175	0.086	0.225	0.159	0.24	0.7
Nickel	86.6	88.4	159.3	72	75.9	67.3	86	51.6
Selenium	0.52	0.13	0.33	<0.09	0.17	<0.09	0.22	
Silver	1.91	0.64	0.49	<0.45	0.67	0.47	0.55	3.7
Zinc	268.6	120	103.2	73.1	109.5	74.4	116.3	410
PAH (ng·g', dry weight)								
Naphthalene	110	10	11	4.7	16	7.3	13	
C1-Naphthalenes	72	8.2	29	3.6	11	5.6	8.9	
C2-Naphthalenes	120	14	48	6.8	16	11	18	
C3-Naphthalenes	110	14	36	<2	14	9	16	
C4-Naphthalenes	110	<2.7	18	<2	14	<2.2	<2.9	
Acenaphthylene	67	6.1	1	2.2	8.9	7.6	8.3	
Acenaphthene	64	3.7	1.2	2.5	6.4	3.9	5.6	
Biphenyl	25	4.1	13	1.4	5.5	3	4.6	
Fluorene	94	5.8	7.3	3.6	8.1	8.5	7.7	
C1-Fluorenes	55	5.4	12	2.8	7.1	5.1	6.8	
C2-Fluorenes	99	9.9	26	<0.83	9.5	<0.89	12	
C3-Fluorenes	220	<1.1	18	<0.83	13	<0.89	<1.2	
Anthracene	430	13	4.6	5.1	21	13	17	
Phenanthrene	730	40	43	21	75	68	63	
C1-Phenanthrenes/anthracenes	470	29	51	13	40	36	45	
C2-Phenanthrenes/anthracenes	440	22	39	7.7	29	18	36	
C3-Phenanthrenes/anthracenes	290	17	18	4.3	19	8.5	25	
C4-Phenanthrenes/anthracenes	630	29	11	5.6	21	17	37	
Dibenzothiophene	55	3.8	2.5	1.6	5.6	4.7	5.4	
C1-Dibenzothiophenes	59	4.6	3.3	1.8	5.5	4.5	7.5	
C2-Dibenzothiophenes	120	7.2	4.2	<0.45	8.8	5.4	11	
C3-Dibenzothiophenes	180	7.9	3.3	<0.45	9	4.6	12	

Appendix B1
SURFACE SEDIMENT DATA - MISSION CREEK

October 1999

STATION	4S	Island 1	Marconi Cove	North Site	Paradise	South Site	Tubbs Island	ERM
Sample Date	10/13/99	10/18/99	10/15/99	10/19/99	10/18/99	10/19/99	10/18/99	
Depth (ft)	0	0	0	0	0	0	0	
Replicate	1	1	1	1	1	1	1	
PAH (ng·g', dry weight)								
Fluoranthene	2200	110	20	41	210	120	170	
Pyrene	3200	150	22	53	270	160	240	
C1-Fluoranthenes/pyrenes	2400	54	23	18	87	54	87	
C2-Fluoranthenes/pyrenes	1600	32	23	8.5	39	22	46	
C3-Fluoranthenes/pyrenes	920	21	14	3.1	26	10	27	
Benzo[a]anthracene	1600	48	9.8	18	95	54	70	
Chrysene	2100	56	19	19	110	57	80	
C1-Chrysenes	1300	24	12	6.1	32	19	35	
C2-Chrysenes	1100	18	10	2.9	24	9	26	
C3-Chrysenes	800	12	7.1	<0.64	19	6.7	18	
C4-Chrysenes	400	9.5	4.8	<0.64	15	4.6	14	
Benzo[b]fluoranthene	3000	95	20	33	180	84	140	
Benzo[k]fluoranthene	1100	28	5.6	8.5	62	20	37	
Benzo[e]pyrene	1600	62	14	20	110	49	93	
Benzo[a]pyrene	2200	85	8.6	29	170	73	130	
Perylene	640	50	8.7	10	70	25	66	
Indeno[1,2,3,-c,d]pyrene	1300	78	9	22	140	53	120	
Dibenzo[a,h]anthracene	320	8.4	2	2.5	14	6.5	14	
Benzo[g,h,i]perylene	1200	85	11	26	140	60	130	
Total LMW PAH (7 compounds)	1567	86.8	97.1	42.7	146.4	113.9	123.5	3160
Total HMW PAH (6 compounds)	11620	457.4	81.4	162.5	869	470.5	704	9600
Total PAH (13 compounds)	13187	544.2	178.5	205.2	1015.4	584.4	827.5	44792
Pesticides & PCB (ng·g dry weight)								
Aldrin	<0.83	<0.4	<0.78	<0.29	<0.71	<0.32	<0.42	
alpha-Chlordane	10	0.12	<0.73	0.03	0.22	0.1	0.18	
gamma-Chlordane	15	<0.37	<0.73	<0.28	<0.66	<0.3	<0.39	
cis-Nonachlor	4.8	0.12	0.14	0.03	0.25	0.08	0.16	
trans-Nonachlor	6.3	0.07	<0.54	0.01	0.09	0.06	0.1	
Heptachlor	0.14	<0.37	<0.73	<0.28	0.07	0.01	<0.39	
Heptachlor Epoxide	<0.78	<0.37	<0.73	<0.28	<0.66	<0.3	<0.39	
Total Chlordane (4 compounds)	36.1	0.31	0.14	0.07	0.56	0.24	0.44	
2,4'-DDT	<1.3	<0.62	<1.2	<0.46	<1.1	<0.5	<0.66	
4,4'-DDT	1.8	0.27	0.21	<0.64	0.54	0.12	0.17	
2,4'-DDE	<1.3	<0.62	<1.2	<0.46	<1.1	<0.5	<0.66	
4,4'-DDE	12	2	0.56	0.28	2	0.68	2.3	
2,4'-DDD	9.8	0.6	<0.73	<0.28	0.95	0.27	0.81	
4,4'-DDD	32	2.3	0.25	<0.64	3.2	0.76	2.4	
Total DDT (6 compounds)	55.6	5.17	1.02	0.28	6.69	1.83	5.68	100
Dieldrin	5.2	<0.37	<0.73	<0.28	2.4	<0.3	<0.39	8
Endrin	<0.78	<0.37	<0.73	<0.28	<0.66	<0.3	<0.39	45
alpha-hexachlorocyclohexan	0.1	<0.32	0.04	<0.24	<0.58	<0.26	<0.34	
beta-hexachlorocyclohexan	<0.34	<0.16	<0.32	<0.12	<0.29	<0.13	<0.17	
delta-hexachlorocyclohexan	<0.54	<0.26	<0.51	<0.19	<0.47	<0.21	<0.28	

Appendix B1
SURFACE SEDIMENT DATA - MISSION CREEK

April 2000

STATION	1N	1S	2N	2S	3N	3S	4N	4S	Island 1	North Site	Paradise	South Site	Tubbs	ERM
Sample Date	4/18/00	4/18/00	4/18/00	4/18/00	4/18/00	4/18/00	4/18/00	4/18/00	4/20/00	4/21/00	4/20/00	4/21/00	4/20/00	
Depth (ft)	0	0	0	0	0	0	0	0	0	0	0	0	0	
Replicate	1	1	1	1	1	1	1	1	1	1	1	1	1	
Toxicity (% Survival)	82	61	87	87	62	65	77	59	68	89	65	80	59	
Total Organic Carbon (%)	1.353	1.789	2.622	2.108	1.936	1.834	1.374	1.548	0.905	0.477	1.161	0.708	1.21	
Grain Size (%)														
Gravel														
Sand	71.2	54.1	61.2	64	21.1	10.8	3.2	6	2.1	73.7	3.5	41.5	5.2	
Silt														
Clay														
Fines (Silt+Clay)	28.8	45.9	38.8	36	78.9	89.2	96.8	94	97.9	26.3	96.5	58.5	94.8	
Metals (µg·g, dry weight)														
Aluminum	16292	19268	18549	18263	36878	45101	46659	46647	41994	28947	39697	19737	43335	
Arsenic	9.04	12	7.16	8.18	11	10	11	13	6.31	6.06	12	5.6	10	70
Cadmium	1.43	1.5	1.75	1.31	1.29	1.25	0.63	0.8	0.35	0.35	0.34	0.55	0.37	9.6
Chromium	86	91	91	98	100	115	113	113	94	81	99	70	100	370
Copper	95.1	109.4	144.2	127.7	121	129.7	113.7	139.7	45.1	28.2	47.6	16.3	52.1	270
Iron	25851	30400	25004	24230	38759	46925	46075	45366	40694	33263	42708	26814	44022	
Lead	418.4	334.8	478.9	377	149.4	144	90.1	106.2	17.9	15.4	21.3	11.8	20.1	218
Mercury	1.65	1.5	2.96	3.19	1.41	0.84	0.55	0.68	0.3	0.27	0.27	0.11	0.31	0.7
Nickel	60.1	74.2	63.6	60	82	97	93	91.2	84	73.9	85.9	75	90.3	51.6
Selenium	0.14	0.1	0.27	0.2	0.37	0.69	0.48	0.43	0.27	0.35	0.42	0.39	0.3	
Silver	3.72	2.82	5.79	4.32	2.61	1.94	0.87	1.07	<0.5	<0.5	<0.5	<0.5	<0.5	3.7
Zinc	382	445	485	369	288	293	210	236	112	91	118	76	125	410
PAH (ng·g^{-1}, dry weight)														
Naphthalene	240	190	140	110	64	64	68	85	12	5.2	18	13	13	
C1-Naphthalenes	320	210	200	120	72	49	41	61	6.1	3.3	9.2	6.3	6.9	
C2-Naphthalenes	540	500	340	190	120	96	75	100	11	5.4	15	12	12	
C3-Naphthalenes	430	840	280	190	130	110	80	110	12	4.3	14	12	11	
C4-Naphthalenes	310	1000	280	140	120	120	68	100	9.7	2.7	11	9.2	8.4	
Acenaphthylene	40	51	50	33	46	44	54	68	8.1	2.9	10	11	9	
Acenaphthene	930	350	120	130	100	47	36	96	3.7	1.5	5.8	7.5	4.5	
Biphenyl	86	53	67	32	32	23	20	27	3.6	1.7	6.2	3.6	4	
Fluorene	790	300	310	190	130	78	74	150	6.7	3.2	9.6	10	7.9	
C1-Fluorenes	240	210	120	80	58	58	44	80	5.7	3.6	7.6	10	6.5	
C2-Fluorenes	290	450	280	100	96	99	52	100	8.7	6.4	11	12	8.9	
C3-Fluorenes	1100	880	580	300	220	230	130	380	15	6.8	15	17	12	
Anthracene	1200	520	930	400	350	340	430	730	18	6.4	25	31	20	
Phenanthrene	6900	1900	1300	1100	570	440	390	1600	56	24	73	100	71	
C1-Phenanthrenes/anthracen	1100	950	610	500	380	400	330	740	35	16	42	59	42	
C2-Phenanthrenes/anthracen	690	1100	720	420	390	420	280	640	27	12	32	38	30	
C3-Phenanthrenes/anthracen	450	1400	1000	460	410	360	240	480	19	6.6	22	24	16	
C4-Phenanthrenes/anthracen	650	1400	1100	680	670	620	560	1200	32	9	38	43	29	
Dibenzothiophene	210	170	100	78	64	47	32	100	4.3	1.8	6	6.8	5.3	
C1-Dibenzothiophenes	130	200	120	69	59	53	38	90	4.7	2	6.1	7.2	5.7	
C2-Dibenzothiophenes	160	480	340	160	140	130	71	160	7.1	3	8.6	9.9	8.2	
C3-Dibenzothiophenes	340	640	530	260	240	220	110	220	7.2	2.9	11	14	8.7	
Fluoranthene	7000	3400	2200	1900	1400	1600	1000	3500	150	50	190	210	160	
Pyrene	7000	3300	2100	1800	1300	1500	1400	3800	200	67	250	270	210	

Appendix B1
SURFACE SEDIMENT DATA - MISSION CREEK

April 2000

STATION	1N	1S	2N	2S	3N	3S	4N	4S	Island 1	North Site	Paradise	South Site	Tubbs	
Sample Date	4/18/00	4/18/00	4/18/00	4/18/00	4/18/00	4/18/00	4/18/00	4/18/00	4/20/00	4/21/00	4/20/00	4/21/00	4/20/00	ERM
Depth (ft)	0	0	0	0	0	0	0	0	0	0	0	0	0	
Replicate	1	1	1	1	1	1	1	1	1	1	1	1	1	
PAH (ng·g^{-1}, dry weight)														
C1-Fluoranthenes/pyrenes	1500	1800	1400	1100	1100	1300	1400	2700	71	23	83	110	73	
C2-Fluoranthenes/pyrenes	1500	1500	1300	850	890	890	890	1700	37	13	44	54	35	
C3-Fluoranthenes/pyrenes	870	1100	1000	620	550	590	470	890	22	6.8	28	26	18	
Benzo[a]anthracene	2800	1200	910	800	630	710	840	2300	64	21	76	94	65	
Chrysene	3400	1400	1000	900	800	830	1300	2600	79	24	88	130	75	
C1-Chrysenes	1400	950	870	560	520	510	680	1500	27	9.2	33	45	28	
C2-Chrysenes	1000	1200	1100	670	560	580	570	1500	20	6.2	23	31	18	
C3-Chrysenes	640	970	920	500	430	450	360	940	17	4.6	19	21	14	
C4-Chrysenes	390	720	780	460	370	330	270	680	11	2.7	12	13	8.5	
Benzo[b]fluoranthene	3700	1700	1400	1200	1100	1300	1900	3000	120	43	170	170	120	
Benzo[k]fluoranthene	1200	520	470	380	340	310	620	1100	36	13	44	40	34	
Benzo[e]pyrene	1900	880	810	650	600	630	940	2000	82	27	100	100	81	
Benzo[a]pyrene	2900	1200	980	820	700	760	1200	2100	120	38	160	150	120	
Perylene	740	380	300	260	240	280	410	860	72	16	76	53	61	
Indeno[1,2,3,-c,d]pyrene	1600	940	840	680	560	550	860	1800	100	33	130	120	93	
Dibenzo[a,h]anthracene	290	220	200	150	120	130	220	450	10	3.3	14	14	9.9	
Benzo[g,h,i]perylene	1600	860	840	640	550	550	770	1600	120	37	150	130	110	
Total LMW PAH (7 compou	10420	3521	3050	2083	1332	1062	1093	2790	110.6	46.5	150.6	178.8	132.3	3160
Total HMW PAH (6 compou	23390	10720	7390	6370	4950	5530	5960	14750	623	203.3	778	868	639.9	9600
Total PAH (13 compounds)	33810	14241	10440	8453	6282	6592	7053	17540	733.6	249.8	928.6	1047	772.2	44792
Pesticides & PCB (ng·g dry weight)														
Aldrin	<0.3	<0.4	<0.4	<0.4	<0.5	<0.6	<0.5	<0.5	<0.4	<0.3	<0.5	<0.4	<0.4	
alpha-Chlordane	26	14	41	15	10	6.8	3.2	6	<0.4	<0.3	<0.4	<0.3	<0.4	
gamma-Chlordane	58	26	58	24	16	8.2	8.6	18	<0.4	<0.3	<0.4	<0.3	<0.4	
cis-Nonachlor	6.8	6.5	14	5.8	4.2	2.8	1.7	2.8	<0.3	<0.3	<0.4	<0.3	<0.4	
trans-Nonachlor	14	8	26	8.8	6.3	3.9	2	3.2	<0.3	<0.2	<0.3	<0.3	<0.3	
Heptachlor	<0.3	<0.4	<0.4	<0.3	<0.5	<0.5	<0.5	<0.5	<0.4	<0.3	<0.4	<0.3	<0.4	
Heptachlor Epoxide	<0.3	<0.4	<0.4	<0.3	<0.5	<0.5	<0.5	<0.5	<0.4	<0.3	<0.4	<0.3	<0.4	
Total Chlordane (4 compo	104.8	54.5	139	53.6	36.5	21.7	15.5	30	<0.4	<0.3	<0.4	<0.3	<0.4	
2,4'-DDT	<0.5	<0.6	<0.6	<0.6	<0.8	<0.9	<0.8	<0.8	<0.6	<0.5	<0.7	<0.6	<0.7	
4,4'-DDT	2.5	22	4	2.3	3.2	3	2.6	2.3	4.8	<0.7	<1	<0.8	<1	
2,4'-DDE	<0.5	<0.6	<0.6	<0.6	<0.8	<0.9	<0.8	<0.8	<0.6	<0.5	<0.7	<0.6	<0.7	
4,4'-DDE	13	13	19	9.6	9.1	8.5	5.5	9.1	2.5	0.52	2.1	1.4	1.9	
2,4'-DDD	16	13	16	8.8	8	7.4	4.3	8.6	0.7	<0.3	0.77	0.52	0.65	
4,4'-DDD	42	41	54	27	20	16	9.3	16	2.3	<0.7	2.3	1	1.8	
Total DDT (6 compounds)	73.5	89	93	47.7	40.3	34.9	21.7	36	10.3	0.52	5.17	2.92	4.35	100
Dieldrin	11	6.8	9.8	4.6	9.6	2.8	2.3	2.9	<0.4	<0.3	<0.4	<0.3	<0.4	8
Endrin	<0.3	<0.4	<0.4	<0.3	<0.5	<0.5	<0.5	<0.5	<0.4	<0.3	<0.4	<0.3	<0.4	45
alpha-hexachlorocyclohexan	<0.3	<0.3	<0.3	<0.3	<0.4	<0.5	<0.4	<0.4	<0.3	<0.3	<0.4	<0.3	<0.4	
beta-hexachlorocyclohexan	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.1	<0.2	<0.2	<0.2	
delta-hexachlorocyclohexan	<0.2	<0.3	<0.3	<0.2	<0.3	<0.4	<0.4	<0.4	<0.3	<0.2	<0.3	<0.2	<0.3	
Lindane	0.58	<0.3	<0.3	<0.3	<0.4	<0.4	0.79	<0.4	<0.3	<0.2	<0.3	<0.3	<0.3	0.99
Mirex	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3	<0.3	<0.3	<0.2	<0.2	<0.2	<0.2	<0.2	

Appendix B1
SURFACE SEDIMENT DATA - MISSION CREEK

April 2000

STATION	1N	1S	2N	2S	3N	3S	4N	4S	Island 1	North Site	Paradise	South Site	Tubbs	ERM
Sample Date	4/18/00	4/18/00	4/18/00	4/18/00	4/18/00	4/18/00	4/18/00	4/18/00	4/20/00	4/21/00	4/20/00	4/21/00	4/20/00	
Depth (ft)	0	0	0	0	0	0	0	0	0	0	0	0	0	
Replicate	1	1	1	1	1	1	1	1	1	1	1	1	1	
Pesticides & PCB (ng/g dry weight)														
PCB 8	4.3	4.8	5.3	2	<0.4	<0.5	<0.5	<0.5	<0.3	<0.3	<0.4	<0.3	<0.4	
PCB 18	4.9	5.4	6	2.6	3.9	1.2	<1	1.1	<0.8	<0.6	<0.9	<0.7	<0.8	
PCB 28	5.4	4.1	6.8	3.2	1.8	1.8	0.78	1.2	<0.5	<0.4	<0.5	<0.4	<0.5	
PCB 44	11	15	25	12	5.2	4.3	2.9	3.6	<0.5	<0.4	<0.6	<0.4	<0.5	
PCB 52	18	32	42	21	8.1	6	4.3	6.7	<0.5	<0.4	<0.6	0.56	<0.5	
PCB 66	25	43	64	32	15	3.1	8.8	12	<0.4	<0.3	1	1.1	0.49	
PCB 77	7.6	12	16	10	<0.8	<0.9	3	4.5	<0.6	<0.5	<0.7	<0.6	<0.7	
PCB 101	31	49	83	36	20	16	11	17	0.62	<0.4	1	1.3	<0.5	
PCB 105	7.6	16	24	10	4	3.9	2.4	3.1	<0.5	<0.4	<0.6	<0.4	<0.5	
PCB 118	24	39	75	32	17	14	8.7	14	0.55	<0.4	0.88	1.3	<0.5	
PCB 126	<0.4	<0.5	<0.5	<0.4	<0.6	<0.7	<0.7	<0.7	<0.5	<0.4	<0.6	<0.4	<0.5	
PCB 128	<0.3	12	20	9.6	7.4	6.6	5.5	7.7	<0.3	<0.3	<0.4	0.33	<0.4	
PCB 138	36	63	98	50	36	27	17	27	1	<0.5	<0.7	1.7	0.82	
PCB 153	40	59	70	40	34	25	16	25	0.81	<0.2	1.5	1.5	0.53	
PCB 170	16	24	21	17	14	8.3	6.1	14	<0.5	<0.4	0.84	<0.4	<0.5	
PCB 180	23	42	44	24	33	18	12	23	0.54	<0.3	2.4	0.62	<0.4	
PCB 187	15	26	23	15	17	12	8.1	13	0.41	<0.3	1.3	0.66	<0.4	
PCB 195	2.6	3.5	2.7	1.9	2.4	1.5	1	2	<0.4	<0.4	<0.5	<0.4	<0.5	
PCB 206	2	3.2	2.6	1.7	1.9	1.2	0.68	1.1	<0.5	<0.4	<0.6	<0.5	<0.6	
PCB 209	0.57	2.6	0.67	0.96	1.3	1.3	<0.6	1.2	<0.5	<0.4	<0.5	<0.4	<0.5	
Total PCB (18 compounds)	266.4	443.6	613.1	311	222	151.2	105.3	172.7	3.93	<0.7	8.92	9.07	1.84	180

APPENDIX B2

Mission Creek
Subsurface Sediment Data

Appendix B2
SUBSURFACE SEDIMENT DATA - MISSION CREEK, October 1998

STATION	1N	1N	2S	2S	2S	2S	3N	3N	3N
Sample Date	11/23/98	11/23/98	12/22/98	12/22/98	12/22/98	12/22/98	10/26/98	10/26/98	10/26/98
Depth (ft)	1-2	2-3	0-1	1-2	2-3	3-4	0-1	1-2	2-3
Replicate	1	1	1	1	1	1	1	1	1
Toxicity (% Survival)									
Total Organic Carbon (%)	2.8		1.1	4.5			3.8	4.4	
Grain Size (%)									
Gravel	1.5		0.6	1.7			1.6	2.2	
Sand	96.4		85.1	82.1			10.1	10.8	
Silt	0.8		2.4	11.2			77.4	74.7	
Clay	1.3		11.9	5			10.9	12.3	
Fines (Silt+Clay)	2.1		14.3	16.2			88.3	87	
Metals (µg·g^{-1}, dry weight)									
Aluminum	10587	9976	10306	15011	14778	10924	39168	37079	16661
Arsenic	3.3	5.14	<0.8	2.1	4.23	5.64	10.8	8.2	7.9
Cadmium	1.62	2.94	1.07	2.49	6	5.67	2.45	2.63	6.05
Chromium	62	82.1	68	108	102.6	98.3	111	103	88.9
Copper	106	189.5	86	164	359.7	295.8	167	155	267.1
Iron	16951	17407	16648	19862	24560	23667	43101	34283	28500
Lead	597	1211.1	254	585	1646.5	2362.7	302	456	1265.8
Mercury	1.6	1.919	0.55	1.53	3.764	6.267	1.28	1.47	2.635
Nickel	32	51.9	34	65	78.6	81	99	83	75
Selenium	0.19	0.16	0.1	0.18	0.56	1.78	0.55	0.54	0.8
Silver	4.2	8.13	2	7	14.55	25.18	6.4	7.3	18.09
Zinc	483	712.3	323	626	1250.9	1288.6	455	464	782.7
PAH (ng·g^{-1}, dry weight)									
Naphthalene	240	330	38	130	1700	2100	110	220	440
C1-Naphthalenes	470	500	48	130	2000	4800	130	500	1200
C2-Naphthalenes	1200	1100	77	360	5400	14000	220	1800	5000
C3-Naphthalenes	1400	1500	87	240	7100	16000	210	2600	7900
C4-Naphthalenes	1200	1000	120	610	5600	9300	280	2400	6200
Acenaphthylene	28	26	22	160	85	80	140	100	86
Acenaphthene	98	87	120	90	590	620	60	130	370
Biphenyl	29	42	14	40	200	180	34	47	140
Dibenzofuran	61		78	61			46	88	
Fluorene	160	160	91	120	620	1200	98	260	760
C1-Fluorenes	360	270	37	260	2500	2500	84	630	1600
C2-Fluorenes	670	590	54	770	5000	4700	190	1400	3400
C3-Fluorenes	1200	800	130	1200	5200	5300	480	2000	4200
Anthracene	170	140	130	430	850	830	580	640	1200
Phenanthrene	730	540	380	1000	3100	4300	560	1000	2200
C1-Phenanthrenes/anthracenes	960	900	170	750	5200	6400	500	1500	3700
C2-Phenanthrenes/anthracenes	1900	1600	190	1600	8000	9100	710	2600	6100
C3-Phenanthrenes/anthracenes	2200	1400	220	1800	6500	8000	730	2300	5700
C4-Phenanthrenes/anthracenes	2300	870	330	1800	4100	5200	1200	2500	2900
Dibenzothiophene	95	78	37	93	850	680	55	210	520
C1-Dibenzothiophenes	360	230	27	340	2200	1900	67	650	1500
C2-Dibenzothiophenes	830	520	86	840	3800	3400	250	1300	2800
C3-Dibenzothiophenes	1200	690	130	1200	4000	3600	380	1500	3200

Appendix B2
SUBSURFACE SEDIMENT DATA - MISSION CREEK, October 1998

STATION	1N	1N	2S	2S	2S	2S	3N	3N	3N
Sample Date	11/23/98	11/23/98	12/22/98	12/22/98	12/22/98	12/22/98	10/26/98	10/26/98	10/26/98
Depth (ft)	1-2	2-3	0-1	1-2	2-3	3-4	0-1	1-2	2-3
Replicate	1	1	1	1	1	1	1	1	1
PAH (ng·g^{-1}, dry weight)									
Fluoranthene	960	910	670	2400	5200	4800	2200	2400	5200
Pyrene	1000	1000	640	2600	5400	5200	2700	3000	4900
C1-Fluoranthenes/pyrenes	1200	940	390	1800	4600	4800	2100	2400	4600
C2-Fluoranthenes/pyrenes	1100	990	300	1500	6200	4800	1600	2000	4000
C3-Fluoranthenes/pyrenes	1200	1000	240	1200	5200	5100	760	1200	3600
Benzo[a]anthracene	460	360	290	1200	1800	1700	1300	1300	2100
Chrysene	790	540	400	1300	2900	2800	1600	1700	3000
C1-Chrysenes	820	700	240	1100	3300	3500	1200	1500	2900
C2-Chrysenes	1000	900	250	1000	4100	4600	970	1600	3400
C3-Chrysenes	920	940	220	990	4600	5000	720	1300	3600
C4-Chrysenes	760	640	170	880	3000	3400	610	1200	2400
Benzo[b]fluoranthene	720	520	460	1400	2900	2400	2400	2200	3000
Benzo[k]fluoranthene	200	120	160	530	700	710	750	620	880
Benzo[e]pyrene	500	380	240	940	1900	2000	1300	1300	2000
Benzo[a]pyrene	440	340	290	1000	1800	1500	1500	1300	1900
Perylene	170	140	100	310	650	600	510	480	650
Indeno[1,2,3,-c,d]pyrene	280	220	190	660	1200	1000	1000	980	1200
Dibenzo[a,h]anthracene	69	49	41	140	290	280	220	190	320
Benzo[g,h,i]perylene	360	350	160	630	1900	1900	1000	1200	1800
Total LMW PAH (7 compounds)	1896	1783	829	2060	8945	13930	1678	2850	6256
Total HMW PAH (6 compounds)	3719	3199	2331	8640	17390	16280	9520	9890	17420
Total PAH (13 compounds)	5615	4982	3160	10700	26335	30210	11198	12740	23676
C10B-Phenyl decanes	460		110	870			380	1100	
C11B-Phenyl undecanes	420		150	1200			470	1200	
C12B-Phenyl dodecanes	130		50	620			170	330	
C13B-Phenyl tridecanes	<8.9		64	320			130	<16	
C14B-Phenyl tetradecanes	<8.9		<0.89	<20			<7	<16	
TPH (µg·g^{-1}, dry weight)									
n-Nonane	<5.1		<0.51	<12			<0.82	<4.6	
n-Decane	1.7		0.12	<0.43			0.17	0.68	
n-Undecane	<0.59		<0.06	<1.4			<0.09	<0.53	
n-Dodecane	<0.59		<0.06	<1.4			<0.09	0.63	
n-Tridecane	<0.8		<0.08	<1.8			<0.13	<0.72	
Isoprenoid RRT 1380	1.2		0.12	<2.2			0.33	3.6	
n-Tetradecane	<1.2		0.14	<2.8			<0.2	<1.1	
Isoprenoid RRT 1470	1.4		0.22	0.67			0.34	4.4	
n-Pentadecane	<0.51		0.06	<1.2			0.13	1	
n-Hexadecane	0.48		0.14	<0.61			0.16	1.2	
Isoprenoid RRT 1650	1.4		0.08	<1.4			0.34	4.8	
n-Heptadecane	0.51		0.1	<0.78			0.4	1.9	
Pristane	2.4		0.61	<1.7			0.52	9	
n-Octadecane	<0.7		0.08	<1.6			0.14	1	
Phytane	2		0.12	0.7			0.63	7	

Appendix B2
SUBSURFACE SEDIMENT DATA - MISSION CREEK, October 1998

STATION	1N	1N	2S	2S	2S	2S	3N	3N	3N
Sample Date	11/23/98	11/23/98	12/22/98	12/22/98	12/22/98	12/22/98	10/26/98	10/26/98	10/26/98
Depth (ft)	1-2	2-3	0-1	1-2	2-3	3-4	0-1	1-2	2-3
Replicate	1	1	1	1	1	1	1	1	1
TPH (µg·g⁻¹, dry weight)									
n-Nonadecane	0.37		0.05	<0.78			<0.05	0.96	
n-Eicosane	1.4		0.06	<0.5			0.21	<0.2	
n-Heneicosane	0.66		0.1	<1.2			<0.08	<0.46	
n-Docosane	1.3		0.15	<0.72			<0.05	1.6	
n-Tricosane	4.3		0.19	<0.54			0.62	2.1	
n-Tetracosane	7.2		0.24	<0.44			<0.03	<0.17	
n-Pentacosane	11		<0.06	<1.4			<0.1	<0.54	
n-Hexacosane	9.6		<0.03	<0.73			<0.05	<0.29	
n-Heptacosane	7.9		0.57	<0.76			1.4	<0.3	
n-Octacosane	5.4		<0.04	2.4			<0.06	<0.34	
n-Nonacosane	3.8		1.1	6			2.7	<2.1	
n-Triacontane	2.2		<0.08	<1.9			<0.13	<0.74	
n-Hentriacontane	2.5		0.74	8.5			2.1	3	
n-Dotriacontane	0.85		0.2	2.5			1.3	41	
n-Tritriacontane	5.2		1.3	<0.9			4.2	6.5	
n-Tetratriacontane	2.8		0.5	<0.79			1.5	<0.31	
n-Pentatriacontane	3.4		0.22	<0.73			<0.05	7.3	
n-Hexatriacontane	0.98		<0.04	1.7			0.71	<0.39	
n-Heptatriacontane	1.1		0.76	<0.89			0.56	1.3	
n-Octatriacontane	0.9		0.19	<0.8			0.76	1.2	
n-Nonatriacontane	0.48		0.12	<0.76			0.42	0.68	
n-Tetracontane	<0.35		0.09	<0.8			0.3	<0.32	
Total Resolved Hydrocarbons	410		83	460			240	770	
Total Petroleum Hydrocarbons	4800		960	5200			3400	9100	
TPH >C8-C10	44		3.2	<12			5.4	51	
TPH >C10-C12	74		6.7	55			25	170	
TPH >C12-C16	120		28	120			82	360	
TPH >C16-C21	420		72	420			300	940	
TPH >C21-C25	980		150	930			600	1700	
TPH >C25-C30	1400		290	1600			1000	2600	
TPH >C30-C35	1000		230	1200			760	1900	
TPH >C35 +	810		180	860			590	1400	
Pesticides & PCB (ng·g⁻¹ dry weight)									
Aldrin	<0.17	<1.1	<0.17	<0.2	<1.5	<0.99	<0.27	<0.38	<1
alpha-Chlordane	61	43	12	39	170	260	26	51	170
gamma-Chlordane	75	57	12	46	250	380	<0.26	65	280
cis-Nonachlor	17	14	2.9	11	56	77	7.4	17	56
trans-Nonachlor	48	30	6.7	24	120	170	17	36	120
Heptachlor	<0.16	<1	<0.16	<0.18	<1.4	<0.92	<0.26	<0.36	<0.98
Heptachlor Epoxide	<0.16	<1	<0.16	<0.18	<1.4	<0.92	<0.26	<0.36	<0.98
Total Chlordane (4 compounds)	201	144	33.6	120	596	887	50.4	169	626
2,4'-DDT	<0.27	<1.7	<0.27	<0.3	<2.3	<1.5	<0.43	<0.6	<1.6
4,4'-DDT	<0.37	4.8	2.2	<0.43	10	7.7	19	<0.84	2.3

Appendix B2
SUBSURFACE SEDIMENT DATA - MISSION CREEK, October 1998

STATION	1N	1N	2S	2S	2S	2S	3N	3N	3N
Sample Date	11/23/98	11/23/98	12/22/98	12/22/98	12/22/98	12/22/98	10/26/98	10/26/98	10/26/98
Depth (ft)	1-2	2-3	0-1	1-2	2-3	3-4	0-1	1-2	2-3
Replicate	1	1	1	1	1	1	1	1	1
Pesticides & PCB (ng/g dry weight)									
2,4'-DDE	<0.27	<1.7	<0.27	<0.3	<2.3	<1.5	<0.43	<0.6	<1.6
4,4'-DDE	<0.27	15	4.5	21	120	130	17	33	100
2,4'-DDD	<0.16	16	3.8	<0.18	98	86	<0.26	12	50
4,4'-DDD	<0.37	49	51	150	280	420	65	89	220
Total DDT (6 compounds)	<0.37	84.8	61.5	171	508	643.7	101	134	372.3
Dieldrin	41	13	13	20	93	72	40	62	58
Endrin	<0.16	0.76	<0.16	<0.18	<1.4	<0.92	<0.26	<0.36	<0.98
alpha-hexachlorocyclohexan		0.24			1	1.4			0.74
beta-hexachlorocyclohexan		<0.44			<0.6	<0.4			<0.42
delta-hexachlorocyclohexan		<0.7			<0.97	<0.65			<0.68
Lindane	<0.12	0.5	<0.12	<0.13	3.8	1.9	<0.19	<0.26	2
Mirex	<0.08	0.63	<0.08	<0.09	6.8	5.8	<0.13	<0.18	5.9
PCB 8	<0.11	8.1	1.5	<0.13	28	33	<0.18	<0.25	18
PCB 18	13	8.3	1.9	7.4	26	36	4.2	8.2	34
PCB 28	18	11	3.2	14	36	56	12	3.7	45
PCB 44	30	17	3.4	18	55	79	9.2	16	62
PCB 52	31	21	5.5	16	46	60	14	23	55
PCB 66	33	31	10	27	91	98	<0.14	40	100
PCB 77	<0.13	28	<0.13	<0.15	30	140	<0.2	<0.29	110
PCB 101	35	33	14	27	120	110	34	50	120
PCB 105	16	9.8	4.7	13	28	33	15	21	40
PCB 118	34	26	11	29	79	110	29	44	96
PCB 126	<0.2	<1.2	<0.2	<0.22	<1.7	<1.1	<0.32	<0.44	23
PCB 128	9.8	9.1	3.4	7.3	31	38	12	14	37
PCB 138	93	38	18	100	180	140	58	90	220
PCB 153	40	54	15	36	400	230	46	73	280
PCB 170	19	11	7	20	58	47	30	51	68
PCB 180	28	23	13	34	140	88	44	76	120
PCB 187	16	16	6.6	17	120	52	23	40	70
PCB 195	6	2.4	1.7	5.7	14	9.5	4.1	10	12
PCB 206	2.8	2.3	0.99	3.6	16	8.9	3.2	6.8	8.6
PCB 209	3.8	0.72	0.59	<0.08	3.9	2.2	2.4	4	3.8
Total PCB (18 compounds)	428.4	321.72	121.48	375	1471.9	1230.6	340.1	570.7	1389.4
Total Aroclor 1016	<11		<11	<12			<17	<24	
Total Aroclor 1221	<11		<11	<12			<17	<24	
Total Aroclor 1232	<11		<11	<12			<17	<24	
Total Aroclor 1242	<11		<11	<12			<17	<24	
Total Aroclor 1248	<11		<11	<12			<17	<24	
Total Aroclor 1254	950		250	650			610	970	
Total Aroclor 1260	290		120	350			500	860	

Appendix B2
SUBSURFACE SEDIMENT DATA - MISSION CREEK, October 1998

STATION	3N	4S	4S	4S	4S	5N	5N	6N	6N
Sample Date	10/26/98	10/26/98	10/26/98	10/26/98	10/26/98	10/26/98	10/26/98	10/26/98	10/26/98
Depth (ft)	3-4	0-1	1-2	2-3	3-4	0-1	1-2	0-1	1-2
Replicate	1	1	1	1	1	1	1	1	1
Toxicity (% Survival)									
Total Organic Carbon (%)		3.3	2.6			1.8	1.8	1.6	1.2
Grain Size (%)									
Gravel		0	0			0	0	0.3	0
Sand		8.1	5.9			2.1	3.1	8	7.2
Silt		78.1	71.1			30.3	33.4	35.2	33.6
Clay		13.8	23			67.6	63.5	56.5	59.2
Fines (Silt+Clay)		91.9	94.1			97.9	96.9	91.7	92.8
Metals (µg·g, dry weight)									
Aluminum	18678	47906	48232	25899	37978	49947	46486	42404	46416
Arsenic	9.89	11	9.1	9.15	7.87	11.6	10.9	10.7	10.3
Cadmium	6.19	1.58	1.62	2.65	2.32	0.47	0.41	0.27	0.31
Chromium	127.9	118	117	100.4	126.6	110	106	104	107
Copper	324.9	113	108	143.8	129.7	72	68	48	51
Iron	33213	44014	42115	36309	41313	44156	43434	41169	40758
Lead	1920.7	210	217	439.9	411.3	48	45	26	28
Mercury	3.871	1.07	1.13	1.284	1.084	0.38	0.35	0.27	0.29
Nickel	107.2	99	97	92.8	96.2	99	93	88	88
Selenium	0.56	0.45	0.44	0.62	0.54	0.35	0.32	0.26	0.28
Silver	19.21	2.3	3.1	4.72	3.89	0.5	<0.5	<0.5	<0.5
Zinc	1032.2	318	300	380.2	358.6	161	154	126	124
PAH (ng·g', dry weight)									
Naphthalene	440	110	87	110	93	40	50	32	36
C1-Naphthalenes	2400	92	65	89	140	28	32	19	17
C2-Naphthalenes	13000	130	100	150	330	54	64	34	28
C3-Naphthalenes	16000	110	100	140	280	38	64	33	26
C4-Naphthalenes	9700	97	98	120	370	40	95	25	22
Acenaphthylene	90	150	190	110	34	48	48	50	42
Acenaphthene	470	40	30	51	100	17	25	22	17
Biphenyl	460	27	26	33	100	13	15	12	12
Dibenzofuran		42	37			26	30	12	11
Fluorene	980	72	62	98	230	36	42	29	22
C1-Fluorenes	2100	67	63	68	290	23	32	26	19
C2-Fluorenes	3800	54	68	280	760	30	53	23	20
C3-Fluorenes	4400	170	240	1100	1300	59	76	28	24
Anthracene	570	520	500	690	450	200	210	150	100
Phenanthrene	2100	530	290	460	360	180	200	220	170
C1-Phenanthrenes/anthracenes	4300	460	330	660	480	150	160	150	110
C2-Phenanthrenes/anthracenes	7200	400	360	1000	1100	130	160	93	70
C3-Phenanthrenes/anthracenes	6700	320	400	1500	1800	91	120	49	37
C4-Phenanthrenes/anthracenes	3800	960	1000	1900	1700	240	260	120	92
Dibenzothiophene	480	40	29	40	86	17	19	18	15
C1-Dibenzothiophenes	1400	41	36	53	210	13	16	15	12
C2-Dibenzothiophenes	2600	100	110	450	710	34	48	26	19
C3-Dibenzothiophenes	2900	130	180	950	1000	39	54	23	13

Appendix B2
SUBSURFACE SEDIMENT DATA - MISSION CREEK, October 1998

STATION	3N	4S	4S	4S	4S	5N	5N	6N	6N
Sample Date	10/26/98	10/26/98	10/26/98	10/26/98	10/26/98	10/26/98	10/26/98	10/26/98	10/26/98
Depth (ft)	3-4	0-1	1-2	2-3	3-4	0-1	1-2	0-1	1-2
Replicate	1	1	1	1	1	1	1	1	1
PAH (ng·g^{-1}, dry weight)									
Fluoranthene	3200	1100	750	3700	2100	450	430	410	410
Pyrene	3500	3300	3800	6300	2300	690	820	550	580
C1-Fluoranthenes/pyrenes	3500	1900	1800	5400	2000	530	520	270	210
C2-Fluoranthenes/pyrenes	3900	1400	1400	3400	1800	300	300	110	98
C3-Fluoranthenes/pyrenes	4200	770	810	2000	1400	140	150	51	48
Benzo[a]anthracene	1200	910	800	3000	870	320	300	230	190
Chrysene	2100	1500	1100	2800	1000	430	470	270	200
C1-Chrysenes	2800	1200	1000	2000	920	260	280	110	92
C2-Chrysenes	3900	990	810	1400	1000	150	170	58	54
C3-Chrysenes	3800	680	490	810	720	87	92	31	36
C4-Chrysenes	2600	460	350	620	570	70	70	27	30
Benzo[b]fluoranthene	1700	2900	2300	3200	1100	790	790	390	400
Benzo[k]fluoranthene	470	1000	830	960	360	230	220	120	130
Benzo[e]pyrene	1400	1500	1200	1900	700	340	360	240	240
Benzo[a]pyrene	1100	2000	1600	2400	750	460	470	380	380
Perylene	490	580	500	710	360	170	190	140	140
Indeno[1,2,3,-c,d]pyrene	720	1100	820	1300	540	260	270	250	280
Dibenzo[a,h]anthracene	190	260	180	280	120	54	54	35	38
Benzo[g,h,i]perylene	1200	1000	790	1300	630	240	250	240	270
Total LMW PAH (7 compounds)	7050	1514	1224	1608	1407	549	607	522	404
Total HMW PAH (6 compounds)	11290	9070	8230	18480	7140	2404	2544	1875	1798
Total PAH (13 compounds)	18340	10584	9454	20088	8547	2953	3151	2397	2202
C10B-Phenyl decanes		130	220			48	42	21	20
C11B-Phenyl undecanes		140	330			55	44	26	28
C12B-Phenyl dodecanes		89	120			26	24	15	22
C13B-Phenyl tridecanes		100	110			42	12	26	16
C14B-Phenyl tetradecanes		<4.1	<4			<0.33	<0.3	<0.26	<0.29
TPH (µg·g^{-1}, dry weight)									
n-Nonane		<2.4	<0.47			<0.19	<0.18	<0.15	<0.17
n-Decane		0.15	0.05			0.01	0.02	0.01	<0.01
n-Undecane		<0.27	0.32			<0.02	0.12	<0.02	<0.02
n-Dodecane		<0.27	<0.05			<0.02	<0.02	<0.02	<0.02
n-Tridecane		<0.37	<0.07			<0.03	<0.03	<0.02	<0.03
Isoprenoid RRT 1380		<0.45	0.25			<0.04	0.04	<0.03	<0.03
n-Tetradecane		<0.57	<0.11			<0.05	<0.04	<0.04	<0.04
Isoprenoid RRT 1470		0.16	0.2			0.05	0.03	0.02	0.01
n-Pentadecane		<0.24	0.09			0.03	0.03	0.02	0.02
n-Hexadecane		<0.12	0.14			0.04	0.03	0.02	0.02
Isoprenoid RRT 1650		<0.28	0.23			0.04	0.04	0.02	<0.02
n-Heptadecane		0.3	0.34			0.1	0.05	0.03	0.03
Pristane		<0.35	0.4			0.09	0.09	0.06	0.04
n-Octadecane		<0.33	<0.06			0.05	0.03	0.03	<0.02
Phytane		0.22	0.34			0.11	0.11	0.08	0.06

Appendix B2
SUBSURFACE SEDIMENT DATA - MISSION CREEK, October 1998

STATION	3N	4S	4S	4S	4S	5N	5N	6N	6N
Sample Date	10/26/98	10/26/98	10/26/98	10/26/98	10/26/98	10/26/98	10/26/98	10/26/98	10/26/98
Depth (ft)	3-4	0-1	1-2	2-3	3-4	0-1	1-2	0-1	1-2
Replicate	1	1	1	1	1	1	1	1	1
TPH ($\mu g \cdot g^{-1}$, dry weight)									
n-Nonadecane		<0.16	0.12			0.05	0.04	0.03	0.02
n-Eicosane		<0.1	<0.02			0.06	0.06	0.06	0.04
n-Heneicosane		<0.23	<0.05			0.05	0.11	0.06	0.06
n-Docosane		1	0.99			0.18	0.06	0.05	0.04
n-Tricosane		0.42	<0.02			0.18	0.13	0.11	0.09
n-Tetracosane		<0.09	<0.02			<0.01	<0.01	0.05	0.03
n-Pentacosane		<0.28	<0.05			0.17	0.11	0.14	0.11
n-Hexacosane		<0.15	<0.03			0.08	<0.01	0.09	0.05
n-Heptacosane		0.73	0.55			0.27	0.29	0.28	0.21
n-Octacosane		<0.17	2.4			<0.01	0.73	0.47	0.46
n-Nonacosane		1.8	1.5			0.68	0.99	0.68	0.46
n-Triacontane		<0.38	<0.07			0.17	<0.03	0.1	0.09
n-Hentriacontane		2.7	1.2			0.98	1.1	0.68	0.63
n-Dotriacontane		0.63	<0.03			0.17	<0.01	0.14	0.07
n-Tritriacontane		3.3	2.5			0.7	0.33	0.21	0.22
n-Tetratriacontane		0.72	1			0.17	0.12	0.07	<0.01
n-Pentatriacontane		<0.15	<0.03			0.11	0.17	0.08	0.07
n-Hexatriacontane		0.46	<0.04			0.12	0.25	0.08	0.09
n-Heptatriacontane		0.49	0.24			0.11	0.19	0.05	0.04
n-Octatriacontane		0.41	<0.03			0.12	0.24	0.05	0.04
n-Nonatriacontane		0.29	<0.03			<0.01	0.22	0.06	0.03
n-Tetracontane		0.24	<0.03			0.05	0.18	0.03	0.03
Total Resolved Hydrocarbons		180	170			40	40	22	21
Total Petroleum Hydrocarbons		2400	2800			430	420	150	180
TPH >C8-C10		5.6	5.8			2.5	1.8	1.6	1.6
TPH >C10-C12		11	15			2	2.1	0.9	0.83
TPH >C12-C16		69	80			10	10	3.8	4.4
TPH >C16-C21		250	310			42	43	19	24
TPH >C21-C25		430	510			72	71	26	32
TPH >C25-C30		720	820			120	120	42	51
TPH >C30-C35		540	600			100	96	35	39
TPH >C35 +		390	460			82	72	26	31
Pesticides & PCB (ng·g dry weight)									
Aldrin	<1.2	<0.32	<0.31	<0.98	<0.93	<0.26	<0.24	<0.2	<0.22
alpha-Chlordane	260	21	18	38	61	2.3	2.9	0.26	<0.21
gamma-Chlordane	410	25	<0.29	<0.92	100	1.8	<0.22	<0.19	<0.21
cis-Nonachlor	82	5.7	<0.27	17	25	0.81	0.79	0.3	0.5
trans-Nonachlor	170	11	11	27	44	0.75	0.76	<0.14	<0.15
Heptachlor	<1.1	<0.3	<0.29	<0.92	<0.87	<0.24	<0.22	<0.19	<0.21
Heptachlor Epoxide	<1.1	<0.3	<0.29	<0.92	<0.87	<0.24	<0.22	<0.19	<0.21
Total Chlordane (4 compounds)	922	62.7	29	82	230	5.66	4.45	0.56	0.5
2,4'-DDT	<1.8	<0.5	<0.48	<1.5	<1.4	<0.4	<0.37	<0.32	<0.35
4,4'-DDT	1.3	28	<0.68	<2.1	6.3	1.6	2.9	2.4	<0.49

Appendix B2
SUBSURFACE SEDIMENT DATA - MISSION CREEK, October 1998

STATION	3N	4S	4S	4S	4S	5N	5N	6N	6N
Sample Date	10/26/98	10/26/98	10/26/98	10/26/98	10/26/98	10/26/98	10/26/98	10/26/98	10/26/98
Depth (ft)	3-4	0-1	1-2	2-3	3-4	0-1	1-2	0-1	1-2
Replicate	1	1	1	1	1	1	1	1	1
Pesticides & PCB (ng/g dry weight)									
2,4'-DDE	<1.8	<0.5	<0.48	<1.5	<1.4	<0.4	<0.37	<0.32	<0.35
4,4'-DDE	140	12	15	38	52	4.3	4.4	2.9	2.8
2,4'-DDD	<1.1	10	7.7	20	22	1.1	1.4	0.67	0.81
4,4'-DDD	320	57	45	67	81	6.4	8.9	3.9	4.6
Total DDT (6 compounds)	461.3	107	67.7	125	161.3	13.4	17.6	9.87	8.21
Dieldrin	120	29	30	13	21	4.7	5	1.8	2.3
Endrin	0.69	<0.3	<0.29	<0.92	<0.87	<0.24	<0.22	<0.19	<0.21
alpha-hexachlorocyclohexan	0.91			<0.79	<0.75				
beta-hexachlorocyclohexan	<0.48			<0.4	<0.38				
delta-hexachlorocyclohexan	<0.77			<0.64	<0.61				
Lindane	2.1	<0.22	<0.21	0.7	0.94	<0.18	<0.16	<0.14	<0.15
Mirex	<0.55	<0.15	<0.14	<0.46	<0.43	<0.12	<0.11	<0.09	<0.1
PCB 8	39	<0.21	<0.2	<0.64	<0.61	<0.17	<0.15	0.36	<0.14
PCB 18	58	3.8	2.9	6.1	17	0.54	0.96	<0.28	<0.3
PCB 28	86	8.8	7	13	26	0.83	<0.22	0.49	<0.21
PCB 44	100	7.1	7.2	17	31	1.1	1.4	0.42	0.49
PCB 52	100	12	12	20	36	2	2.3	0.75	0.88
PCB 66	270	20	20	42	75	3.4	3.7	1.5	2
PCB 77	270	<0.24	<0.23	38	72	<0.19	<0.18	<0.15	<0.17
PCB 101	300	28	26	45	77	3.8	4.5	1.6	2
PCB 105	56	9.4	10	12	16	1.8	1.7	0.68	1.2
PCB 118	220	24	25	41	62	3.8	4.6	1.7	2.2
PCB 126	28	<0.37	<0.36	<1.1	<1.1	<0.3	<0.27	<0.23	<0.26
PCB 128	64	9.1	9.2	20	22	<0.13	1.7	<0.1	<0.11
PCB 138	370	48	46	72	100	7.6	8	3.1	8.1
PCB 153	500	38	34	90	150	5.7	6.6	2.7	6.7
PCB 170	130	29	25	29	43	3	3.5	1.2	6.9
PCB 180	290	38	32	54	82	3.9	4.7	1.8	10
PCB 187	130	21	19	32	46	2.9	3.1	1.4	4.7
PCB 195	25	4.2	3.6	6.4	9.6	0.43	0.62	0.29	1
PCB 206	19	3.4	3	7	7.1	0.61	0.76	0.29	0.77
PCB 209	3.4	1.1	1.1	3.9	3	0.21	0.3	0.24	0.28
Total PCB (18 compounds)	2760.4	304.9	283	510.4	802.7	41.62	48.44	18.52	47.22
Total Aroclor 1016		<20	<19			<16	<15	<13	<14
Total Aroclor 1221		<20	<19			<16	<15	<13	<14
Total Aroclor 1232		<20	<19			<16	<15	<13	<14
Total Aroclor 1242		<20	<19			<16	<15	<13	<14
Total Aroclor 1248		<20	<19			<16	<15	<13	<14
Total Aroclor 1254		500	470			65	71	23	30
Total Aroclor 1260		440	350			56	65	30	94

APPENDIX B3

Mission Creek
Clam Tissue Bioaccumulation Data

Appendix B3
CLAM TISSUE BIOACCUMULATION DATA - MISSION CREEK, April 2000

STATION	1N	1S	2N	2S	2S	2S	2S	2S	3N
Sample Date	4/18/00	4/18/00	4/18/00	4/18/00	4/18/00	4/18/00	4/18/00	4/18/00	4/18/00
Replicate	1	1	1	1	2	3	4	5	1
Metals (µg/g, dry weight)									
Mercury	0.15	0.226	0.244	0.128	0.143	0.171	0.152	0.13	0.141
Pesticides & PCB (ng/g dry weight)									
Aldrin	<0.83	<0.63	<0.67	<0.82	<0.79	<0.76	<0.87	<0.82	<0.7
alpha-Chlordane	21	7.2	11	17	18	25	20	21	7.2
gamma-Chlordane	22	0.74	11	16	17	24	19	19	0.82
cis-Nonachlor	6.8	1.6	3.4	5.3	5.8	6.9	5.6	6	1.9
trans-Nonachlor	13	3.2	6.5	10	11	14	13	12	4.6
Heptachlor	<1.1	<0.84	<0.89	<1.1	<1	<1	<1.2	<1.1	<0.93
Heptachlor Epoxide	<0.96	<0.74	<0.78	<0.96	<0.92	<0.88	<1	<0.96	<0.82
Total Chlordane (4 compounds)	62.8	12	31.9	48.3	51.8	69.9	57.6	58	13.7
2,4'-DDT	1.5	1.2	1.2	1.5	1.4	1.4	1.6	1.5	1.3
4,4'-DDT	1.7	1.3	1.4	1.7	1.6	1.6	1.8	1.7	1.4
2,4'-DDE	1.4	1	1.1	1.4	1.3	1.2	1.4	1.4	1.2
4,4'-DDE	14	4.5	6.3	13	13	15	15	14	9.2
2,4'-DDD	8.2	4	3.8	6.8	7.6	11	9.8	8.5	3.4
4,4'-DDD	29	15	18	24	29	37	28	29	15
Total DDT (6 compounds)	51.2	23.5	28.1	43.8	49.6	63	52.8	51.5	27.6
Dieldrin	9	5.4	5.8	8.3	6.7	10	6.9	8.5	3.8
Endrin	<0.96	<0.74	<0.78	<0.96	<0.92	<0.88	<1	<0.96	<0.82
alpha-hexachlorocyclohexan	<0.83	<0.63	<0.67	<0.82	<0.79	<0.76	<0.87	<0.82	<0.7
beta-hexachlorocyclohexan	<0.83	<0.63	<0.67	<0.82	<0.79	<0.76	<0.87	<0.82	<0.7
delta-hexachlorocyclohexan	<0.83	<0.63	<0.67	<0.82	<0.79	<0.76	<0.87	<0.82	<0.7
Lindane	<0.96	<0.74	<0.78	<0.96	<0.92	<0.88	<1	<0.96	<0.82
Mirex	<0.55	<0.42	<0.44	<0.55	<0.53	<0.5	<0.58	<0.55	<0.47
PCB 8	2.5	1.9	2	2.4	2.4	2.2	2.6	2.4	2.1
PCB 18	4.4	2	2.1	4.6	3.5	3.8	6.2	4.1	2.2
PCB 28	21	3.9	4.3	1.3	8.9	10	7.8	12	4.4
PCB 44	13	5	3.2	10	9.7	12	11	11	1.6
PCB 52	18	15	8.9	13	16	17	16	16	6.6
PCB 66	6.8	4.4	4	5.7	7.6	8.4	8.2	7.3	3.4
PCB 77	<3.1	<2.3	<2.5	<3	<2.9	<2.8	<3.2	<3	<2.6
PCB 101	31	20	15	24	26	29	32	30	16
PCB 105	3.5	4	4.7	3	3.3	4.5	5.1	4.8	3.2
PCB 118	21	13	11	19	20	24	23	23	12
PCB 126	<2.6	<2	<2.1	<2.6	<2.5	<2.4	<2.7	<2.6	<2.2
PCB 128	4.6	2.3	1.9	2.8	2.9	3.5	3.8	3.3	1.6
PCB 138	25	12	15	18	19	21	21	20	16
PCB 153	50	17	14	37	40	44	42	43	19
PCB 170	5.6	1.3	1.5	2.6	3.2	3.2	3.1	3.6	2.7
PCB 180	9.9	4.8	4.8	5.7	6.6	7	6.6	6.2	5.3
PCB 187	9.5	3.5	3.5	5.1	6	6.6	6	6.3	5.5
PCB 195	1.5	2.4	1.2	1.5	1.5	1.4	1.6	1.5	3.6
PCB 206	1.2	5.6	1.7	0.81	0.78	0.74	0.86	0.81	8.4
PCB 209	2.8	2.1	2.2	2.8	2.7	2.6	3	2.8	3.4

Appendix B3
CLAM TISSUE BIOACCUMULATION DATA - MISSION CREEK, April 2000

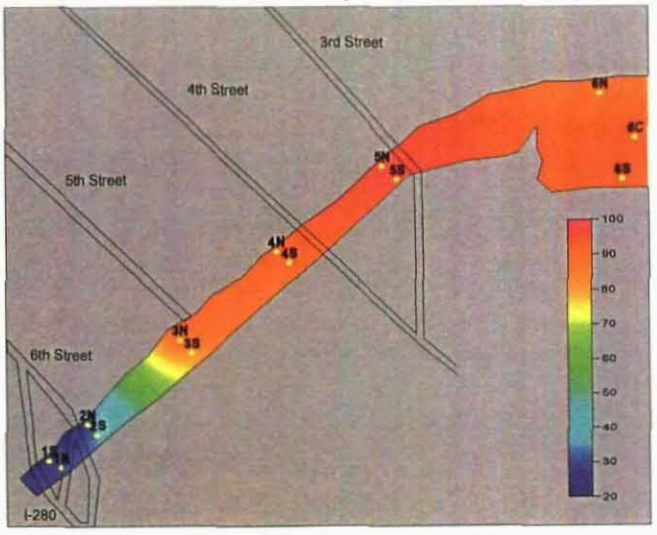
Station	3S	4N	4S	Island 1	North Site	Paradise	South Site	Tubbs
Sample Date	4/18/00	4/18/00	4/18/00	4/20/00	4/21/00	4/20/00	4/21/00	4/20/00
Replicate	1	1	1	1	1	1	1	1
Metals (µg/g, dry weight)								
Mercury	0.211	0.163	0.257	0.185	0.183	0.194	0.217	0.242
Pesticides & PCB (ng/g dry weight)								
Aldrin	<0.58	<0.68	<0.57	<0.67	<0.68	<0.68	<0.52	<0.7
alpha-Chlordane	5.8	6.7	7.4	0.9	1.2	0.91	0.7	0.93
gamma-Chlordane	4.6	5.9	5.4	0.78	0.8	0.8	0.61	0.82
cis-Nonachlor	2.3	2.2	2.6	0.9	1	1.1	0.71	0.93
trans-Nonachlor	4.1	3.8	4.1	0.67	0.84	0.74	0.52	0.7
Heptachlor	<0.78	<0.91	<0.77	<0.9	<0.91	<0.91	<0.7	<0.93
Heptachlor Epoxide	<0.68	<0.8	<0.67	<0.78	<0.8	<0.8	<0.61	<0.82
Total Chlordane (4 compounds)	16.8	18.6	19.5	<0.7	3.04	1.84	0.71	<0.7
2,4'-DDT	1.1	1.2	1	1.2	1.2	1.2	0.96	1.3
4,4'-DDT	1.2	1.4	1.2	1.4	1.4	1.4	1.1	1.4
2,4'-DDE	0.97	1.1	0.96	1.1	1.1	1.1	0.87	1.2
4,4'-DDE	12	12	17	7.6	8.5	8.2	0.87	6.9
2,4'-DDD	3.3	4.2	6.8	1	1	1.2	0.79	1
4,4'-DDD	14	15	22	4.6	4	4.7	2.2	3.6
Total DDT (6 compounds)	29.3	31.2	45.8	12.2	12.5	14.1	2.2	10.5
Dieldrin	2	3.1	3.4	1	2.4	1.3	0.84	1.2
Endrin	<0.68	<0.8	<0.67	<0.78	<0.8	<0.8	<0.61	<0.82
alpha-hexachlorocyclohexan	<0.58	<0.68	<0.57	<0.67	<0.68	<0.68	<0.52	<0.7
beta-hexachlorocyclohexan	<0.58	<0.68	<0.57	<0.67	<0.68	<0.68	<0.52	<0.7
delta-hexachlorocyclohexan	<0.58	<0.68	<0.57	<0.67	<0.68	<0.68	<0.52	<0.7
Lindane	<0.68	<0.8	<0.67	<0.78	<0.8	<0.8	<0.61	<0.82
Mirex	<0.39	<0.46	<0.38	<0.45	<0.46	<0.46	<0.35	<0.47
PCB 8	1.7	2	1.7	2	2	2	1.6	2.1
PCB 18	1.8	2.1	1.8	2.1	2.1	2.1	1.7	2.2
PCB 28	14	3	2.6	12	1.6	1.4	4.1	1.1
PCB 44	1.5	5.8	4.6	1.5	1.6	1.6	1.2	1.6
PCB 52	4.8	5.8	7.1	1.5	1.5	1.5	1.2	1.6
PCB 66	2.9	3.3	3.7	1.4	1.9	1.2	1.7	1.2
PCB 77	<2.2	<2.5	<2.1	<2.5	<2.5	<2.5	<1.9	<2.6
PCB 101	16	17	22	1.3	2.1	2.5	2	0.9
PCB 105	1.9	3.6	5.4	0.78	1.5	1.2	0.61	0.81
PCB 118	13	13	17	1.7	2.6	1.8	1.8	1.3
PCB 126	<1.8	<2.1	<1.8	<2.1	<2.1	<2.1	<1.6	<2.2
PCB 128	2.1	2.6	3.2	1.6	1.6	1.6	1.2	1.6
PCB 138	16	17	21	2.6	5.3	4.2	4	2.3
PCB 153	28	16	20	5	7.8	6.5	7	5.4
PCB 170	2.9	2	3.6	1.1	1.1	1.1	0.86	1.2
PCB 180	4.8	7.6	5.9	0.87	1.9	2.6	1.8	0.9
PCB 187	4.7	8	5.8	1.3	3.2	3.2	1.9	1.3
PCB 195	1.1	1.3	1.3	1.2	2.3	1.3	0.97	1.3
PCB 206	0.57	25	2	0.66	4.5	10	0.52	1.6
PCB 209	2	12	1.9	2.3	2.3	3.3	1.8	2.4

APPENDIX B4

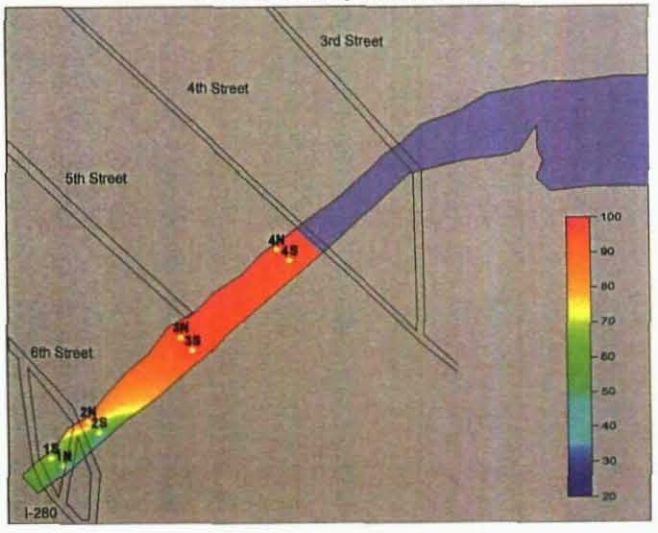
Mission Creek
Surface Sediment Distributions

Appendix B4
SURFACE SEDIMENT DISTRIBUTIONS - MISSION CREEK

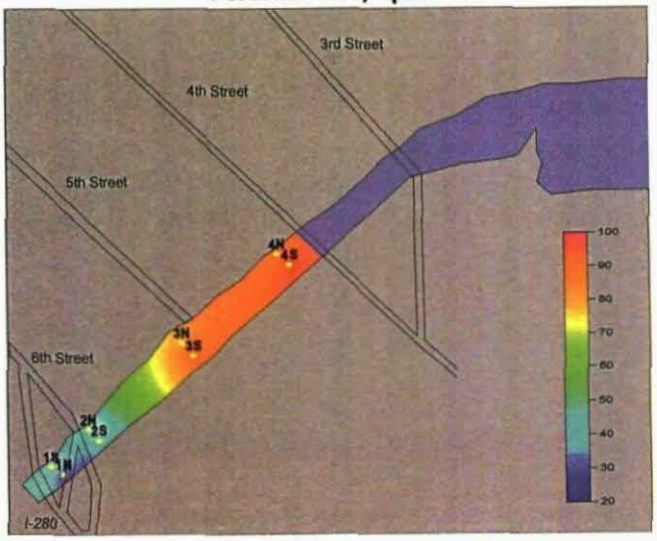
Percent Fines, October 1998



Percent Fines, October 1999

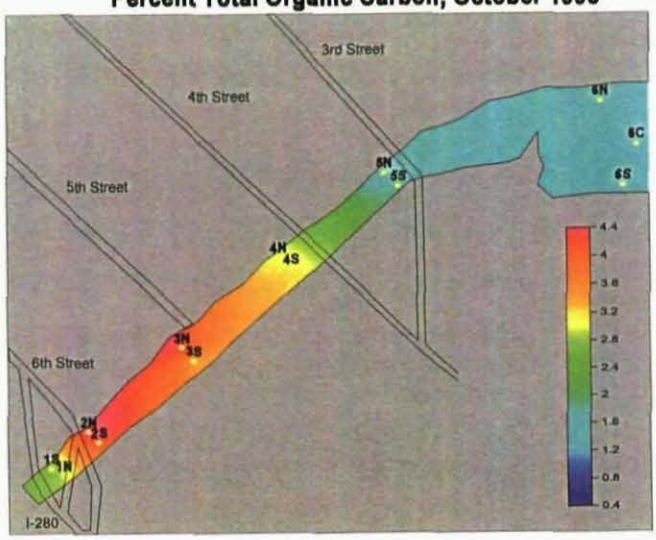


Percent Fines, April 2000

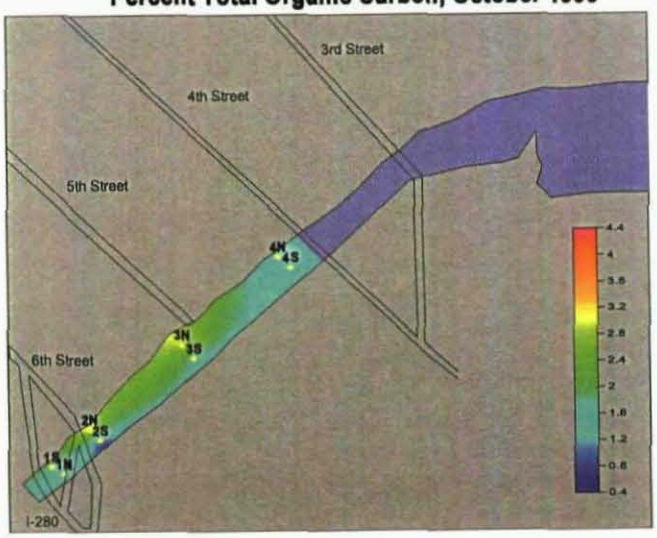


Appendix B4
SURFACE SEDIMENT DISTRIBUTIONS - MISSION CREEK

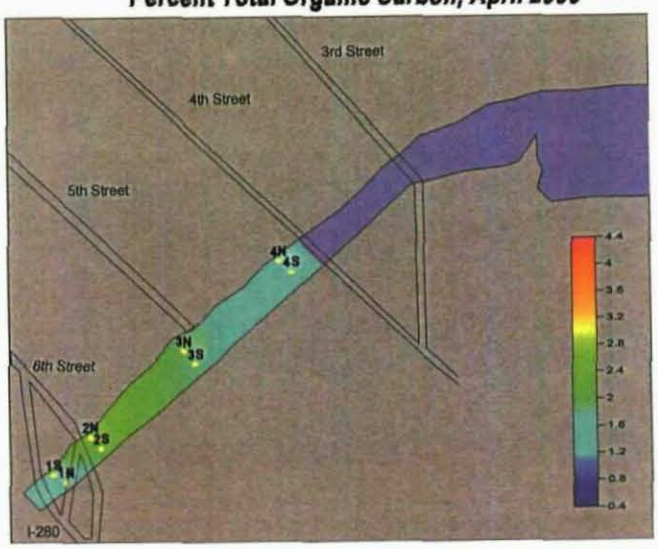
Percent Total Organic Carbon, October 1998



Percent Total Organic Carbon, October 1999

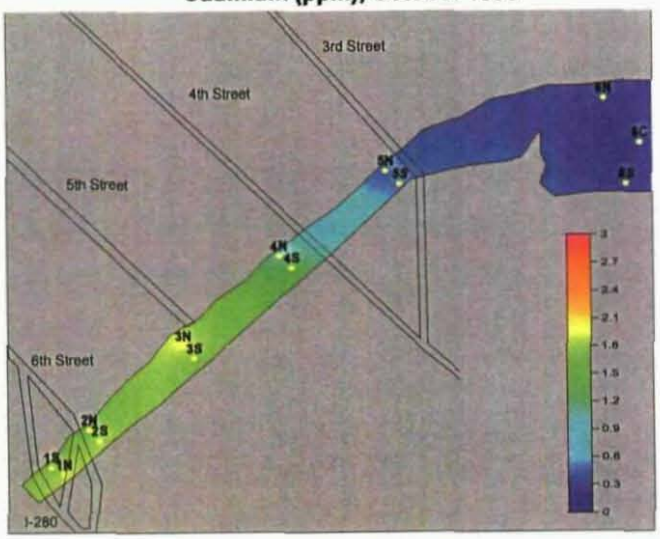


Percent Total Organic Carbon, April 2000

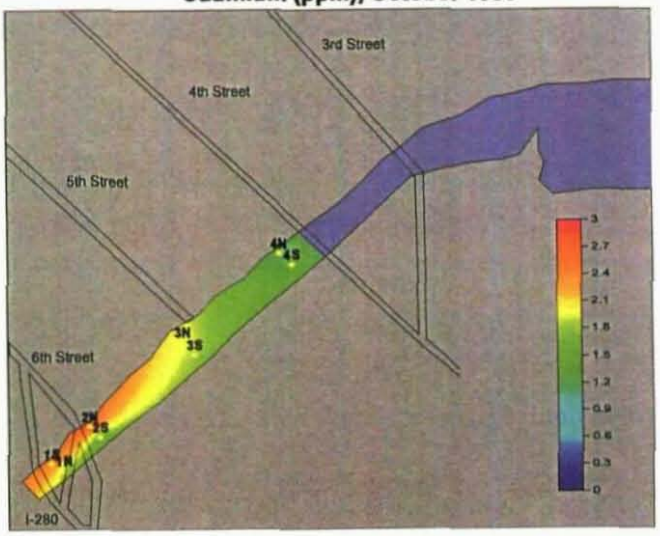


Appendix B4
SURFACE SEDIMENT DISTRIBUTIONS - MISSION CREEK

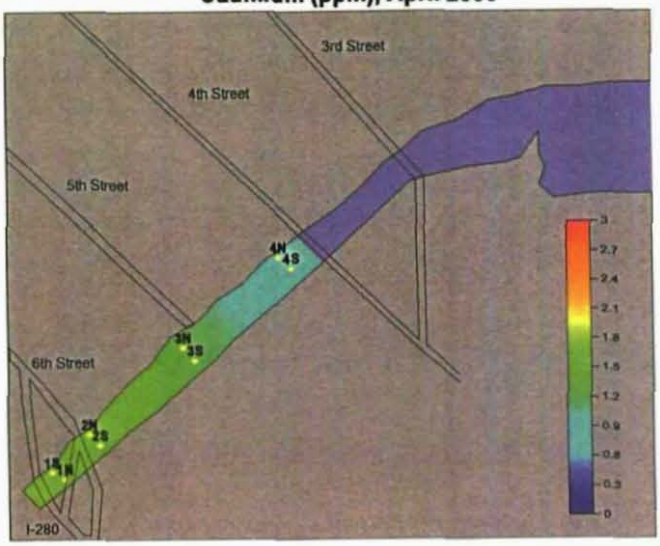
Cadmium (ppm), October 1998



Cadmium (ppm), October 1999

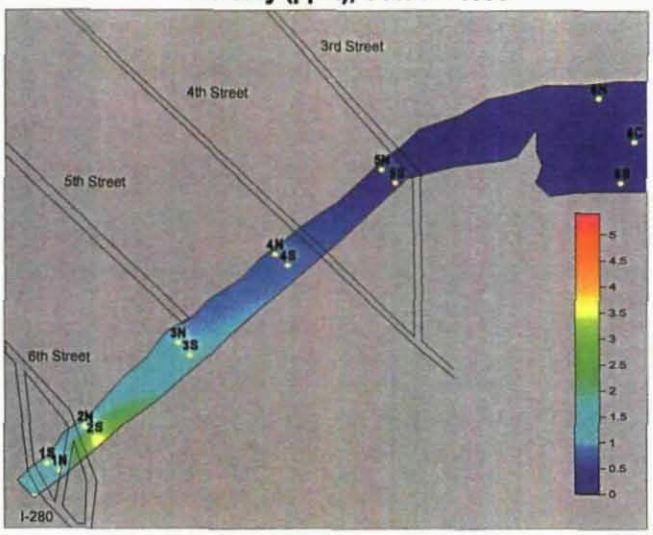


Cadmium (ppm), April 2000

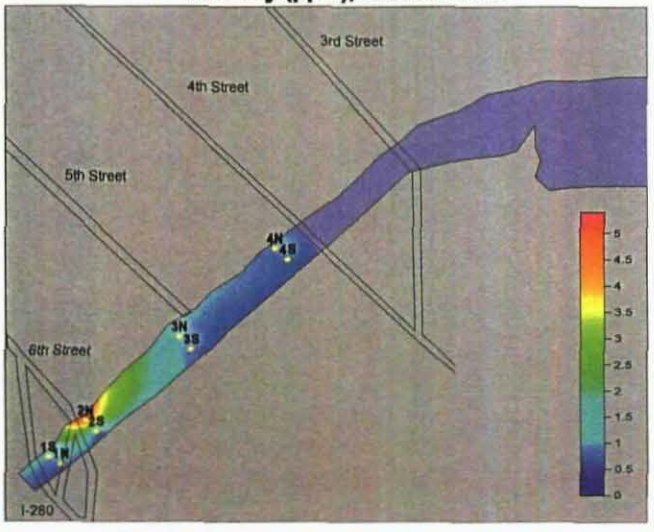


Appendix B4
SURFACE SEDIMENT DISTRIBUTIONS - MISSION CREEK

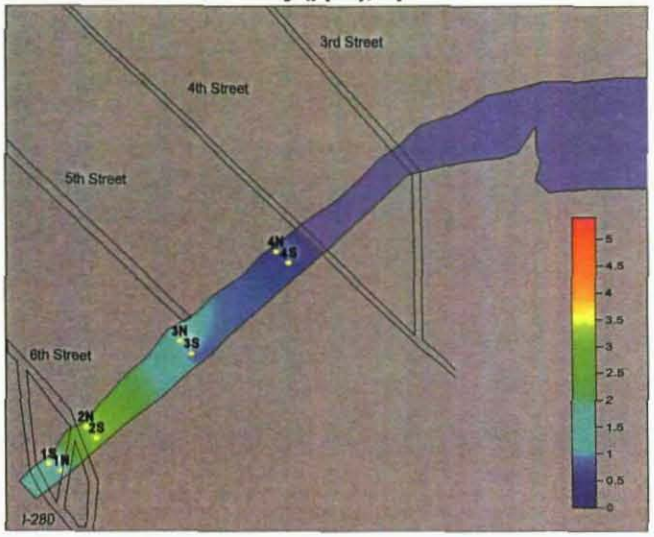
Mercury (ppm), October 1998



Mercury (ppm), October 1999

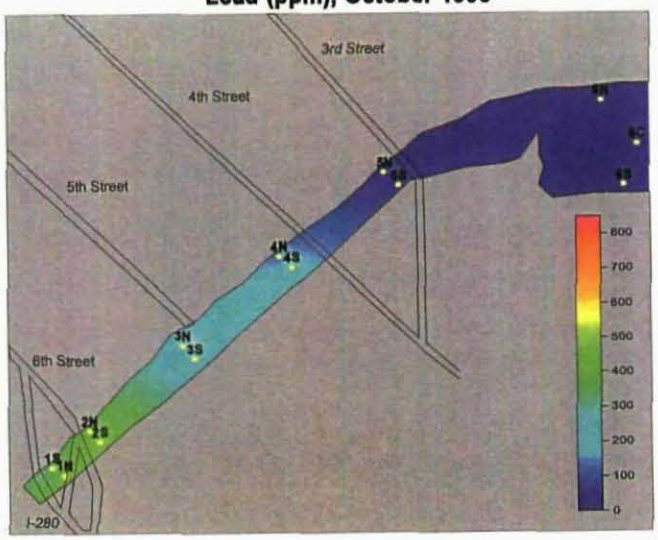


Mercury (ppm), April 2000

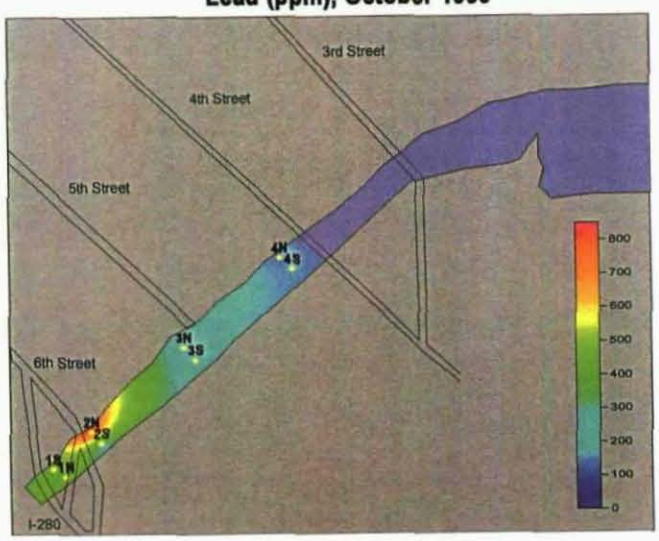


Appendix B4
SURFACE SEDIMENT DISTRIBUTIONS - MISSION CREEK

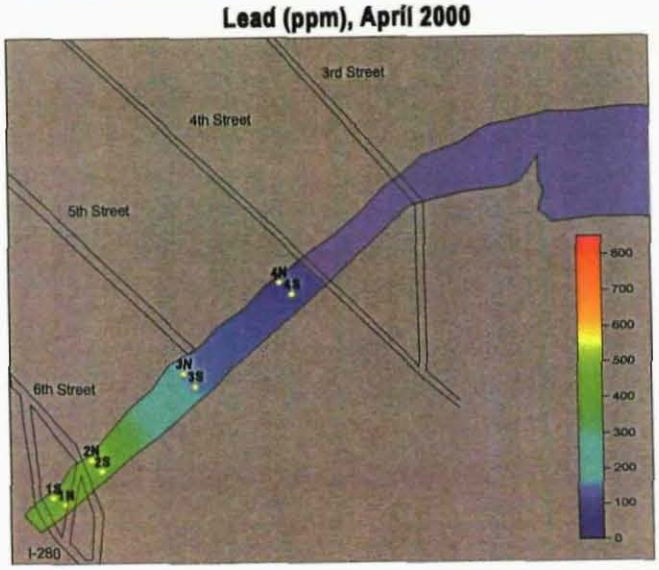
Lead (ppm), October 1998



Lead (ppm), October 1999

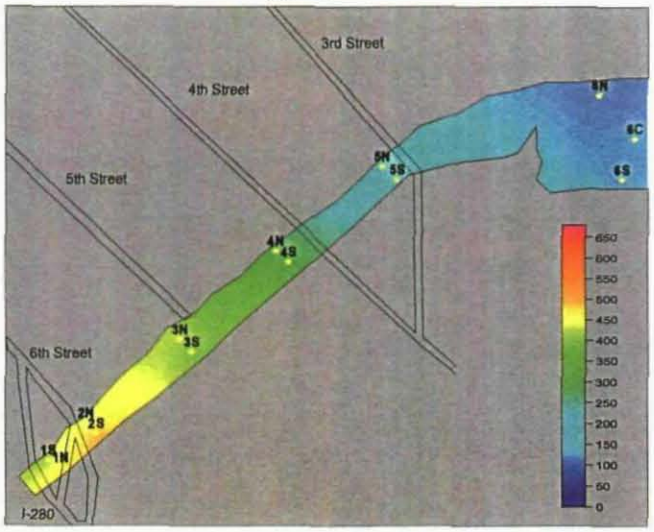


Lead (ppm), April 2000

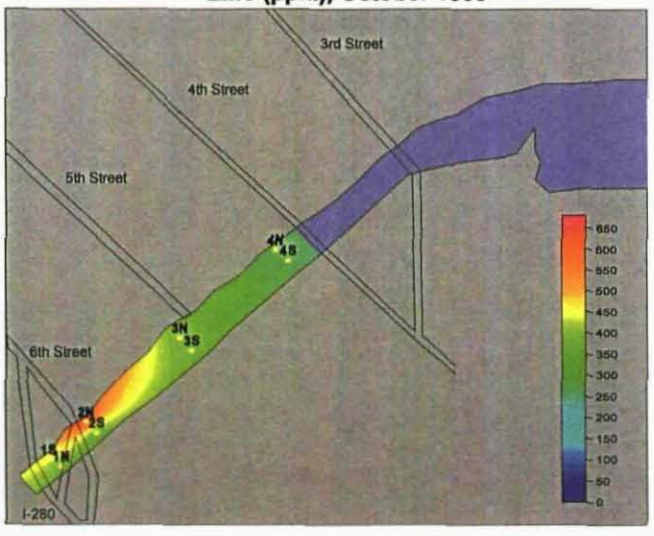


Appendix B4
SURFACE SEDIMENT DISTRIBUTIONS - MISSION CREEK

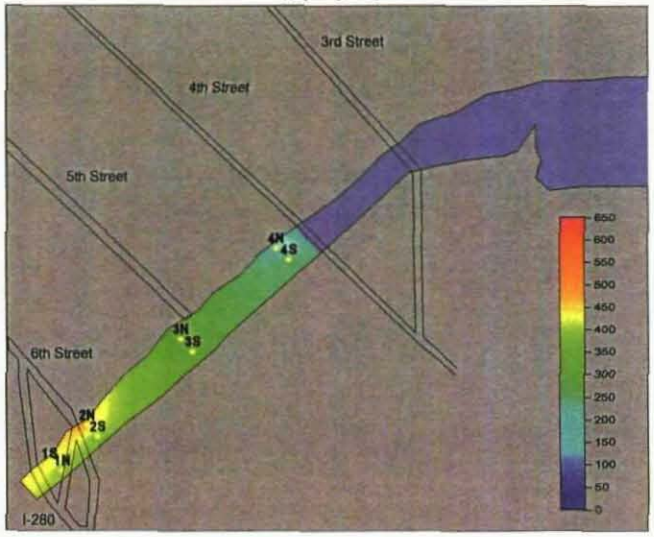
Zinc (ppm), October 1998



Zinc (ppm), October 1999

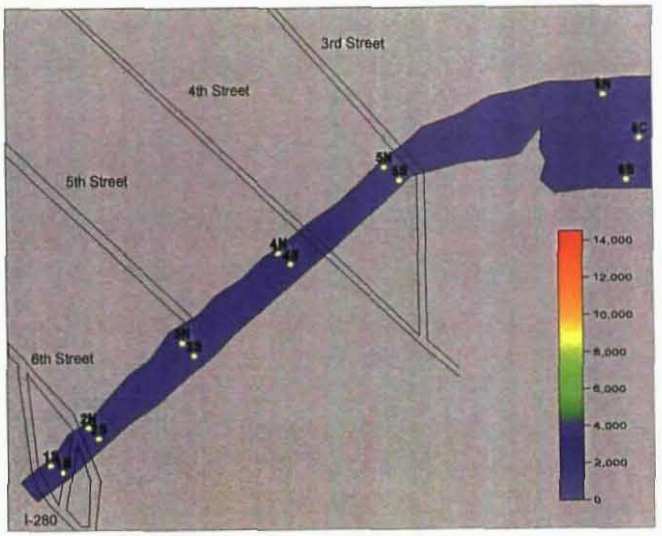


Zinc (ppm), April 2000

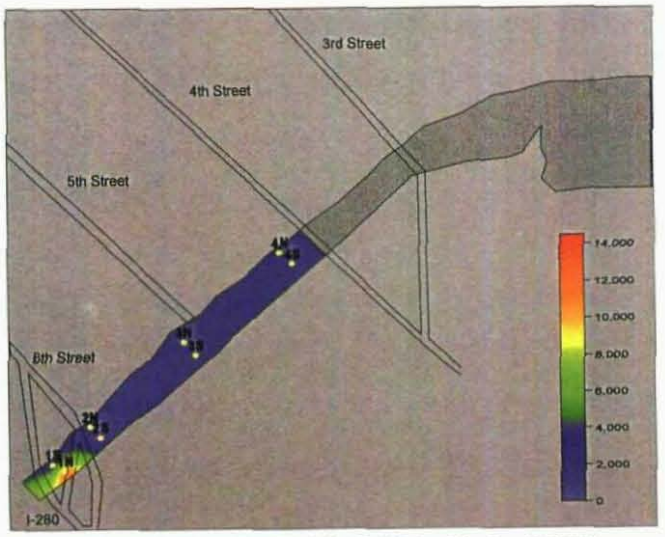


Appendix B4
SURFACE SEDIMENT DISTRIBUTIONS - MISSION CREEK

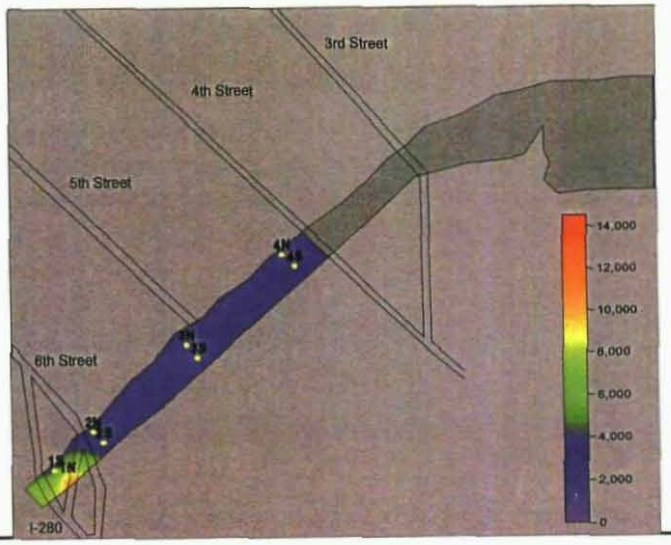
Low Molecular Weight PAH (ppb), October 1998



Low Molecular Weight PAH (ppb), October 1999

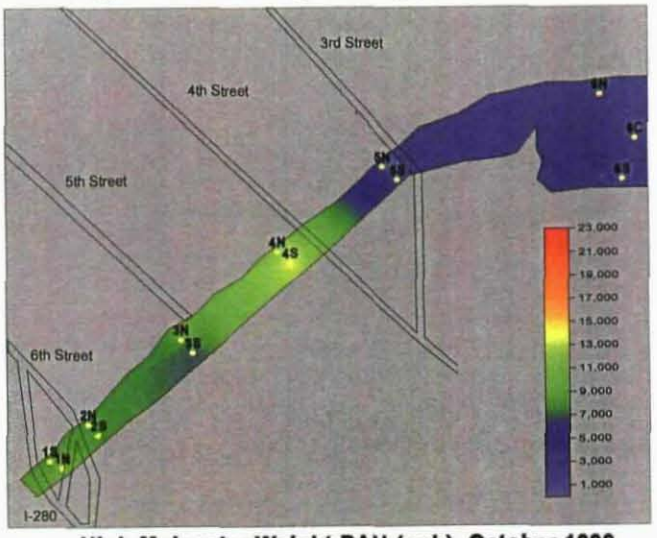


Low Molecular Weight PAH (ppb), April 2000

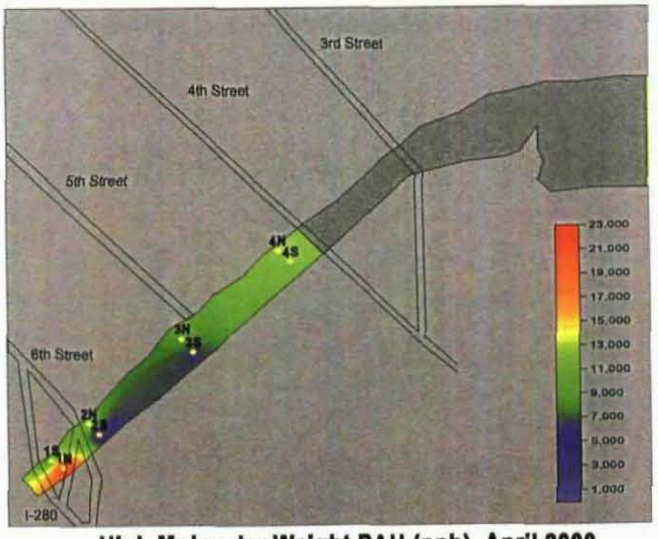


Appendix B4
SURFACE SEDIMENT DISTRIBUTIONS - MISSION CREEK

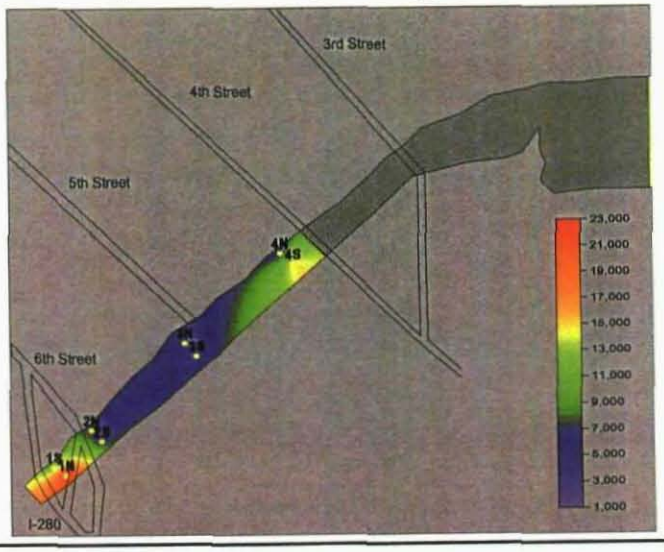
High Molecular Weight PAH (ppb), October 1998



High Molecular Weight PAH (ppb), October 1999

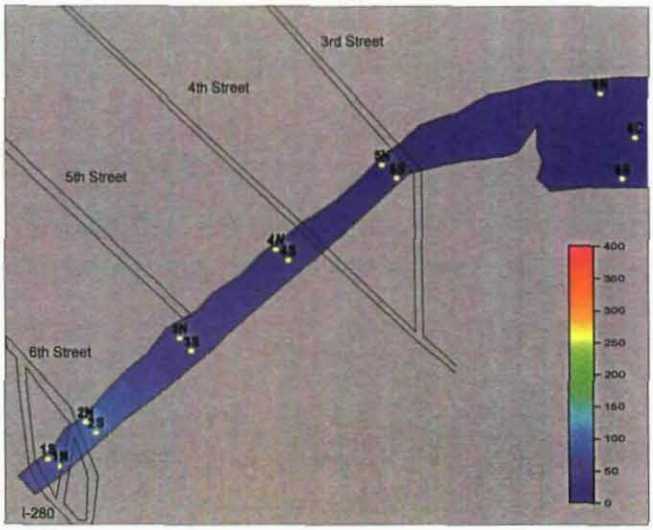


High Molecular Weight PAH (ppb), April 2000

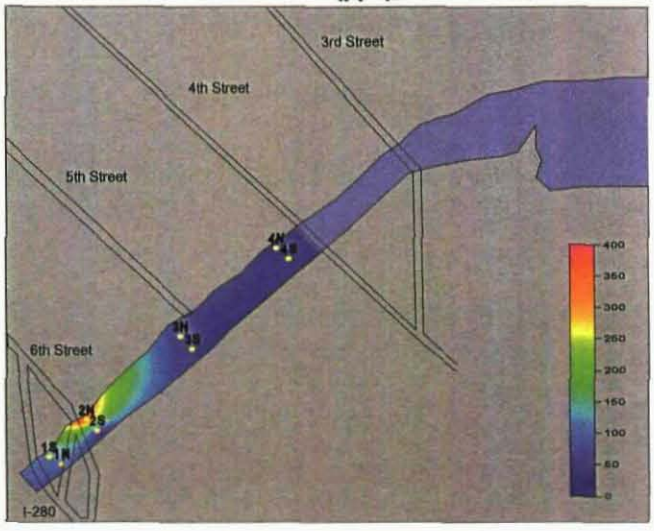


Appendix B4
SURFACE SEDIMENT DISTRIBUTIONS - MISSION CREEK

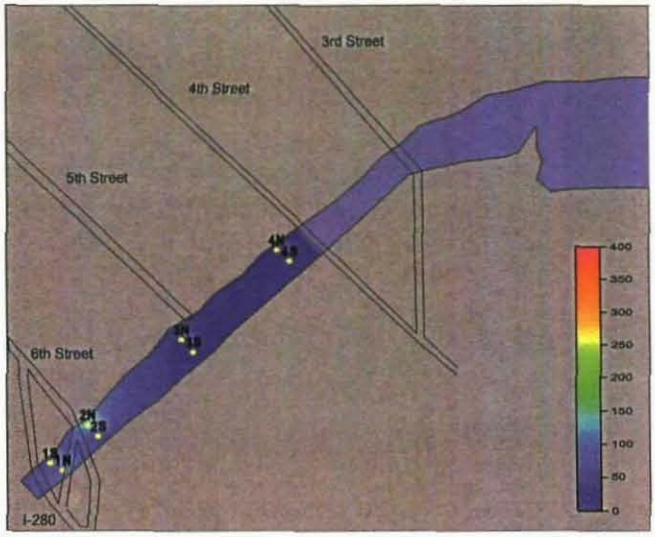
Total Chlordane (ppb), October 1998



Total Chlordane (ppb), October 1999

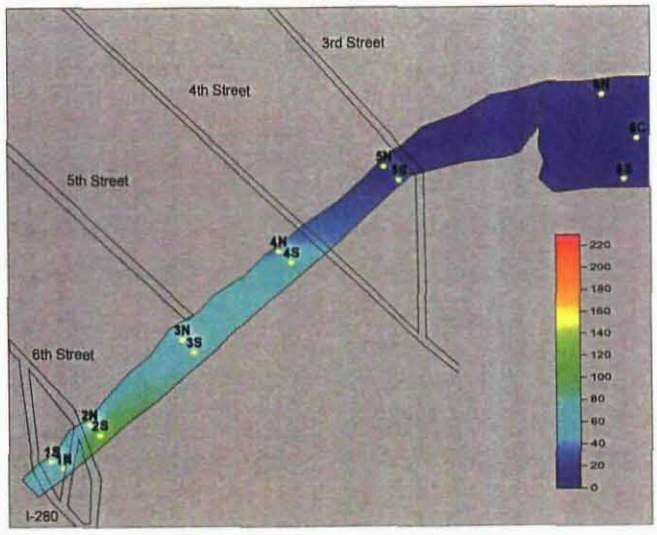


Total Chlordane (ppb), April 2000

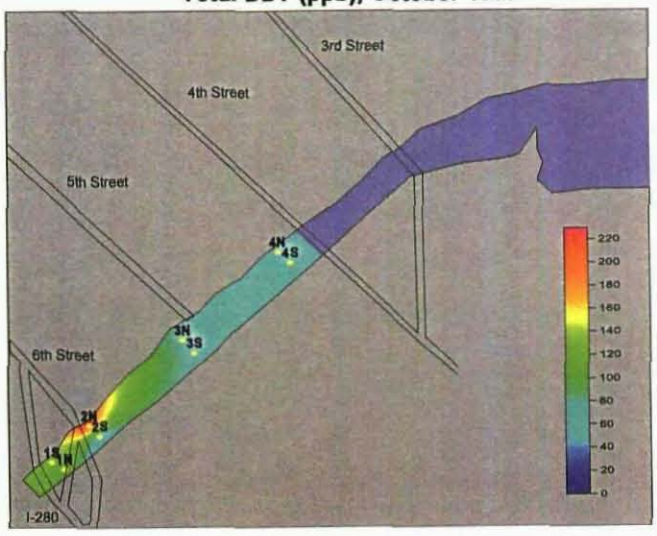


Appendix B4
SURFACE SEDIMENT DISTRIBUTIONS - MISSION CREEK

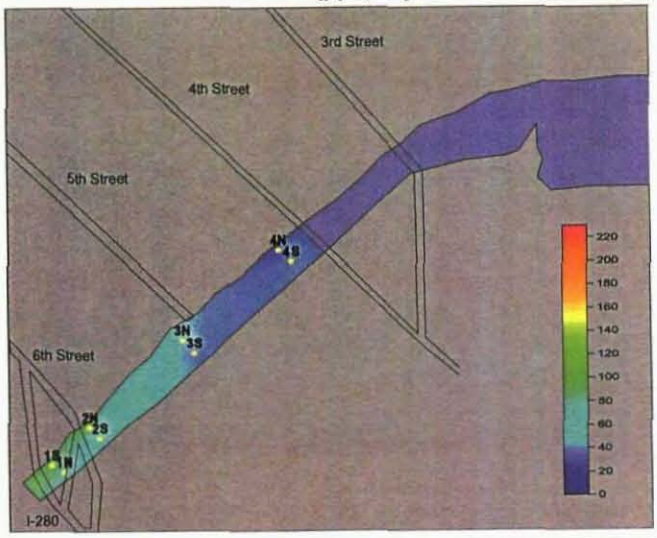
Total DDT (ppb), October 1998



Total DDT (ppb), October 1999

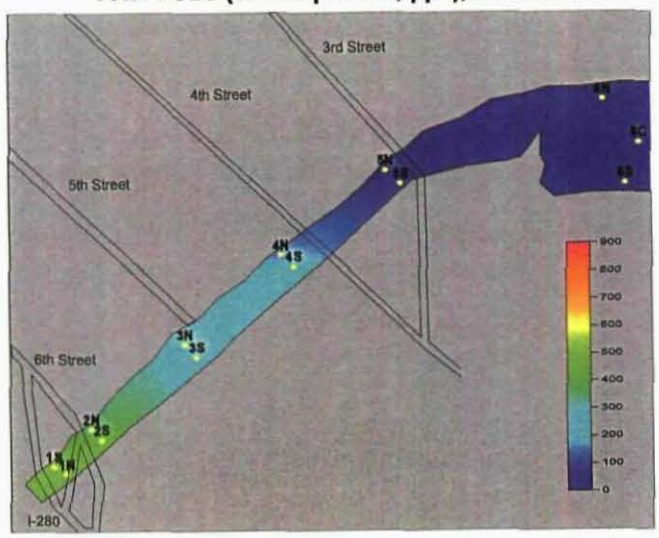


Total DDT (ppb), April 2000

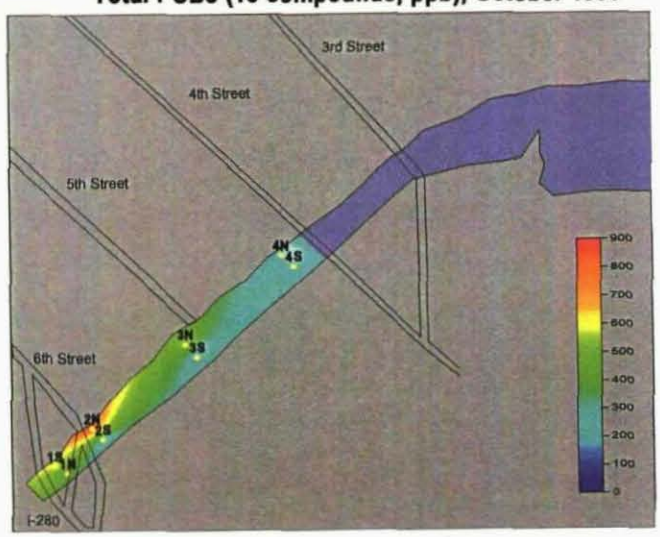


Appendix B4
SURFACE SEDIMENT DISTRIBUTIONS - MISSION CREEK

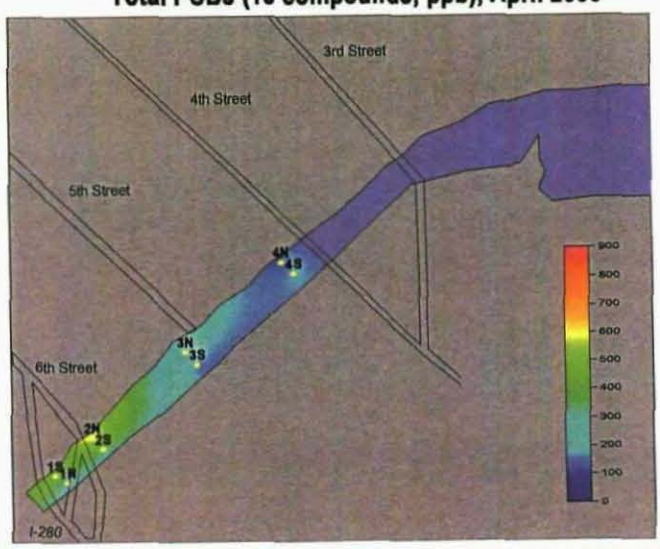
Total PCBs (18 compounds, ppb), October 1998



Total PCBs (18 compounds, ppb), October 1999



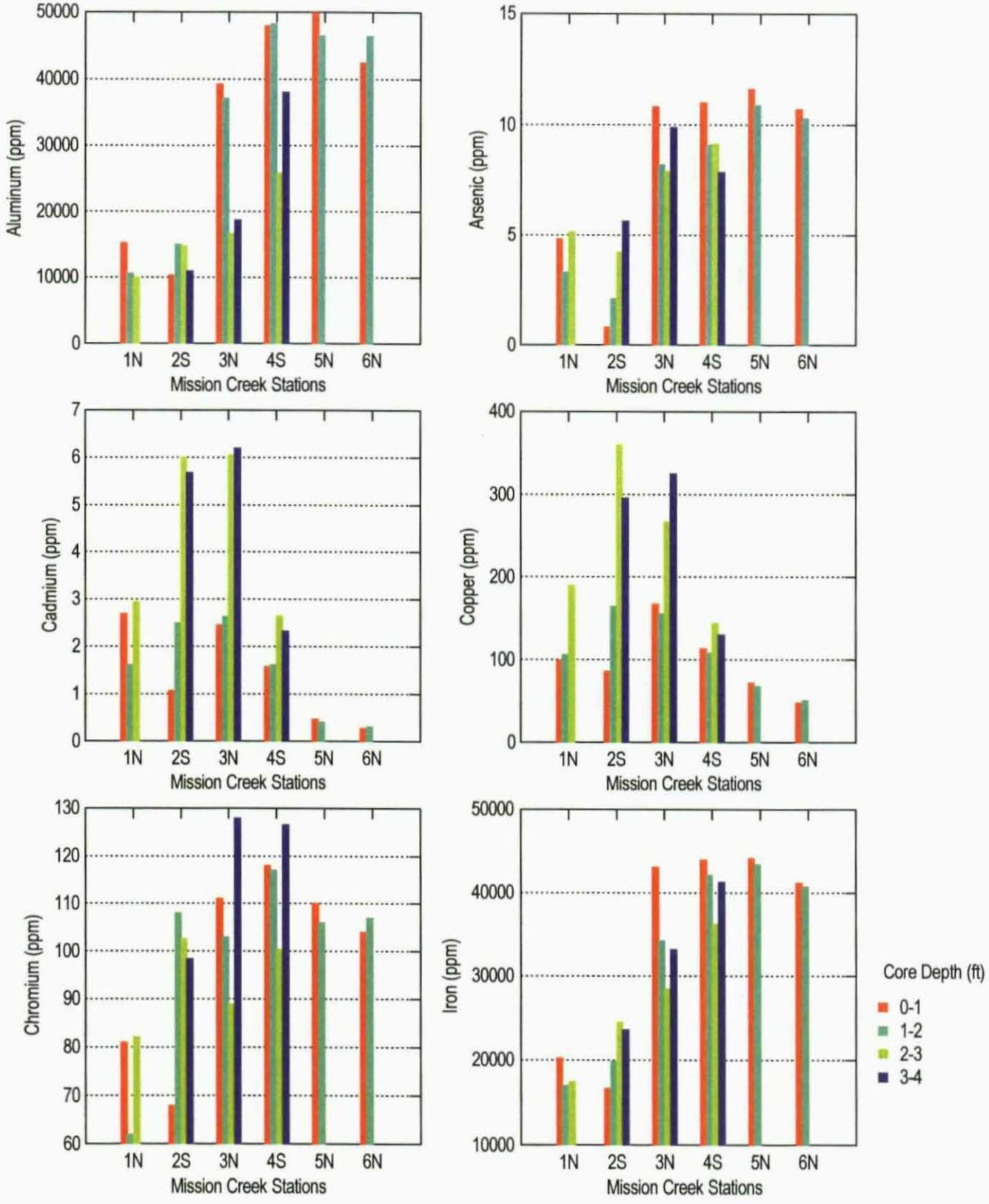
Total PCBs (18 compounds, ppb), April 2000



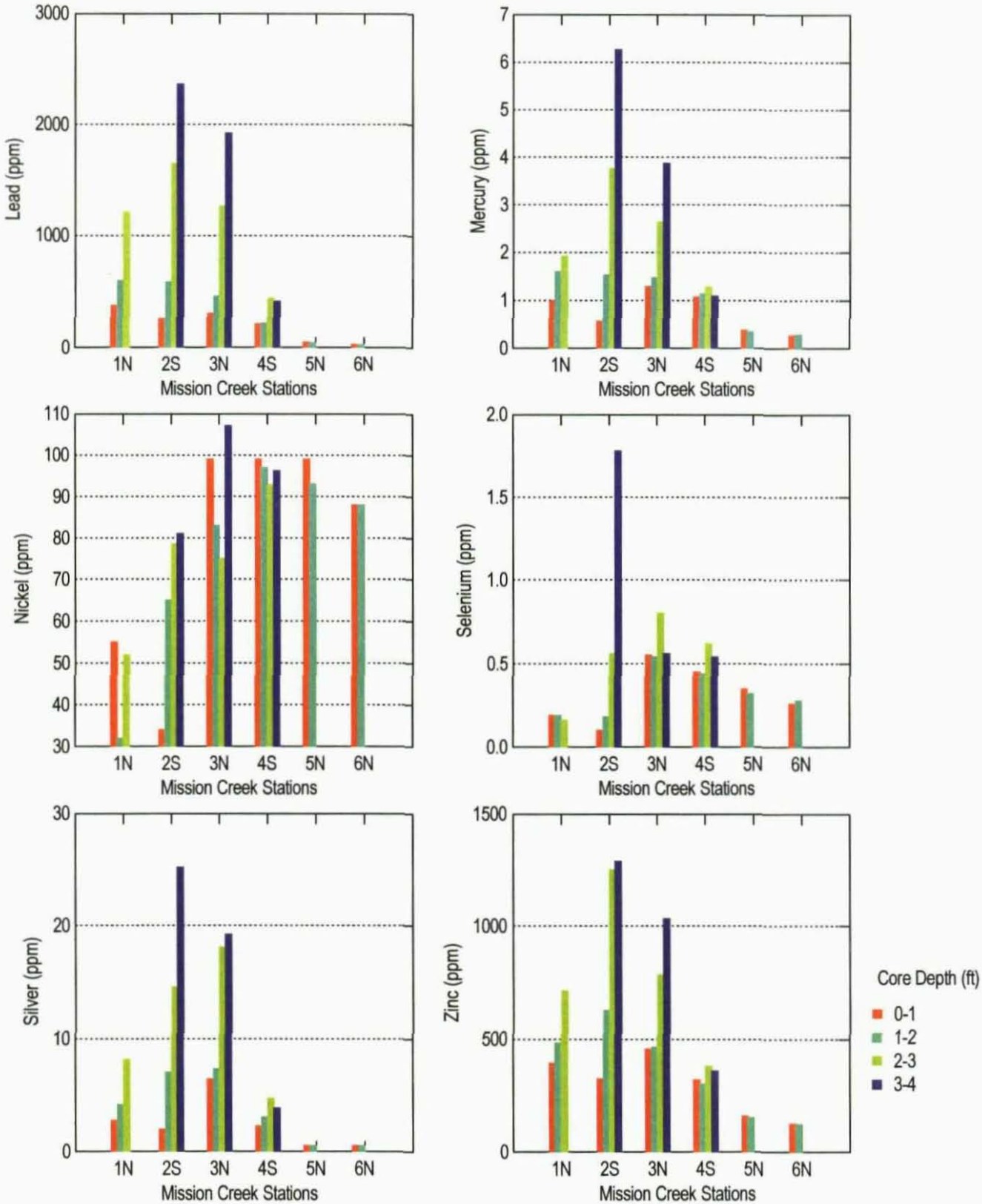
APPENDIX B5

Mission Creek
Subsurface Sediment Plots

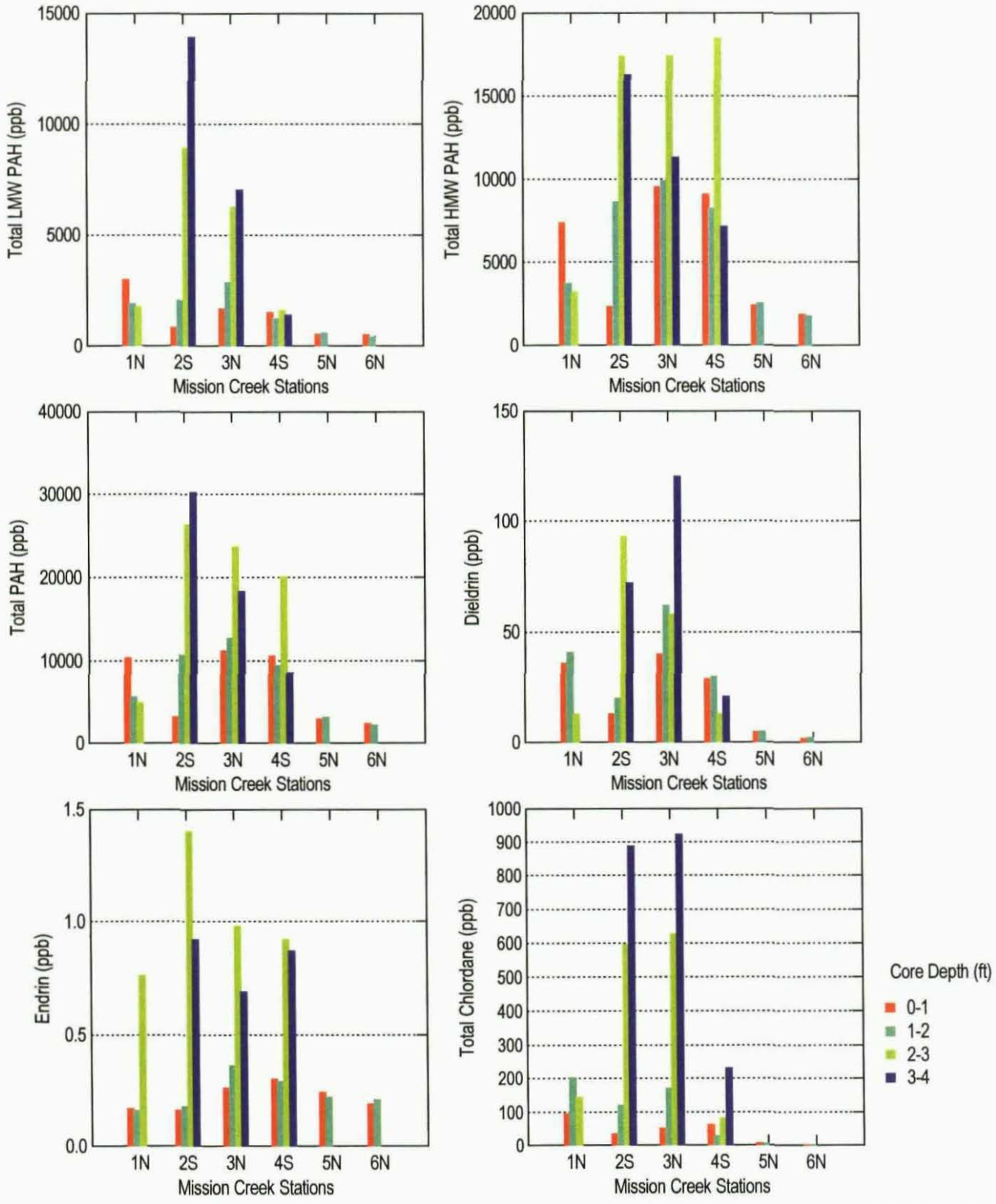
Appendix B5
SUBSURFACE SEDIMENT DISTRIBUTIONS - MISSION CREEK (October 1998)



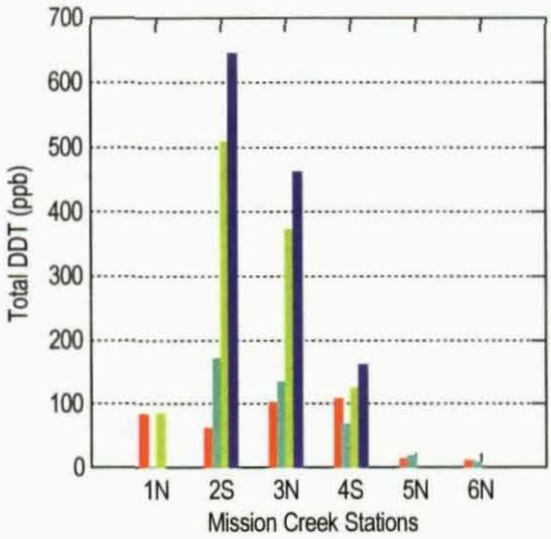
Appendix B5
SUBSURFACE SEDIMENT DISTRIBUTIONS - MISSION CREEK (October 1998)

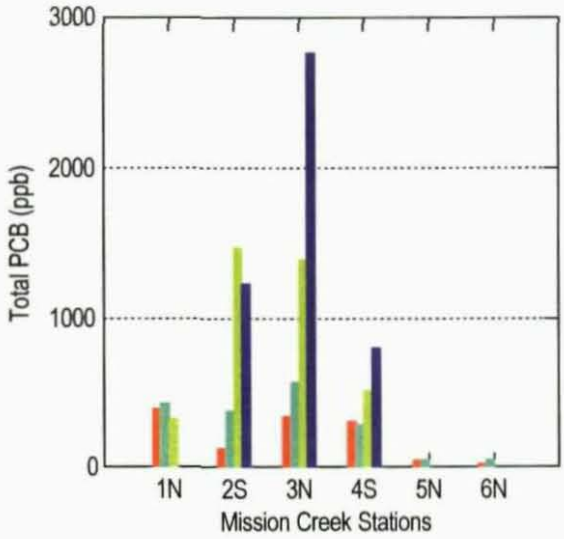


Appendix B5
SUBSURFACE SEDIMENT DISTRIBUTIONS - MISSION CREEK (October 1998)



Appendix B5
SUBSURFACE SEDIMENT DISTRIBUTIONS - MISSION CREEK (October 1998)





APPENDIX C

San Francisco Bay Sediment Quality Guidelines

APPENDIX C1

San Francisco Bay
ERMs and 85% Tolerance Limits

APPENDIX C1
Sediment chemical toxicity effects ranges-median (ERM) and BPTCP San Francisco Bay reference envelope 85% tolerance limits

Chemical Name	Tolerance Limit p = 0.85 (Hunt et al., 1998)	ERM (Long et al., 1995)
Aluminum	N/A	N/A
Antimony	N/A	N/A
Arsenic	15.3	70
Cadmium	0.33	9.6
Chromium	112	370
Copper	68.1	270
Iron	N/A	N/A
Lead	43.2	218
Manganese	N/A	N/A
Mercury	0.43	0.7
Nickel	112	51.6
Silver	0.58	3.7
Selenium	0.64	N/A
Tin	N/A	N/A
Zinc	158	410
Aldrin	N/A	N/A
Chloropyrifos	N/A	N/A
Total Chlordane	1.1	6
Dacthal	N/A	N/A
Total DDT (Swartz)	7.0	100 $ng \cdot g^{-1}$ OC
pp-Dichlorobenzophenone	N/A	N/A
Dieldrin	0.44	8
Endosulfan I	N/A	N/A
Endosulfan II	N/A	N/A
Endosulfan Sulfate	N/A	N/A
Endrin	N/A	45
Ethion	N/A	N/A
Alpha-HCH	N/A	N/A
Beta-HCH	N/A	N/A
Gamma-HCH (Lindane)	N/A	0.99 (PEL)
Delta-HCH	N/A	N/A
Heptachlor	N/A	N/A
Heptachlor Epoxide	N/A	N/A
Hexachlorobenzene	0.48	N/A
Methoxychlor	N/A	N/A
Mirex	N/A	N/A
Oxadiazon	N/A	N/A
Oxychlordane	N/A	N/A
Toxaphene	N/A	N/A
Tributyltin	N/A	N/A
Total PCB	14.8	180
Low MW PAHs	434	3160
High MW PAHs	3060	9600
Total PAHs	3390	44792
Total Organic Carbon	N/A	N/A
Mean ERM Quotent	N/A	N/A
Mean PEL Quotent	N/A	N/A

APPENDIX C2

Chemicals Used in ERM Quotients

Appendix C2
Chemicals used in ERM Quotients

Category	Chemical Name
Total Chlordane	alpha-Chlordane
	cis-Nonachlor
	gamma-Chlordane
	Oxychlordane
	trans-Nonachlor

Dieldrin	Dieldrin
Endrin	Endrin

Total DDTs	2,4'-DDD
	2,4'-DDE
	2,4'-DDT
	4,4'-DDD
	4,4'-DDE
	4,4'-DDT

Total PCBs	101 - 2,2',4,5,5'-Pentachlorobiphenyl (C15)
	105 - 2,3,3',4,4'-Pentachlorobiphenyl (C15)
	118 - 2,3',4,4',5-Pentachlorobiphenyl (C15)
	128 - 2,2',3,3',4,4'-Hexachlorobiphenyl (C16)
	138 - 2,2',3,4,4',5'-Hexachlorobiphenyl (C16)
	153 - 2,2',4,4',5,5'-Hexachlorobiphenyl (C16)
	170 - 2,2',3,3',4,4',5-Heptachlorobiphenyl (C17)
	180 - 2,2',3,4,4',5,5'-Heptachlorobiphenyl (C17)
	187 - 2,2',3,4',5,5',6-Heptachlorobiphenyl (C17)
	195 - 2,2',3,3',4,4',5,6-Octachlorobiphenyl
	206 - 2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (C17)
	209 - 2,2',3,3',4,4',5,5',6,6'-Decachlorobiphenyl (C110)
	28 - 2,4,4'-Trichlorobiphenyl (C13)
	44 - 2,2',3,5'-Tetrachlorobiphenyl (C14)
	52 - 2,2',5,5'-Tetrachlorobiphenyl (C14)
	66 - 2,3',4,4'-Tetrachlorobiphenyl (C14)
	18 - 2,2',5-Trichlorobiphenyl (C13)
	8 - 2,4'-Dichlorobiphenyl (C12)

abbrev	Battelle_Analyte	Battelle_order	Battelle_Hi_low	Group
N	Naphthalene	1	low	PAH
MN	2-Methylnaphthalene	6	low	PAH
AC	Acenaphthylene	11	low	PAH
ACE	Acenaphthene	12	low	PAH
F	Fluorene	13	low	PAH
P	Phenanthrene	17	low	PAH
A	Anthracene	18	low	PAH
FL	Fluoranthene	28	high	PAH
PY	Pyrene	29	high	PAH
BA	Benzo(a)anthracene	33	high	PAH
BA3	Benz(a)anthracene	33.3	high	PAH
C	Chrysene	34	high	PAH
BE	Benzo(e)pyrene	41	high	PAH
DA	Dibenz(a,h)anthracene	45	high	PAH