Elliott Bay Waterfront Recontamination Study

Volume I: Field Investigation Report

Elliott Bay/Duwamish Restoration Program

Prepared for the
Elliott Bay/Duwamish Restoration Program Panel
by the
Washington State Department of Ecology
Panel Publication 9
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Volume I: Field Investigation Report

Results of Monitoring Conducted along the Central Seattle Waterfront - October 1993 to October 1994

Elliott Bay/Duwamish Restoration Program

Prepared for the
Elliott Bay/Duwamish Restoration Program Panel
by

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Abstract

The Washington State Department of Ecology conducted a year-long field investigation between October 1993 and October 1994 along the central Seattle Waterfront to identify potential sources of sediment recontamination, mechanisms of contaminant transport and resuspension, and sedimentation rates. The primary purpose of the study was to determine the feasibility of conducting sediment cleanup along the waterfront, at the request of the Elliott Bay/Duwamish Restoration Panel.

The field investigation focused on the nearshore waterfront area extending from Terminal 46 on the south to Pier 59 on the north. To characterize physical and chemical conditions in this area of Elliott Bay, settling particulate matter, bottom sediments, sediment cores, current velocity measurements and vertical profiles of light transmittance were collected between October 1993 and October 1994. Estimates of bottom sediment resuspension rates are also provided.

The data generated from the field investigation (Volume I) are combined with other available information on the area in Volume II of the Elliott Bay Waterfront Recontamination Study to develop a conceptual site model for the study area. This site model is then used to provide remedial design recommendations which will guide future sediment cleanup projects along the Seattle Waterfront.

Summary

Introduction

The Elliott Bay/Duwamish Restoration Panel, which is composed of federal, state, and local agencies, and tribes, was formed under the terms of a settlement of a Natural Resource Damage Assessment. The panel's primary mission is to conduct sediment cleanup and habitat restoration in areas of Elliott Bay and the Duwamish River associated with METRO and City of Seattle outfalls. Recent studies (Romberg, P., 1993a,b,c and Hart Crowser, 1990) have indicated that recontamination of sediments along the Seattle Waterfront is a concern and could affect the success of cleanup projects in the area. Based on this information, the Panel decided to conduct a resuspension/recontamination study prior to final selection of cleanup sites along the waterfront.

Objectives

The Elliott Bay Waterfront Recontamination Study was designed to evaluate the feasibility of undertaking sediment remediation projects within the central Seattle Waterfront area by 1997. More specifically the study was directed at meeting the following objectives:

- Measure the rate of recontamination and determine the rate of sedimentation/natural recovery.
- Identify the components of recontamination and quantify the contribution of each component to the extent possible, including an evaluation of uncertainties.
- Model the impact of these recontamination processes on potential sediment remediation options for the waterfront area.
- If the rate of recontamination is unacceptable, identify source control and/or resuspension control measures that would reduce recontamination to an acceptable rate.
- Based on the above, provide recommendations to the Panel on whether cleanup along the waterfront is feasible, the most appropriate project location(s) for sediment remediation, and the size and type of project(s) that would have the greatest chance of success.

The Recontamination Study was carried out in two phases. Phase I was a year-long field investigation (October 1993 to October 1994) designed to fill data gaps that have been identified along the Seattle Waterfront. Phase II combined the results of the field investigation with existing information to develop a conceptual site model for the area. The Department of Ecology was selected to oversee and manage the overall Recontamination Study and conduct the field investigation. A modeling team, which consisted of a group of consultants, was contracted to perform modeling and provide remedial design recommendations. The results of this work are presented in Volume II of the Elliott Bay Waterfront Recontamination report.

During the process of scoping the field investigation the following data collection needs were identified to develop a conceptual site model:

- Characterize chemical concentrations (metals and organics) associated with settling particulate matter (SPM) at various points along the central Seattle Waterfront;
- Determine sediment accumulation rates in the study area, including an estimation of net sedimentation (deep burial) and resuspension (gross sedimentation minus net sedimentation);
- Estimate current velocity (speed and direction) in various portions of the nearshore waterfront area; and
- Identify sediment transport pathways and areas of deposition and erosion.

These data needs formed the basis of the field investigation study objectives. In addition, a number of studies were conducted in cooperation with the Recontamination Study to form a more comprehensive view of the processes occurring in Elliott Bay and the Duwamish River. These included a regional sediment transport study and two independent investigations of the effects of vessel prop wash on sediments.

Conclusions

In general, the spatial distribution of contaminants measured in SPM along the central Seattle Waterfront was in relatively good agreement with previous information on the area. Metals concentrations were fairly low and consistent during monitoring. An exception was mercury which exceeded Ecology's sediment Cleanup Screening Level (CSL) over a large portion of the study area (84% of the samples analyzed were >CSL). The average mercury concentration in SPM during the course of the study was 0.96 mg/kg, dry weight. This concentration is approximately 1.5 times higher than the CSL.

In contrast to metals, organics concentrations were variable both spatially and temporally along the waterfront. Peak concentrations of most organics tended to occur in the northern portion of the study area between Pier 52 (Ferry Terminal) and Pier 57. Concentrations of 18 individual organics exceeded levels in SPM which would be expected to produce some adverse effects on biological resources (the Sediment Quality Standard - SQS). Twelve of these compounds also exceeded the CSLs.

Vertical profiles in bottom cores indicate that in the northern portion of the study area (between Pier 52 and Pier 57) concentrations of most contaminants typically peak at depths ranging from 16 to 42 cm. In contrast, north of Pier 48 the highest concentrations were present in the top 7 cm. These data indicate that sediment cleanups in the northern portion of the study area that only involved sediment removal (i.e., dredging) would probably expose more highly contaminated material then currently exists at the surface.

Net current speeds (surface and bottom) at all locations were weak along the waterfront being <5.0 cm/sec. The mean net speed for the entire study period was 1.3 cm/sec. Although net speeds were weak, a number of short-term spikes (on the order of minutes) were observed in the current records. These maximums ranged from 5.8 to 135 cm/sec. The occurrence of spikes in the records suggests that short-term events such as vessel movements are affecting near bottom (3' above the bottom) current speeds.

Overall net current directions tend to be oriented parallel to the faces of piers. In addition a convergent zone which moves water offshore to the west in the vicinity of Pier 52 was present. This convergent zone located near Pier 52 appears to separate the study area hydrodynamically into a northern and southern region. The most likely explanation for the presence of this convergent zone is ferry operations at Pier 52. When docked, the ferries typically apply forward thrust to the stern propellers to hold the vessel in the berth during loading and unloading of cars and passengers. This causes an offshore current to be generated which moves away from Pier 52 to the west. The potential effects of vessel activities on nearshore currents is discussed in more detail in Volume II of the study report.

Gross sedimentation (net + resuspension) rates determined from bottom trap (3' above the bottom) data ranged from 0.3-1.8 g/cm^2/yr with a mean of 0.8±0.17 g/cm^2/yr. The highest rates were typically measured immediately south of the Seattle Ferry Terminal. Net sedimentation rates for the waterfront ranged from 0.1 - 0.72 g/cm^2/yr, with a mean of 0.28±0.26 g/cm^2/yr. Resuspension estimates for bottom sediments along the Seattle Waterfront ranged from 0.13±0.28 to 1.1±0.54 g/cm^2/yr.

Locations with the most variable gross sedimentation rates tended to correspond to areas with the highest amount of vessel traffic. These data in conjunction with current velocity measurements and ^{210}Pb results suggest that vessel movements play an important role in resuspending bottom sediments along the central Seattle Waterfront, especially during the summer and early fall.

In general, cores from the northern portion of the study area between Piers 54 and 57 exhibited vertical contaminant profiles with peak concentrations occurring at depth. This was especially true for mercury between Pier 56 and 57, where concentrations as high as 16 mg/kg, dry weight occurred at a depth of 105-168 cm. In contrast, maximum concentrations for most chemicals in a core collected north of Pier 48 occurred in the top 7 cm.

Recommendations

Based on the results of information collected during the field investigation portion of the Elliott Bay Waterfront Recontamination Study the following recommendations are made:

- Further evaluate the relative contributions of various bottom sediment resuspension processes such as vessel prop wash, vessel generated wakes, and wind generated waves. This information will be useful in the selection of appropriate remedial design options for the area.

- Evaluate the ability of selected sediment cleanup technologies to withstand vessel activities in the area. This would include an evaluation of design considerations such as water depth, appropriated capping materials (grain size), and necessary armoring to prevent erosion.

- Based on bottom current circulation patterns the northern (Pier 52 to Pier 59) and southern (Pier 52 to Pier 46) portions of the study area could probably be separated into distinct areas for remedial design purposes.

- In the northern portion of the study area, sediment removal alone (i.e., dredging) should not be used as a remediation technology due to the potential to expose more highly contaminated sediments.

A more detailed analysis of remedial design considerations is presented in Volume II of this report.

Acknowledgements

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1.0 Project Overview

This report presents the results of a field investigation conducted by the Washington State Department of Ecology (Ecology) to identify sources of recontamination along the Seattle waterfront, mechanisms of contaminant transport and resuspension, and sedimentation rates. The primary purpose of the Elliott Bay Waterfront Recontamination Study was to determine the feasibility of conducting sediment cleanup along the waterfront.

The study was funded by and conducted on behalf of the Elliott Bay/Duwamish Restoration Program Panel, which is composed of federal, state, and local agencies and tribes who have been entrusted with selecting areas for cleanup and habitat restoration in Elliott Bay and the Duwamish River. These activities are being conducted under a settlement between the federal, state, and tribal Natural Resource Trustees, METRO, and the City of Seattle. Cleanup and restoration activities under the settlement are to focus on areas associated with Combined Sewer Overflows (CSO) and storm drain outfalls operated by METRO and the City of Seattle.

The Panel has been evaluating potential cleanup sites in Elliott Bay and the Duwamish River, several of which are located along the central Seattle waterfront. Recent studies (Romberg, P., 1993a,b,c and Hart Crowser, 1990) suggested that recontamination of sediments along the waterfront was a concern and could affect the success of cleanup projects in the area. Based on this information, the Panel decided to conduct a resuspension/recontamination study prior to final selection of cleanup sites along the waterfront.

Potential sources of recontamination evaluated as part of the current study included ongoing discharges, local resuspension of contaminated sediments, and longshore transport of contaminated sediments from other areas (the Duwamish River to the south and contaminated shoreline to the north). The study focused on the nearshore waterfront area extending from Pier 48 on the south to Pier 59 on the north (see Figure 1), but included limited evaluation of more distant sources, including the Duwamish River plume and the Denny Way CSO.

Study Objectives

The Panel directed Ecology to provide preliminary information needed to answer the following general question by February 1995:

> **Is it feasible for the Panel to undertake sediment remediation projects within the waterfront area by 1997?**

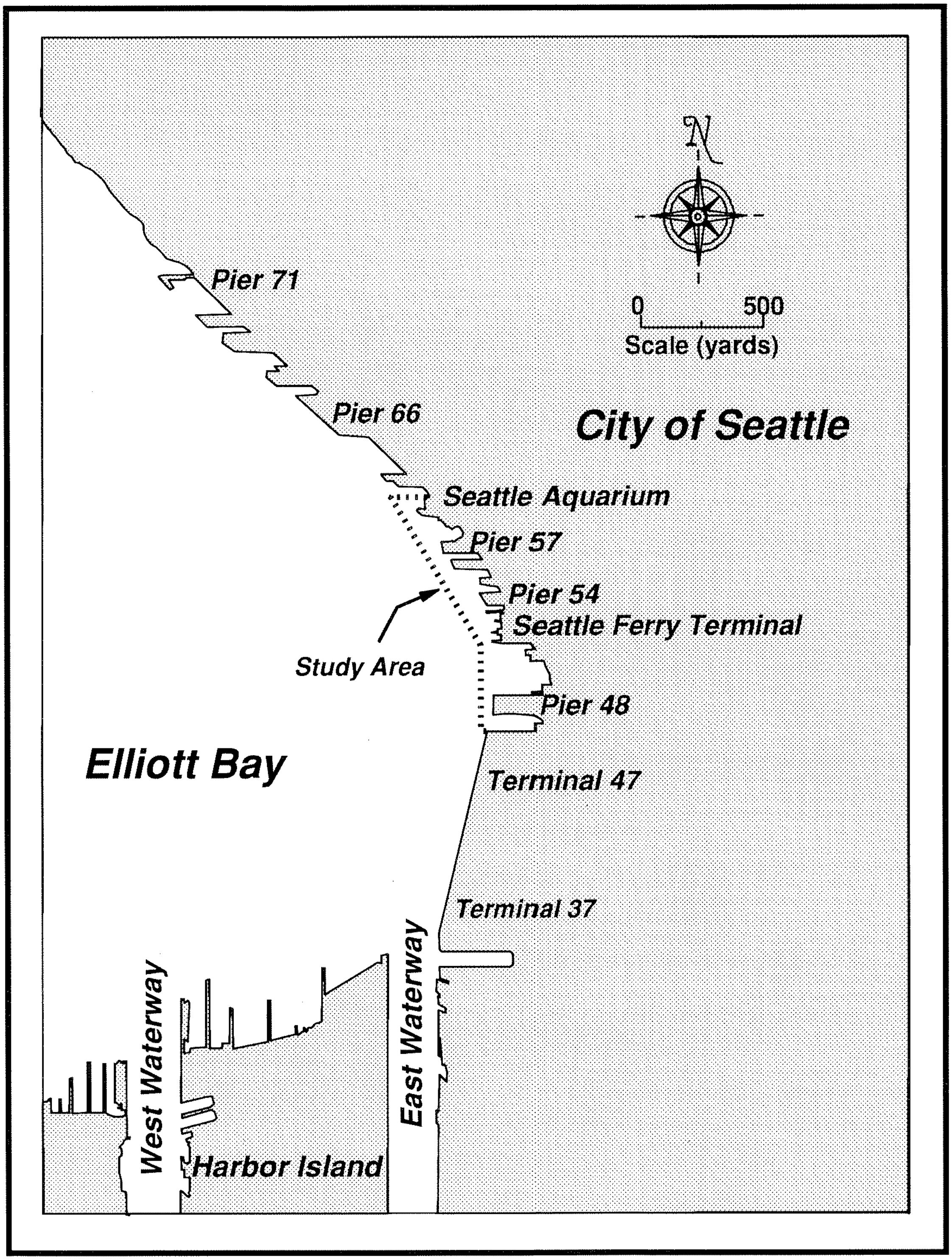

Figure 1: Elliott Bay Waterfront Recontamination Study Area.

More specifically, the waterfront study was directed toward meeting the objectives listed below:

- Measure the rate of recontamination and determine the rate of sedimentation/natural recovery.
- Identify the components of recontamination and quantify the contribution of each component to the extent possible, including an evaluation of uncertainties.
- Model the impact of these recontamination processes on potential sediment remediation options for the waterfront area.
- If the rate of recontamination is unacceptable, identify source control and/or resuspension control measures that would reduce recontamination to an acceptable rate.
- Based on the above, provide recommendations to the Panel on whether cleanup along the waterfront is feasible, the most appropriate project location(s) for sediment remediation, and the size and type of project(s) that would have the greatest chance of success.

Individual components of the overall recontamination study are described in the *Elliott Bay Waterfront Recontamination Study - Scope of Work* (Ecology, 1993). This volume of the study report discusses the results of a one-year field investigation (Phase I), which was focused on addressing the first two objectives described above. The following data collection needs were identified for the field investigation to achieve the overall objectives of the waterfront recontamination study:

- Characterize chemical concentrations (metals and organics) associated with settling particulate matter (SPM) at various points along the central Seattle Waterfront;
- Determine sediment accumulation rates in the study area, including an estimation of net sedimentation (deep burial) and resuspension (gross sedimentation - net sedimentation);
- Estimate current velocity (speed and direction) in various portions of the nearshore waterfront area; and
- Identify sediment transport pathways and areas of deposition and erosion.

Scoping Activities

A number of scoping activities were carried out before and during the field investigation to guide sampling activities and ensure that the field investigation would provide the data needed to answer the questions posed by the Panel. Prior to developing the sampling plan, a literature search was conducted to assist in identifying data gaps, selecting study locations, and interpreting results.

Topic areas covered by the literature search included currents, resuspension, distribution of suspended particulates, chemical analysis of suspended particulates, sediment trap studies, sediment accumulation rates, and bottom sediment surveys. For each subject area, a brief summary of current knowledge was prepared. In addition, ongoing monitoring activities along the waterfront were reviewed to determine whether data collected as part of these monitoring programs could be used to supplement the field investigation. A copy of the literature search is included in Appendix A, along with a detailed bibliography, keyed to topic areas.

A planning meeting was held on August 12, 1993 to scope the field investigation portion of the recontamination study. Participants in the planning meeting included Dr. Teresa Michelsen (Ecology overall project manager), Dale Norton (Ecology manager for the field investigation), Bob Clark (Panel representative), and nine additional local experts in the fields of sediment trap studies, sediment sampling, sediment transport, sedimentation rates, oceanography, geochemistry, aquatic chemistry, and modeling. The experts represent a wide range of relevant disciplines and include representatives of federal, state, and local agencies; academia; and consultants. An audience of approximately 50 people attended and provided additional input on the study design.

Prior to the meeting each participant was provided with a copy of the following background materials: description of the study objectives, the literature review, a proposed scope of work for the field investigation, an agenda, and questions for discussion. The experts were asked to follow up with written recommendations or comments within one week of the meeting. Meeting notes, along with the written recommendations of the experts, were used in revising the field investigation sampling plan.

In addition, a modeling team (Phase II) was selected in November 1993. This team provided valuable recommendations and mid-course corrections to the field study. Finally, the experts and interested audience participants were invited back to a presentation and discussion of the first six months of sampling results in July 1994, and a presentation of the final results in January 1995.

Modeling and Remedial Design Support

Volume II of the study report integrates the data collected during the field investigation with other available information (including a source control evaluation) and ongoing studies to develop a conceptual site model for the Seattle Waterfront. The potential effects of prop wash and wind waves are modeled and compared to data generated during the field investigation in Volume II of this report. Recommendations are made on areas that could effectively be cleaned up without significant recontamination. Finally, these data are used to provide recommendations on cap thickness and remedial technologies for areas under piers to provide support for the remedial design effort.

Related Studies

This investigation was conducted in cooperation with a number of studies that were ongoing simultaneously. The various studies, when taken together, provide a more comprehensive view of processes occurring in Elliott Bay and the Seattle Waterfront. These concurrent studies are briefly described below. In addition, information from these studies is evaluated along with data generated during the Waterfront Recontamination Study in Volume II of this report.

Regional Sediment Transport

A sediment transport study of Elliott Bay and the Duwamish River was conducted in October 1993 by GeoSea Consulting, and was partially funded by the Restoration Panel. The sediment transport study consisted of a grain size study of the Duwamish/Elliott Bay area to determine sediment transport pathways and potential linkages between contaminated sites in the region and areas of erosion, equilibrium, and sediment deposition. Results of the grain size study are provided separately in a report entitled *Sediment Transport in Elliott Bay and the Duwamish River: Implications to Estuarine Management* (GeoSea Consulting, 1994) and are discussed along with the results of this investigation in Volume II.

Vessel Prop Wash

Two independent investigations of the effects of prop wash on sediments along the Seattle Waterfront were undertaken during the study period. One modeling effort was conducted by the Washington State Department of Transportation (WDOT), Hart-Crowser, and Hartman Associates. This study was intended to determine the effects of the passenger-only ferries on contaminated bottom sediments south of the Seattle Ferry Terminal (Colman Dock- Pier 52). In addition, Michael Francisco (NOAA Panel secretary) completed a master's thesis for the University of Washington School of Marine Affairs entitled *Prop Wash Scour and the Management of Contaminated Sediments on the Seattle Central Waterfront* (Francisco, 1995). This investigation looked more widely at the potential for various vessels operating in or near the waterfront to resuspend contaminated sediments. Data were shared and jointly peer reviewed among these two investigations and the waterfront recontamination study. The data from all three investigations is discussed where relevant to the overall goals of the waterfront recontamination study in Volume II of this report.

2.0 Methods

Site Selection

Sampling locations for the field investigation are shown in Figure 2. These stations were selected to characterize spatial variability among different physical configurations occurring in the study area (*i.e.*, near CSO, under piers, within slips, and exposed pier faces). Detailed descriptions of each station and the purpose for its location are provided in Appendix B, Table B1.

Station positions were recorded with the use of a Magellan Nav 5000D® GPS receiver, in conjunction with depth readings. In addition, distances from fixed onshore structures were recorded. In general, water depths in the study area ranged from 23' (MLLW) to 72' (MLLW) with a mean of 42'. Generalized bathymetry for the study area is shown in Figure 3.

Sample Collection

To characterize conditions in the nearshore area of the central Seattle Waterfront settling particulate matter (SPM), bottom sediments, sediment cores, current velocity measurements and vertical profiles of light transmittance were collected between October 1993 and October 1994. To evaluate seasonal variations, the study period was divided into four sampling quarters: Quarter 1= October to December 1993; Quarter 2= January to April 1994; Quarter 3= May to July 1994; and Quarter 4= August to October 1994. Table 1 presents a summary of the sampling conducted for the field investigation. In addition, each component of the field investigation is briefly described below. All field work was conducted in accordance with procedures outlined in the *Elliott Bay Waterfront Recontamination Study: Sampling and Analysis Plan; and Health and Safety Plan.* A copy of the Sampling and Analysis plan (SAP) is included in Appendix A. Modifications to the SAP which occurred during the course of the study are also documented in Appendix A.

Sediment

Nearshore Grain Size Mapping

To define depositional and erosional environments within the study area and aid with selection of bottom core sampling points, 69 surface sediment samples (top 2 cm) were collected along 15 transects (north to south) and analyzed for grain size distribution (PSEP, 1986). Where feasible, spacing between stations was 40 yards moving offshore to a maximum depth of 60 feet and 50 yards between transects moving north to south. However, due to physical constraints

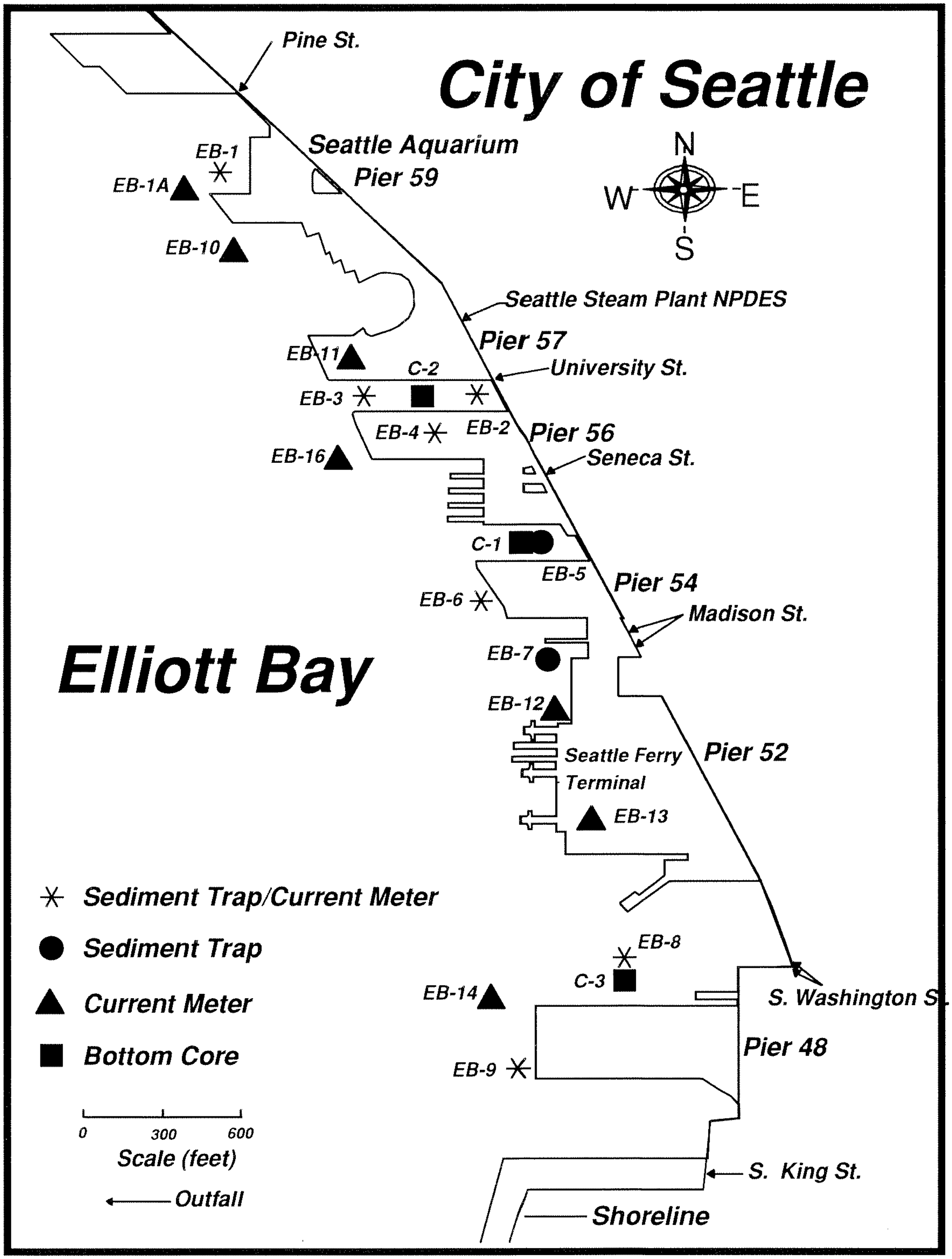

Figure 2: Station locations for the Elliott Bay Waterfront Recontamination Study.

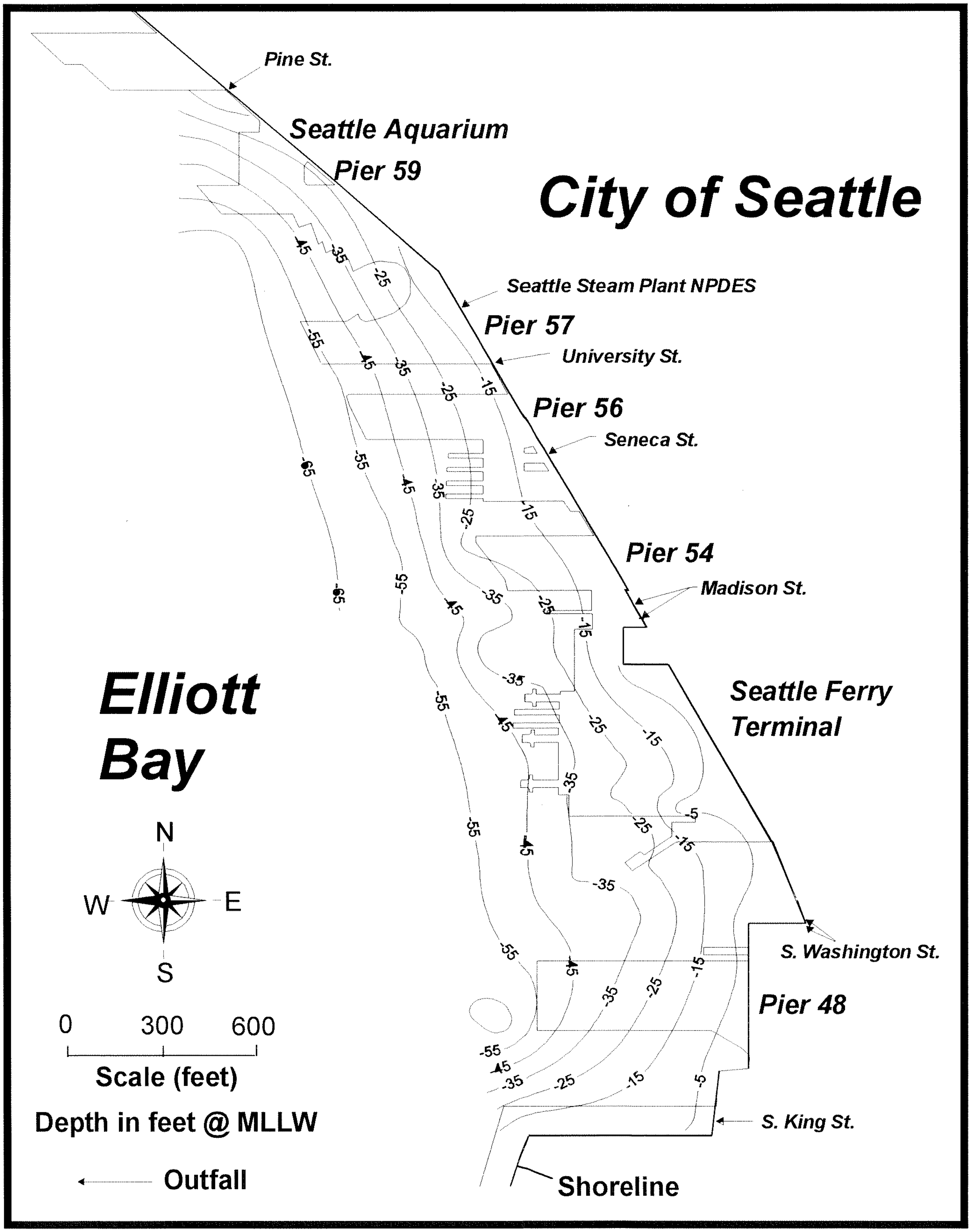

Figure 3: Bathymetry for the Elliott Bay Waterfront Recontamination Study area.

Table 1: Summary of sampling conducted for the Elliott Bay Waterfront Recontamination Study, October 1993 to October 1994.

Analysis	Sampler	Number Stations	Sampling Frequency	Duration of Deployments
I. WATER				
Light Transmittance	SeaTech 25cm Beam Transmissometer	One	Bi-weekly	Six Months
Current Velocity	Aanderra RCM-4	Six	Quarterly	One Year
" "	Interocean S4	Eleven	Monthly	Nine Months
II. SETTLING PARTICULATE MATTER				
Percent Solids	Sediment Traps	Nine	Quarterly	One Year
Grain Size	"	"	"	"
Total Organic Carbon	"	"	"	"
Total Metals				
Aluminum	"	"	"	"
Arsenic	"	"	"	"
Cadmium	"	"	"	"
Chromium	"	"	"	"
Copper	"	"	"	"
Iron	"	"	"	"
Lead	"	"	"	"
Manganese	"	"	"	"
Mercury	"	"	"	"
Silver	"	"	"	"
Zinc	"	"	"	"
Organics				
Semivolatiles	"	"	"	"
PCBs	"	"	"	"
Pb-210	"	"	"	"
III. BOTTOM SEDIMENT CORES				
Percent Solids	4" Barrel Core	Three	Once	N/A
Grain Size	"	"	"	"
Total Organic Carbon	"	"	"	"
Metals				
Aluminum	"	"	"	"
Copper	"	"	"	"
Iron	"	"	"	"
Lead	"	"	"	"
Manganese	"	"	"	"
Mercury	"	"	"	"
Zinc	"	"	"	"
Organics				
PCBs	"	"	"	"
Pb-210	"	"	"	"
Cs-137	"	"	"	"
IV. BOTTOM SEDIMENT				
Grain Size Mapping	Van Veen/Ponar	Sixty Nine	Once	N/A

encountered in the field this grid was modified. Final locations of the grain size stations are shown in Figure 4.

Settling Particulate Matter

At nine stations SPM was collected with the use of moored sediment traps positioned three feet above the bottom. In addition, to evaluate surface (low salinity) and bottom (high salinity) conditions, at two locations (EB-1 and EB-6) sediment traps were also deployed on floating moorings designed to keep the traps at a constant position of three feet below the water surface. The location of each of the sediment trap stations is shown in Figure 2. The traps were deployed beginning in October 1993 and sampled every three months thereafter, until October 1994. The deployment and retrieval schedule for each trap in shown in Appendix B, Table B2.

A diagram of the mooring configuration and construction details of the traps is shown in Appendix B, Figure B1. These traps have been used successfully by Ecology in the waterways of Commencement Bay over the past six years to monitor contaminant concentrations associated with SPM and estimate bottom sediment resuspension rates (Norton and Barnard, 1992a,b; Norton, 1993).

Briefly, the traps are straight-sided glass cylinders with a collection area of 78.5 cm^2 and a height to width ratio of 5. Each mooring holds two cylinders for a total collection area of 157 cm^2 per mooring. To collect enough material for quarterly analysis of all parameters and reduce the possibility of missing data points, two independent moorings were installed at each station.

Prior to deployment, the collection cylinders were cleaned with sequential washes of hot tap water/Liquinox® detergent, 10% nitric acid, distilled deionized water, and pesticide grade acetone, then wrapped in aluminum foil until used in the field. At deployment the traps were filled with two liters of high salinity distilled water (4% NaCl), which contains sodium azide (2%) as a preservative to reduce microbial degradation of the samples during the deployment period.

Upon retrieval of the traps, water overlying the sediment layer in the collection cylinders was removed with a peristaltic pump. The salinity of water immediately overlying the sediment layer was determined to see if the traps had been disturbed and preservative was still present. SPM was then transferred to 1/2 gallon sample containers and taken to the laboratory for processing, where the particulate fraction was isolated with the use of a centrifuge. Prior to determining sample weights and conducting physical and chemical analyses all visual nekton >2cm was removed from the samples.

Bottom Sediment Coring

To supplement existing data on the area, three sediment cores were collected for ^{210}Pb and ^{137}Cs

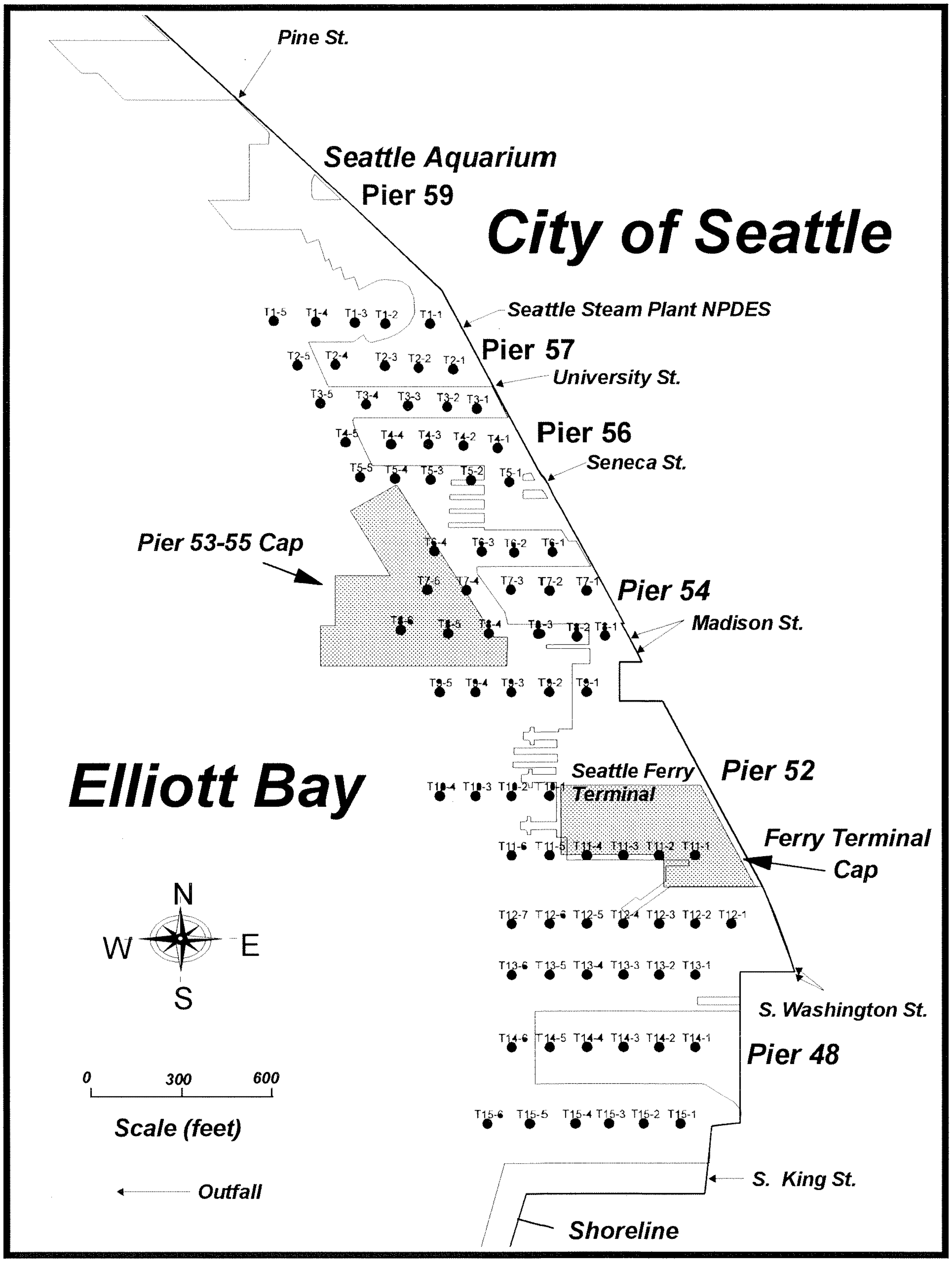

Figure 4: Grain size mapping stations for the Elliott Bay Waterfront Recontamination Study.

dating and selected chemical analysis. The location of the sediment cores are also shown in Figure 2.

All cores were collected using a gravity corer deployed from the *R/V Kittiwake*. The barrel corer was equipped with a stainless steel core cutter and brass core catcher mounted on the end of a four inch diameter by six foot long PVC barrel. Sediment recoveries obtained with this apparatus ranged in length from 84 to 155 cm (compacted).

Upon retrieval of the sampler both sediment penetration and sediment recovery were recorded before extruding the core onto a foil-lined table for processing. Each core was sectioned with the use of pre-cleaned stainless steel pie servers. Field logs for each of the cores, which describe the physical characteristics of the sediment obtained and the sections retained for analysis, are included in Appendix B.

Water

Current Velocity

Current velocity (speed and direction) measurements were made at a total of 14 stations described below. Aanderra® Model RCM-4 current meters were placed at six stations (EB-1, EB-1A, EB-3, EB-6, EB-8, and EB-9) to measure near bottom current velocities. These meters were deployed three feet off the bottom and sampled quarterly for a period of one year. The meter at station EB-1 was moved offshore to station EB-1A during the third and fourth quarter of monitoring to better reflect conditions outside the pier line. In addition to the bottom meters, at station EB-6 one meter was placed in the upper seven feet of the water column to measure surface current velocities. Each meter was set to take instantaneous readings every 15 minutes for all channels except current speed. Current speed was recorded as 15 minute averages.

Current velocity information from the first quarter of monitoring indicated that a significant portion of the current speeds in the study area was below the RCM4's recording threshold of 2.5 cm/sec. To better characterize current velocities <2.5 cm/sec, starting on January 28 and ending October 14 two Interocean® S4 current meters were rotated monthly among a total of 11 locations (EB-1A, EB-2, EB-4, EB-6 (surface), EB-6 (bottom), EB-8, EB-9, EB-10, EB-11, EB-12, EB-13, EB-14). The S4 meters were set to record one minute averages for all channels every 15 minutes.

In addition, to estimate the effects of vessel prop wash on bottom currents at two locations (EB-8 and EB-16) S4 current meters were deployed for two days between October 25-27 and set to record 30 second averages of current velocity continuously. This recording frequency was used to evaluate spikes anticipated from short-term events.

Transmissometers

An attempt was made to evaluate the height of sediment resuspension at station EB-6 with the use of three 25 cm beam transmissometers in a vertical array at three depths. Transmissometers were placed at heights of two feet, ten feet, and 20 feet above the bottom. These instruments were serviced (change batteries, clean optics, and download stored data) every two weeks, between January and June 1994.

Sample Handling

All sediment samples were placed in appropriate containers, properly labeled and held on ice in insulated coolers while in the field. Ice was kept in watertight bags to prevent potential contamination of the samples. SPM samples were frozen within 12 hours of collection until processed at the laboratory. All bottom sediment samples were held at 4°C and delivered fresh to the laboratory within 24 hours of collection.

Sample tracking procedures followed those outlined in the Manchester Laboratory Users Manual (Ecology, 1991a). Briefly, Chain-of-Custody forms were completed for each set of samples. The chief scientist was responsible for ensuring that these forms were properly completed and signed at the time of sample transfer.

Sample Analysis and Quality Assurance

All physical/chemical analyses of samples for the Elliott Bay Recontamination Study were conducted using procedures specified in the Puget Sound Protocols (PSEP, 1986) as amended and updated, except for Total Organic Carbon (TOC), which was analyzed according to the 1993 PSSDA modifications to the PSEP method. In addition, the type and frequency of laboratory quality assurance (QA) samples at a minimum followed those specified in the Manchester QA Manual (Ecology, 1988). Table 2 summarizes the analytical methods and laboratories used for the field investigation.

All laboratories conducting analyses for this study supplied information to support a QA1 review of the data as specified in *PSDDA Guidance Manual - Data Quality Evaluation for Proposed Dredged Material Disposal Projects* (PTI, 1989). Quality of the data sets were evaluated with the use of the following sample types: duplicates, matrix spikes, internal standards, surrogate spikes, reference materials and method blanks. QA samples and their frequency of analysis for this project are summarized in Appendix C, Table C1. Results of analysis of reference materials and blind field duplicates are also summarized in Appendix C, Tables C2-C4. A detailed QA review of each data set was performed by staff at the Ecology/EPA Manchester Laboratory. Individual case narratives for each data set are provided in Appendix C.

Table 2: Summary of analytical methods for Elliott Bay Waterfront Recontamination Study.

Analysis	Method	Reference	Laboratory
Percent Solids	Dry @ 104°C	PSEP, 1986	Ecology/EPA- Manchester, WA.
Grain Size	Seive and Pipet Apparent (w/o H2O2 addition) True (w/ H2O2 addition)	PSEP, 1986	Soil Technology Inc.- Bainbridge Is., WA.
Total Organic Carbon	Combustion/CO2 Measurement as modified by PSSDA	PSDDA, 1993	Weyerhaeuser Tech. Center- Tacoma, WA. Analytical Resources Inc.- Seattle, WA Sound Analytical Services- Tacoma, WA.
Total Metals			
Aluminum	ICP	EPA, 1986	Ecology/EPA- Manchester, WA.
Arsenic	GFAA	"	"
Cadmium	GFAA	"	"
Chromium	ICP	"	"
Copper	ICP	"	"
Iron	ICP	"	"
Lead	GFAA	"	"
Manganese	ICP	"	"
Mercury	CVAA	"	"
Silver	ICP	"	"
Zinc	ICP	"	"
Organics			
Semivolatiles	GC/MS #8270	EPA, 1986	Ecology/EPA- Manchester, WA.
PCBs	GC/ECD #8080	"	"
Radiodating			
Pb-210	Polonium-210 activity	Koide et.al., 1973	Battelle Northwest- Sequim, WA.
Cs-137	Gamma Spectroscopy	-	"

Overall, no major analytical problems were encountered in the analysis of samples for the study. Notable exceptions to this statement are discussed below. Consequently, the data generated are considered acceptable for use as qualified in the following data tables and noted in the case narratives (Appendix C).

Silver results for all collections are qualified as estimates based on low recoveries obtained in the analysis of matrix spikes and reference materials. It is believed that the results underestimate actual environmental levels Consequently the reported silver data should be used with caution. To a lesser extent, low spike recoveries were also obtained for arsenic in all SPM samples, mercury in SPM during the first quarter and lead and zinc in bottom cores. As a result, these data have also been qualified as estimated values. The reader is referred to Appendix C case narratives and Table C2 for more details.

Variable detection limits were obtained for a number of the semivolatile organics between monitoring quarters which hindered some data interpretations. The presence of high background concentrations of aromatic hydrocarbons, lipids, and sulfur in a number of the samples is the most likely explanation for the degradation in quantitation limits.

Unless otherwise noted all concentrations in this document are reported on a dry weight basis. All of the raw physical and chemical data generated during this study have been compiled in a separate data report. Limited copies of this data report are available by contacting Ecology's Publications Office (see inside front cover of this report).

Results and Discussion

Water

Transmissometers

Results of transmissometer measurements collected at the west end of Pier 54 were analyzed by Mike Francisco of NOAA and are discussed in Volume II of the report as part of the conceptual site model.

Current Velocity

To characterize current velocities (speed and direction) in the study area 39 current meter records were collected and analyzed. Table 3 presents a summary of the current meter data collected.

Examination of these data indicates that net current speeds (the sum of the vector additions of all current vectors contained in the usable record) are quite weak in the study area being <5.0 cm/sec. The net speed average for all records was 1.3 cm/sec. The highest net speeds were typically measured near the surface at the west end of Pier 54 (EB-6).

Although net speeds were low along the waterfront, a number of short-term spikes (on the order of minutes in duration) were observed in the current records. These maximums ranged from 5.8 to 135 cm/sec. The occurrence of spikes in the current records suggest that short-term events such as vessel movements along the waterfront are affecting near bottom current speeds. Current records for the study area are analyzed in greater detail in Volume II of this report.

Generalized net bottom current circulation patterns along the central Seattle Waterfront are shown in Figure 5. Several distinct patterns are evident in the bottom circulation patterns. Overall net current directions tend to be oriented parallel to the faces of piers. In addition a convergence zone which moves offshore to the west in the vicinity of Pier 52 is present. This convergent zone located near Pier 52 appears to separate the study area hydrodynamically into a northern and southern region.

From Pier 48 on the southern end of the study area net bottom currents outside the pier faces flow north until they reach Pier 52 (Seattle Ferry Terminal), at which point they turn west and move offshore. In contrast, between Piers 52 and 57 currents flow south from Pier 57 along the pier faces until they reach Pier 52, again turning west and moving offshore. The most likely explanation for the occurrence of this convergent zone is ferry operations at the Colman Dock. When docked, the ferries typically apply forward thrust to the stern propellers to hold the ferry in

Table 3: Summary of current velocity data collected for the Elliott Bay Waterfront Recontamination Study.

	Meter	Period of	Speed (cm/sec)		Net Dir.	Speed (cm/sec)*								
Station	Type	Record	Max.	Net	(deg/T)	0–2.5	2.5–5.0	5.0–7.5	7.5–10	10–12.5	12.5–15	15–17.5	17.5–20	>20
EB1	RCM4	10/20/93–1/10/94	20.7	0.35	177	62.4	25.6	8.3	2.7	0.7	0.2	0.05	0.05	0.03
EB1	RCM4	1/10–4/14/94	19.8	0.17	180	65.7	24.1	7.6	1.9	0.4	0.18	0.02	0.01	-
EB1A	RCM4	4/14–7/12/94	22.3	1.4	319	70.0	14.0	8.8	4.6	1.9	0.69	0.16	0.04	0.01
EB1A	RCM4	7/12–10/10/94	17.8	0.85	302	84.4	9.2	4.2	1.4	0.5	0.16	0.03	0.01	-
EB1A	S4	10/13–25/94	11.2	0.80	297	52.0	39.3	7.5	1.0	0.2	-	-	-	-
EB2	S4	7/14–8/16/94	8.1	0.11	213	93.4	6.1	0.44	0.03	-	-	-	-	-
EB3	RCM4	10/13/93–1/12/94	28.3	1.02	227	51.4	27.2	13.0	5.0	2.0	0.89	0.32	0.2	0.16
EB3	RCM4	1/12–4/13/94	21.2	1.52	210	40.7	31.4	17.7	6.8	2.3	0.63	0.25	0.1	0.01
EB3	RCM4	5/7–7/14/94	26.9	1.25	215	44.2	30.9	15.3	5.8	2.2	0.97	0.37	0.18	0.13
EB3	RCM4	7/14–10/10/94	30.5	1.26	226	54.4	25.5	11.5	4.8	2.1	0.99	0.34	0.15	0.22
EB4	S4	1/28–3/15/94	5.8	0.36	266	97.3	2.6	0.1	-	-	-	-	-	-
EB6S	RCM4	10/20/93–1/11/94	45.7	3.72	242	4.1	3.5	3.8	5.9	10.3	14.0	14.9	13.5	30
EB6S	RCM4	1/11–3/9/94	47.5	3.05	268	0.86	3.0	6.0	10.5	15.5	19.7	17.2	10.1	17.3
EB6S	S4	6/16–7/13/94	20.7	0.56	284	35.7	46.5	13.3	2.8	1.2	0.3	0.2	0.04	0.04
EB6S	RCM4	4/11–5/8/94	40.4	3.07	267	0.72	5.1	10.7	15.5	17.0	15.2	13.0	9.1	13.7
EB6S	RCM4	7/14–7/27/94	45.7	4.98	266	-	0.3	0.3	1.4	8.6	11.5	16.0	17	45
EB6B	RCM4	10/20/93–1/12/94	20.4	0.87	149	56.7	30.6	9.4	2.6	0.5	0.1	0.06	0.01	0.01
EB6B	RCM4	1/11–4/11/94	37.3	4.2	155	24.0	32.5	26.3	12.7	3.8	0.62	0.09	0.03	0.04
EB6B	S4	5/16–6/16/94	13.2	0.81	162	63.3	29.9	5.9	0.7	0.2	0.03	-	-	-
EB6B	RCM4	4/13–7/11/94	16.1	1.02	139	61.8	28.0	8.0	1.7	0.34	0.14	0.03	-	-
EB6B	RCM4	7/11–9/26/94	27.8	0.35	158	64.5	21.9	8.8	2.9	1.1	0.5	0.15	0.11	0.26
EB8	RCM4	10/12/93–12/29/93	17.7	0.12	331	89.9	6.9	2	0.9	0.2	0.07	-	0.01	-
EB8	RCM4	1/11–2/18/94	10.6	1.61	178	97.0	2.5	0.46	0.2	0.03	-	-	-	-
EB8	RCM4	3/2–4/14/94	18.5	2.37	357	70.3	22.3	5.5	1.2	0.39	0.19	0.05	0.05	-
EB8	S4	4/15–5/16/94	24.8	0.96	138	70.2	25.6	3.5	0.3	0.3	0.1	-	-	0.06
EB8	RCM4	4/14–7/13/94	24.8	0.29	147	88.0	7.3	2.8	1.3	0.46	0.24	0.08	0.08	0.03
EB8	RCM4	7/13–8/22/94	21.8	0.30	194	81.0	11.3	4.6	1.9	0.86	0.23	0.18	0.05	0.03
EB8	S4	10/27–10/30/94	7.5	0.30	170	85.6	13.2	0.87	-	-	-	-	-	-
EB9	RCM4	10/12/93–1/10/94	16.3	0.45	038	98.9	0.7	0.3	0.5	0.03	-	0.01	-	-
EB9	RCM4	1/10–4/15/94	21.6	1.24	284	98.4	0.84	0.36	0.17	0.1	0.09	0.01	-	0.02
EB9	S4	3/15–4/15/94	52.7	1.31	353	77.9	19.5	1.6	0.3	0.2	-	0.1	-	0.3
EB9	RCM4	4/15–7/12/94	20.5	0.41	042	97.5	1.54	0.46	0.24	0.15	0.04	0.02	0.04	0.01
EB9	RCM4	7/12–10/12/94	25.6	0.72	002	97.0	1.5	0.6	0.39	0.29	0.15	0.03	0.01	0.02
EB10	S4	7/14–8/16/94	28.0	3.5	248	27.5	46.8	20.4	4.2	0.73	0.22	0.09	0.06	0.06
EB11	S4	9/25–10/13/94	135	0.64	162	83.0	15.4	0.74	0.23	0.6	-	0.06	0.06	0.11
EB12	S4	8/16–9/20/94	28.2	0.30	247	45.4	34.3	13.2	4.3	1.9	0.65	0.24	-	0.09
EB13	S4	8/16–9/20/94	11.7	2.79	276	30.4	59.4	9.2	0.92	0.12	-	-	-	-
EB14	S4	6/16–7/13/94	20.9	1.75	003	55.3	33.4	8.9	1.7	0.4	0.1	0.1	0.04	0.04
EB16	S4	10/25–10/27/94	14.4	0.34	150	55.2	29.0	12.1	2.9	0.8	0.1	-	-	-

*= Values shown represent percent of values in speed range

RCM4= Aanderra Instruments RCM4 current meter

S4= Interocean S4 current meter

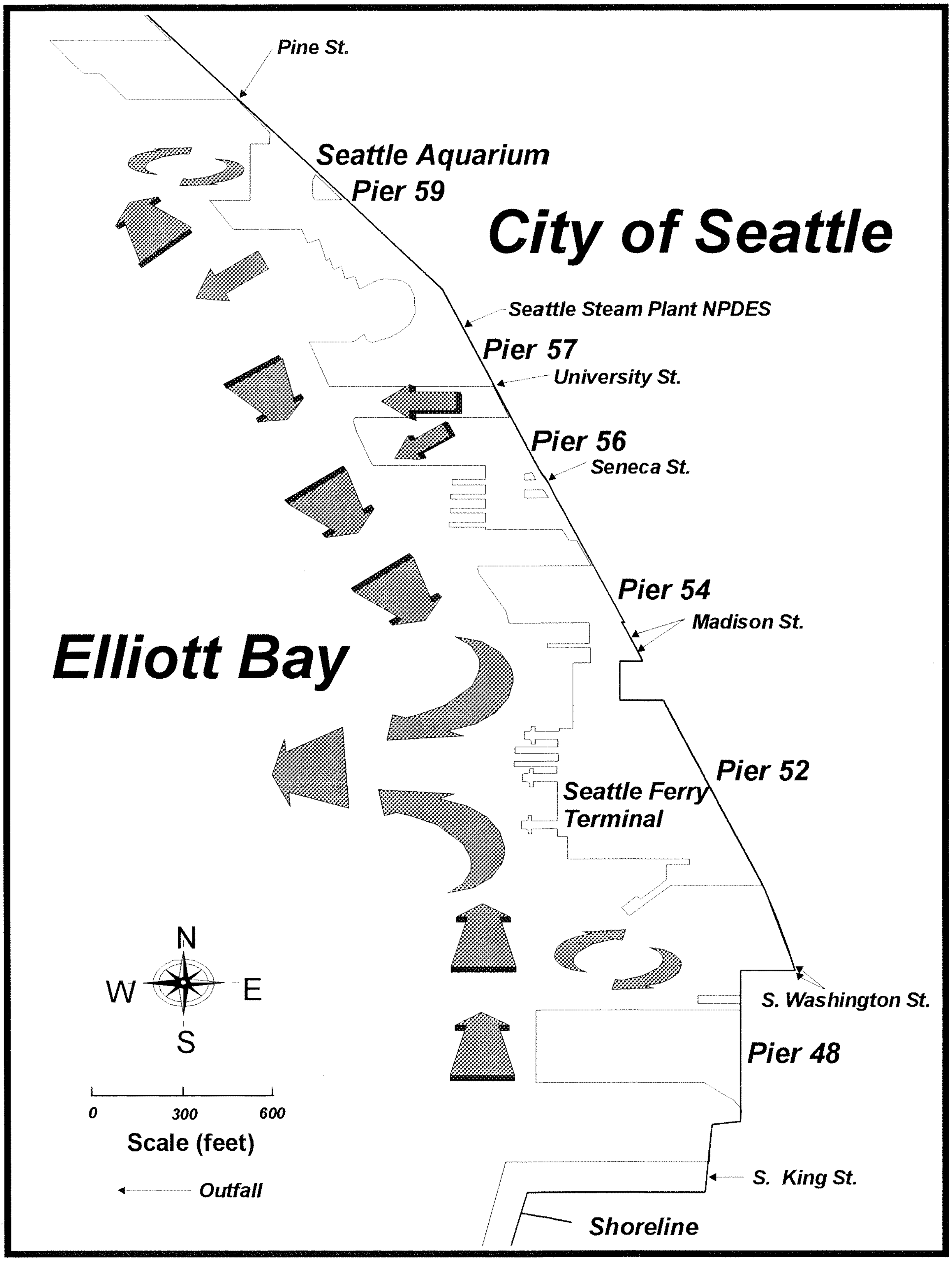

Figure 5: Generalized bottom current circulation from net currents.

the berth during loading and unloading. This results in a offshore current being generated which moves away from Pier 52 to the west. The reader is again referred to Volume II of this report for a more detailed discussion of the impacts of vessels on nearshore currents.

In the vicinity of Pier 59 the dominate net current direction is again to the north with a small offshore current occurring just south of Pier 59. Small clockwise gyres are also indicated inside the outer pier limits at two locations: north of Pier 59 and between Piers 48 and 52. Within the slip between Pier 56 and 57 the dominant current direction is westerly. Currents are discussed in greater detail as part of the conceptual site model in Volume II.

Settling Particulate Matter (SPM)

Distribution of Contaminants

Out of 88 sediment traps deployed for the recontamination study, 86 were successfully recovered (98%). The results of conventionals (percent solids, grain size and total organic carbon), and metals analysis of SPM samples collected between October 1993 and October 1994 are shown in Appendix D, Table D1.

Percent solids concentrations (post-centrifugation) measured over the study period ranged from 15 to 36%. Grain size analysis indicates that the sediment trap samples were relatively consistent in their composition containing primarily silt and clay size particles (<62um). For most stations the percentage of sand size (>62um) particles increased during the fourth quarter of monitoring. TOC levels in SPM were somewhat variable throughout the study period ranging from 3.2 to 18.7% with a mean of 7.2%. TOC concentrations in excess of 10% were measured at two locations along the waterfront, EB-2 and EB-5. These high values are believed to be attributed to the presence of decomposing marine organisms (primarily squid) that had entered the sediment trap cylinders and expired.

Summarized below are selected metals concentrations in SPM from the central Seattle Waterfront:

Summary of selected metals in SPM (mg/kg, dry weight).

Metal	Range	Mean	C.V.	N
Arsenic	5.2-41	16	0.37	44
Cadmium	0.56-4.5	1.7	0.47	44
Chromium	24-650	67	1.4	44
Copper	85-390	140	0.40	44
Lead	63-200	120	0.28	44
Mercury	0.25-4.4	0.96	0.70	44
Silver	0.3-5.2	1.6	0.66	44
Zinc	130-390	230	0.24	44

C.V.= Coefficient of variation (std/mean)
N= Number of samples

Metals concentrations in SPM were generally low and fairly consistent along the Seattle Waterfront throughout the monitoring period. Overall, most metals concentrations varied by less than a factor of 8. An exception was mercury which varied by more than an order of magnitude. Mercury concentrations on a dry weight basis ranged from 0.25 to 4.4 mg/kg with a mean of 0.96 mg/kg. The highest values were consistently measured at the head of the slip between Piers 56 and 57. The lowest values typically occurred in surface samples collected near Pier 59. A similar distribution to mercury was observed for silver with the highest concentrations occurring at station EB-2. Silver was not detected in surface samples near Pier 59.

Anomalously high concentrations of copper and chromium were seen during the first quarter of monitoring at stations EB-2 and EB-6 (surface), respectively. While there is no strong analytical evidence to discount these measurements, they do not appear to fit the pattern of other measurements at these locations. For perspective, copper during the first quarter at EB-2 was elevated by a factor of 2 compared to other values at this location. The anomalously high chromium value (650 mg/kg, dry weight) is approximately an order of magnitude higher than the overall mean (67 mg/kg, dry weight) recorded for all monitoring stations.

Appendix D, Table D2 summarizes the results of semivolatile organics and polychlorinated biphenyls (PCB) analysis of SPM samples on a dry weight basis. Thirty-four target organics were detected in SPM during the course of monitoring. Detected concentrations of selected organics in mg/kg, dry weight are summarized below:

Summary of selected organics detected in SPM (ug/kg, dry weight).

Compound	Range	Mean	C.V.	Detection Frequency	N
LPAH	6.9-180	53	0.78	100%	41
HPAH	15-210	86	0.55	100%	41
Dibenzofuran	0.57-19	3.8	0.93	100%	41
2-Methylnapthalene	0.25-9.6	2.9	1.1	98%	40
Pentachlorophenol	0.32-1.9	0.85	0.70	24%	10
Bis(2EH)phthalate	2.8-91	13	1.7	37%	15
Benzoic Acid	1.6-8.8	4.7	0.45	46%	19
Total PCBs	0.13-1.1	0.52	0.37	90%	37

C.V.= Coefficient of variation (std/mean)
N= Number of samples

In contrast to metals, organics concentrations were variable both spatially and temporally along the waterfront. Peak concentrations of most organics tended to occur in the northern portion of the study area between Pier 57 and 52 (Ferry Terminal). In particular, maximum concentrations of polynuclear aromatic hydrocarbons (PAHs) and several chemically related compounds (dibenzofuran, 2-methylnapthalene, and carbazole) occurred in the vicinity of Piers 56 and 57. The lowest concentrations of most organics were typically found south of the ferry terminal in the vicinity of Pier 48. Exceptions to this pattern were 4-methylphenol and bis(2-ethyl hexyl)phthalate which peaked south of the ferry terminal, at station EB-8. Pentachlorophenol was only detected in the northern portion of the study area between Piers 59 and 54 (Stations EB-1 to EB-5). Relatively low concentrations of PCBs were detected throughout the study area. Concentrations of most organics detected were higher in bottom traps than in surface traps at concurrent locations during all monitoring quarters.

At all stations, the sum of HPAH (high molecular weight PAH) exceeded the sum of LPAH (low molecular weight PAH). This enrichment of HPAH in SPM is not unexpected since weathering processes such as evaporation, photochemical oxidation, dissolution, and microbial degradation can preferentially remove PAHs with molecular weights less than that of fluoranthene (Merill and Wade, 1985). The apparent enrichment of HPAHs relative to LPAHs would suggest that historical sources of these compounds have played an important role in the PAH contamination of sediments observed along the waterfront.

Additional organics detected in SPM included: isophorone, retene, 1,4 dichlorobenzene, phenol, 4,6 dinitro-2-methylphenol, benzyl alcohol, benzoic acid, di-n-butylphthalate, di-n-octylphthalate, and butylbenyl phthalate. All these compounds were detected in <50% of the samples analyzed with the exception of retene, which had a detection frequency of 68%. Background information on several of these compounds is provided below.

Isophorone is used as a solvent for polyvinyl and nitrocellulose resins and lacquer finishes. Benzyl alcohol is used in perfumes and a variety of flavors. Benzoic acid is a naturally occurring compound which has several uses including: food preservative, manufacture of alkyl resins, production of phenol, and as a plasticizer to manufacture or modify resins such as PVC. 1,4 dichlorobenzene is a component of moth repellents, as well as air and toilet deodorizers (Verschueren, 1983). Phthalates are used extensively as plasticizers and are present in a wide variety of plastic products. In addition, they are used in the manufacture of non-plastic products such as lubricating oils and insecticides. Retene is a naturally occurring resin acid-derived compound that is commonly associated with wood waste (Prahl and Carpenter, 1984).

Temporally, intra-station concentrations of most organics tended to be somewhat variable. PAH concentrations most commonly peaked during the second quarter of monitoring (February to April) when normalized to organic carbon content. This pattern is no doubt related to the fact that TOC levels were also at a minimum during the second quarter of monitoring. While less variable than PAH concentrations a similar pattern was seen for PCBs, with maximum levels typically occurring in the second quarter. Organic carbon normalization reduces the variability in organics concentrations associated with differences in sediment TOC content. No consistent seasonal pattern was evident for most of the other organic compounds detected. However, differences in quantitation limits among monitoring quarters hinder interpretations of temporal trends for several of these organics.

Comparisons to Sediment Management Standards

In 1991, Ecology adopted the Sediment Management Standards (SMS), WAC 173-204. These standards identified specific contaminant levels below which no adverse effects would be observed in benthic communities, the "Sediment Quality Standards (SQS)". The standards also established "Cleanup Screening Levels (CSL)" which represent the upper limit of allowable minor adverse effects on biological resources. Contaminant concentrations above the CSLs are a high priority for remediation activities.

Contaminant concentrations in SPM from the central Seattle Waterfront are compared to the SMS in Tables 4 and 5. Chemicals which exceeded the SQS are summarized in Table 6. Concentrations of 18 individual compounds exceeded the SQS in SPM. The widest suite of exceedences was observed at the head of the slip between Pier 56 and 57 (EB-2), where 13 individual chemicals were above the SQS. All stations had at least seven chemicals above the SQS. The most widespread contaminant was mercury which was above the SQS in 89% of the samples analyzed. PAHs and to a lesser extent dibenzofuran were also above the SQS at all locations. PCBs only exceeded the SQS near Pier 59 and south of the ferry terminal at station EB-8.

Listed in Table 7 are chemicals which also exceeded the CSL in SPM. Fifteen chemicals fall into this category. The greatest number of exceedences were again measured in the vicinity of Pier 56

Table 4: Comparison of metals in settling particulate matter (SPM) to Ecology's Sediment Management Standards.

			Grain Size (%)				Total Metals (mg/kg, dry weight)										
		Solids	Sand	Silt	Clay	TOC											
Station	Quarter	(%)	>62um	62-4um	<4um	(%)	As	Cd	Cr	Cu	Pb	Hg	Ag	Zn	Al	Fe	Mn
EB1-Surface	1	27	-	-	-	7.5	41	1.6 j	74	200	140	0.41 j	0.3 uj	390	21000	41000	1300
	2	28	10	31	59	4.8	23 j	1.5	43	130	100	0.30	0.3 uj	290	20000	34000	960
	3	16	11	33	56	8.4	14 j	1.3	24 j	100	70	0.25 j	0.3 uj	200 j	9500	22000	400 j
	4	15	27	23	50	8.6	12 j	1.1	26	88	63	0.32 j	0.3 uj	170	8600	16000	390
EB1-Bottom	1	31	-	-	-	6.3	18	1.0 j	80	110	130	0.71 j	1.1 j	200	25000	33000	1000
	2	33	8	48	44	3.4	13 j	1.1	54	120	110	0.54	0.6 j	220	21000	31000	720
	3	20	8	37	55	6.1	12 j	1.0	30 j	86 j	93 j	0.61	1 j	150 j	11000	21000	340 j
	4	23	-	-	-	6.8	15 j	1.5	47	130	130	0.74	0.6 j	200	16000	29000	520
EB2	1	25	-	-	-	18.7	17	4.5 j	66	390	130	2.4 j	2.0 j	280	17000	26000	260
	2	28	10	40	50	6.8	18 j	2.6	68	190	180	1.6	2.0 j	310	20000	32000	690
	3	24	11	37	52	9.7	16 j	2.7	42 j	150 j	160 j	4.4 j	3.7 j	260 j	15000	25000	350 j
	4	23	19	42	39	11	19 j	3.7	48	190	170	2.0	0.64 j	300	16000	27000	370
EB3	1	29	-	-	-	6.7	22	1.4 j	80	130	140	0.86 j	1.4 j	220	27000	30000	1100
	2	32	9	43	48	6.3	16 j	1.2	70	120	110	0.80	1.3 j	200	22000	28000	1000
	3	24	8	35	57	7	12 j	1.3	38 j	110 j	100 j	0.94	1.8 j	170 j	17000	24000	7800
	4	22	13	37	50	8.4	15 j	1.7	41	120	120	0.79	0.96 j	210	17000	26000	560
EB4	1	27	-	-	-	8.7	26	2.0 j	79	150	130	0.92 j	1.5 j	240	25000	35000	1200
	2	30	10	34	56	5.1	18 j	1.7	59	140	120	0.70	1.4 j	250	23000	33000	1100
	3	23	7	34	59	8.5	15 j	1.7	39 j	130 j	120 j	1.4	2.7 j	210 j	17000	27000	470 j
	4	22	14	33	53	8.7	16 j	2.1	36	120	110	0.96	0.99 j	190	15000	24000	560
EB5	1	27	8	41	51	10.7	26	2.8 j	88	190	150	1.1 j	2.5 j	280	24000	35000	620
	2	25	8	45	47	6.4	18 j	2.1	57	170	140	0.94	2.2 j	270	19000	30000	670
	3	23	7	40	53	9.5	16 j	2.7	49 j	170 j	140 j	1.3	3 j	260 j	18000	29000	390 j
	4	25	16	39	45	9.9	19 j	3.2	55	170	150	1.1	2 j	270	20000	30000	340
SMS-SQS		-	-	-	-	-	57	5.1	260	390	450	0.41	6.1	410	-	-	-
SMS-CSL		-	-	-	-	-	93	6.7	270	390	530	0.59	6.1	960	-	-	-

j= Estimated value
uj= Estimated detection limit
SMS= Ecology Sediment Management Standards (WAC 173-204)
SQS= Sediment Quality Standards
CSL= Cleanup Screening Levels
▨ =Exceeds CSL

Quarter 1= Oct to Dec 1993
Quarter 2= Jan to April 1994
Quarter 3= May to July 1994
Quarter 4= August to Oct 1994

Table 4 (cont.): Comparison of metals in settling particulate matter (SPM) to Ecology's Sediment Management Standards.

			Grain Size (%)				Total Metals (mg/kg, dry weight)										
		Solids	Sand	Silt	Clay	TOC											
Station	Quarter	(%)	>62um	62-4um	<4um	(%)	As	Cd	Cr	Cu	Pb	Hg	Ag	Zn	Al	Fe	Mn
EB6-Surface	1	26	-	-	-	-	22	2.0 j	▨ 650	140	150	0.38 j	0.5 j	280	24000	35000	300
	2	22	-	-	-	4.2	18 j	1.0	56	130	100	▨ 0.71	0.3 j	350	21000	33000	520
	3	20	6	36	58	7.3	8.6 j	1.4	25 j	85 j	63 j	▨ 1.1	0.52 j	170 j	11000	18000	130 j
	4	19	14	27	59	9.8	13 j	1.5	32	90	77	0.33	0.53 j	170	12000	18000	440
EB6-Bottom	1	28	-	-	-	6.4	23	1.4 j	98	130	120	▨ 0.93 j	1.2 j	210	22000	35000	1300
	2	27	11	41	48	4.7	14 j	1.0	50	120	100	▨ 0.66	1.1 j	200	19000	29000	790
	3	21	10	37	53	7.1	12 j	1.2	36 j	110 j	90 j	▨ 0.75	1.5 j	170 j	15000	24000	410 j
	4	23	24	36	40	7.6	11 j	1.6	39	120	100	▨ 0.63	1.5 j	180	16000	23000	370
EB7	1	29	-	-	-	7.3	23	0.98 j	83	140	150	▨ 0.86 j	2.2 j	240	24000	36000	860
	2	32	19	38	43	3.8	14 j	1.3	61	150	130	▨ 0.64	1.7 j	240	21000	31000	740
	3	23	15	38	47	7.1	12 j	1.4	40 j	110 j	110 j	▨ 0.86	2.4 j	190 j	14000	23000	360 j
	4	25	18	42	40	7.0	12 j	2.2	48	140	150	▨ 0.96	0.65 j	230	17000	26000	290
EB8	1	32	-	-	-	8.9	12	1.6 j	67	340	190	▨ 1.2 j	5.2 j	280	19000	31000	270
	2	34	12	47	41	4.5	16 j	1.3	61	190	200	▨ 1.2	3.0 j	240	20000	27000	460
	3	36	11	44	45	5.1	12 j	1.0	41 j	120 j	150 j	▨ 1.1	3.3 j	170 j	14000	22000	260 j
	4	36	23	47	30	4.5	5.2 j	1.7	40	130	200	▨ 1.4	3.1 j	220	13000	14000	330
EB9	1	35	-	-	-	4.2	15	0.65 j	100	180	98	▨ 0.66 j	1.5 j	190	22000	29000	1200
	2	33	10	46	44	3.2	10 j	0.56	51	100	94	▨ 0.63	1.2 j	170	21000	24000	860
	3	20	12	39	49	4.5	7.7 j	1.3	30 j	96 j	65 j	0.5	1.8 j	130 j	14000	19000	370 j
	4	22	10	42	48	7.7	11 j	0.95	42	120	94	▨ 0.67	1.7 j	170	20000	25000	850
Overall Mean		24	12	39	49	7.2	16 j	1.7 j	67	140 j	120 j	▨ 0.96 j	1.6 j	230 j	18000	28000	780 j
SMS-SQS		-	-	-	-	-	57	5.1	260	390	450	0.41	6.1	410	-	-	-
SMS-CSL		-	-	-	-	-	93	6.7	270	390	530	0.59	6.1	960	-	-	-

j= Estimated value
uj= Estimated detection limit
SMS= Ecology Sediment Management Standards (WAC 173-204)
SQS= Sediment Quality Standards
CSL= Cleanup Screening Levels
▨ =Exceeds CSL

Quarter 1= Oct to Dec 1993
Quarter 2= Jan to April 1994
Quarter 3= May to July 1994
Quarter 4= August to Oct 1994

Table 5: Comparison of semivolatile organics detected in settling particulate matter to Ecology's Sediment Management Standards.

Station	EB1				EB1				EB2					
Depth	Surface	–	–	–	Bottom	–	–	–	Bottom	–	–	–	SMS	
Quarter	1	2	3	4	1	2	3	4	1	2	3	4	SQS	CSL
TOC (%)	7.5	4.8	8.4	8.6	6.3	3.4	6.1	6.8	18.7	6.8	9.7	11	–	–
DRY WEIGHT NORMALIZED CONCENTRATIONS (UG/KG)														
Phenol	120 j	79 j	1100 u	540 uj	–	140 j	940 uj	520 uj	–	600 u	640 uj	3200	420	1200
4-Methylphenol	97 j	380 u	1100 u	540 u	–	350 u	940 uj	520 uj	–	600 u	640 uj	5100	670	670
Pentachlorophenol	1900	1300	1200 j	6500 uj	–	350 j	9400 uj	5200 uj	–	1600 j	6400 uj	1400 uj	360	690
Benzyl Alcohol	81 j	380 uj	2100 u	540 u	–	13000 j	1900 u	520 uj	–	600 u	1300 u	270 u	57	73
Benzoic Acid	6800	2600 uj	6900 j	16000 uj	–	350 uj	2700 j	5200 uj	–	600 uj	2300 j	8800	650	650
ORGANIC CARBON NORMALIZED CONCENTRATIONS (MG COMPOUND/KG ORGANIC CARBON)														
Sum LPAH	390	230 j	120 j	190 j	–	740	330 j	470	–	1100	450	610	370	780
Sum HPAH	950	710	390	560	–	2000	890 j	1300	–	2100	730	1200	960	5300
2-Methylnaphthalene	16	6 j	4 j	5 j	–	23	14 j	25	–	43	32	29 uj	38	64
Dibenzofuran	24	12	7 j	9	–	38	20	34	–	72	39	43	15	58
1,4-Dichlorobenzene	2 u	8 u	13 u	6 u	–	10 u	15 u	8 u	–	6 j	4 j	5	3.1	9
Di-n-butylphthalate	3 uj	9 uj	13 uj	6 u	–	10 u	15 u	8 u	–	9 u	7 uj	2 u	220	1700
Di-n-octylphthalate	2 u	10	25 u	31 uj	–	10 u	69	38 uj	–	9 u	13 u	13 uj	58	4500
Butylbenzylphthalate	2 u	9 uj	13 u	31 uj	–	10 u	15 u	38 uj	–	9 u	7	13 uj	4.9	64
Bis(2EH)phthalate	130 uj	230	1200 u	24 uj	–	82	75 uj	15 uj	–	130	66 uj	65 j	47	78
Total PCBs	7	10	6	5 j	–	12	11	16 j	–	–	7	8	12	65

u=Not detected at detection limit shown

j=Estimated concentration

SMS= Sediment Management Standards (WAC 204-173)

SQS= Sediment Quality Standards

CSL= Cleanup Screening Level

▨ =Exceeds Cleanup Screening Level

uj=Estimated detection limit

-=No sample

Quarter 1= Oct to Dec 1993

Quarter 2= Jan to April 1994

Quarter 3= May to July 1994

Quarter 4= August to Oct 1994

Table 5(cont.): Comparison of semivolatile organics detected in settling particulate matter to Ecology's Sediment Management Standards.

Station	EB3				EB4				EB5				SMS	
Depth	Bottom	–	–	–	Bottom	–	–	–	Bottom	–	–	–		
Quarter	1	2	3	4	1	2	3	4	1	2	3	4	SQS	CSL
TOC (%)	6.7	3.6	7.0	8.4	8.7	5.1	8.5	8.7	10.7	6.4	9.5	9.9		
DRY WEIGHT NORMALIZED CONCENTRATIONS														
Phenol	82 j	76 j	820 uj	800 uj	110 j	120 j	750 uj	390 uj	160	890 u	780 uj	320 u	420	1200
4-Methylphenol	74 j	450 u	820 u	▨ 870 j	120 j	580 u	▨ 730 j	390 uj	▨ 2100	890 u	780 uj	340 uj	670	670
Pentachlorophenol	440 j	320 j	8200 uj	2900 uj	540 j	340 j	7500 uj	2100 uj	690 u	890 u	480 j	3200 uj	360	690
Benzyl Alcohol	▨ 150 j	450 u	1700 u	440 u	210 u	7600 uj	1500 u	390 u	140 u	4700 uj	1600 u	320 u	57	73
Benzoic Acid	▨ 3500	2500 uj	▨ 3700 j	6900 uj	▨ 6600	580 u	▨ 5600 j	4600 uj	▨ 3400	890 u	▨ 6000 j	3200 uj	650	650
ORGANIC CARBON NORMALIZED CONCENTRATIONS														
Sum LPAH	▨ 1300	▨ 2400	▨ 840 j	▨ 820	▨ 2000	▨ 2000	▨ 1300	▨ 2100 j	▨ 1200	▨ 1500	620	540	370	780
Sum HPAH	1900	3600	1100 j	1200	2400	2700	1300	2100	1700	2200	960	1000	960	5300
2-Methylnaphthalene	60	▨ 110	53	57	▨ 94	▨ 100	▨ 110	▨ 200	54	▨ 69	44	26	38	64
Dibenzofuran	▨ 97	▨ 190	▨ 66	▨ 73	15	▨ 170	▨ 130	▨ 220	▨ 77	▨ 100	53	38	15	58
1,4-Dichlorobenzene	2 u	13 u	12 u	1 j	2 u	11 u	9 uj	4 u	1 j	14 u	8 u	3 u	3.1	9
Di-n-butylphthalate	590 j	13 u	12 u	12 uj	6 uj	11 u	9 uj	11 uj	79 uj	14 u	18	4 uj	220	1700
Di-n-octylphthalate	2 u	13 u	24 u	26 uj	2 uj	11 u	18 u	22 uj	1 uj	14 u	17 u	7 uj	58	4500
Butylbenzylphthalate	3 uj	13 u	12 u	26 uj	3 uj	11 uj	9 u	22 uj	1 u	▨ 500	8 u	16 uj	4.9	64
Bis(2EH)phthalate	52 uj	▨ 500	230 uj	32 uj	67 uj	▨ 140	62 uj	45 uj	79 uj	▨ 160	▨ 95	58 uj	47	78
Total PCBs	6	10	7	7 j	6	8	7	6	5	7 j	7	6	12	65

u=Not detected at detection limit shown

j=Estimated concentration

SMS= Sediment Management Standards (WAC 204-173)

SQS= Sediment Quality Standards

CSL= Cleanup Screening Level

▨ =Exceeds Cleanup Screening Level

uj uj=Estimated detection limit

-= -=No sample

Quarter 1= Oct to Dec 1993

Quarter 2= Jan to April 1994

Quarter 3= May to July 1994

Quarter 4= August to Oct 1994

Table 5(cont.): Comparison of semivolatile organics detected in settling particulate matter to Ecology's Sediment Management Standards.

Station	EB6				EB6				EB7					
Depth	**Surface**	–	–	–	**Bottom**	–	–	–	**Bottom**	–	–	–	SMS	
Quarter	1	2	3	4	1	2	3	4	1	2	3	4	SQS	CSL
TOC (%)	–	4.2	7.3	9.8	6.4	4.7	7.1	7.6	7.3	3.8	7.1	7.0		
DRY WEIGHT NORMALIZED CONCENTRATIONS														
Phenol	–	1900 u	860 uj	▨ 2600	100 j	110 j	880 u	650 uj	54 j	120 j	920 u	670 uj	420	1200
4-Methylphenol	–	1900 u	860 u	550 uj	130 u	450 u	880 u	▨ 14000	130	470 u	920 u	▨ 4600	670	670
Pentachlorophenol	–	1900 u	8600 uj	5500 u	660 u	450 u	8800 u	4500 u	620 u	470 u	9200 uj	3500 u	360	690
Benzyl Alcohol	–	1900 u	1700 u	550 u	130 u	450 u	1800 u	450 u	120 u	470 u	1800 u	350 u	57	73
Benzoic Acid	–	76000 uj	▨ 3000 j	15000 uj	2200 uj	3400 uj	▨ 6700 j	4500 u	▨ 2700	2000 uj	▨ 4900 j	3100 uj	650	650
ORGANIC CARBON NORMALIZED CONCENTRATIONS														
Sum LPAH	–	520 j	450 j	580	▨ 1200	▨ 1400	440 j	580	▨ 1000	▨ 1300	700 j	600	370	780
Sum HPAH	–	1800 j	580 j	900	1900	2000	700 j	960	1900	2400	1300 j	1400	960	5300
2-Methylnaphthalene	–	6 j	26	43	50	49	25	29	44	61	44	24	38	64
Dibenzofuran	–	17 j	41	50	▨ 89	▨ 110	35	45	▨ 71	50	▨ 61	44	15	58
1,4-Dichlorobenzene	–	45 u	12 u	6 u	2 u	10 u	12 u	6 u	2 u	12 u	13 u	5 u	3.1	9
Di-n-butylphthalate	–	45 u	12 u	10 uj	52 uj	10 u	12 u	11 uj	3 uj	12 u	14 uj	5 uj	220	1700
Di-n-octylphthalate	–	45 u	23 u	29 uj	2 u	10 u	25 u	30 uj	2 u	12 u	25 u	26 uj	58	4500
Butylbenzylphthalate	–	45 u	12 u	29 uj	2 u	10 u	12 u	30 uj	3	12 u	13 u	26 uj	4.9	64
Bis(2EH)phthalate	–	▨ 260	59 uj	36 uj	72	▨ 130	45 uj	30 uj	56 uj	▨ 130	660 uj	31 uj	47	78
Total PCBs	–	–	–	4 j	6	6	6 j	7	6	–	6 j	7	12	65

u=Not detected at detection limit shown

j=Estimated concentration

SMS= Sediment Management Standards (WAC 204-173)

SQS= Sediment Quality Standards

CSL= Cleanup Screening Level

▨ =Exceeds Cleanup Screening Level

uj=Estimated detection limit

-=No sample

Quarter 1= Oct to Dec 1993

Quarter 2= Jan to April 1994

Quarter 3= May to July 1994

Quarter 4= August to Oct 1994

Table 5(cont.): Comparison of semivolatile organics detected in settling particulate matter to Ecology's sediment management standards.

Station	EB8				EB9				SMS	
Depth	Bottom	–	–	–	Bottom	–	–	–		
Quarter	1	2	3	4	1	2	3	4	SQS	CSL
TOC (%)	8.9	4.5	5.1	4.5	4.2	3.2	4.5	7.7		
DRY WEIGHT NORMALIZED CONCENTRATIONS										
Phenol	▨ 5100	240 j	490 uj	210 uj	51 j	570 u	810 uj	450 uj	420	1200
4-Methylphenol	▨ 380000	440 u	920	210 uj	520	570 u	810 uj	450 u	670	670
Pentachlorophenol	590 u	440 u	4900 u	2100 u	560 u	570 u	8100 uj	4500 u	360	690
Benzyl Alcohol	120 u	440 u	980 u	210 u	120 u	570 u	1600 u	450 u	57	73
Benzoic Acid	▨ 3600	2500 uj	▨ 1600 j	5100 uj	▨ 2700	570 u	▨ 7800 j	6400 uj	650	650
ORGANIC CARBON NORMALIZED CONCENTRATIONS										
Sum LPAH	140	420	200 j	290	160	470 j	290 j	220	370	780
Sum HPAH	260	890	530 j	710	360	1000 j	580 j	420	960	5300
2-Methylnaphthalene	7	16	12	13	10	23	24	17	38	64
Dibenzofuran	10	29	16	21	15	34	24	19	15	58
1,4-Dichlorobenzene	1 u	10 u	▨ 10	5 u	3 u	18 u	18 u	6 u	3.1	9
Di-n-butylphthalate	1 u	10 u	10 uj	6 uj	3 uj	18 u	18 u	17 uj	220	1700
Di-n-octylphthalate	1 uj	10 u	19 u	24 uj	3 uj	56 j	36 u	30 uj	58	4500
Butylbenzylphthalate	1 u	10 u	10 u	24 uj	3 uj	18 u	18 u	30 uj	4.9	64
Bis(2EH)phthalate	29 uj	▨ 100	3 uj	▨ 2000 j	1100 uj	▨ 170	19 uj	25 uj	47	78
Total PCBs	8	22 j	9	16	6	9	3 j	6 j	12	65

u=Not detected at detection limit shown
j=Estimated concentration
SMS= Sediment Management Standards (WAC 204-173)
SQS= Sediment Quality Standards
CSL= Cleanup Screening Level
▨ =Exceeds Cleanup Screening Level

uj=Estimated detection limit
–=No sample
Quarter 1= Oct to Dec 1993
Quarter 2= Jan to April 1994
Quarter 3= May to July 1994
Quarter 4= August to Oct 1994

Table 6: Summary of metals and organics detected in settling particulate matter from the central Seattle Waterfront that exceeded Ecology's Sediment Management Standards, Sediment Quality Standards (SQS), WAC 173-204.

Station	Location	Chemical	Total Number of Chemicals
EB1-Surface	West end of Pier 59	Mercury, LPAH, dibenzofuran, bis(2EH)phthalate, pentachlorophenol, benzoic acid, benzyl alcohol	7
EB1-Bottom	-	Mercury, LPAH, HPAH, dibenzofuran, bis(2EH)phthalate, di-n-octyl phthalate, TPCBs, benzyl alcohol, benzoic acid	9
EB2	Between 56/57 @ Head of Slip	Mercury, copper, LPAH, HPAH, 2-methylnapthalene, dibenzofuran, 1,4-dichlorobenzene, bis(2EH)phthalate, phenol, 4-methylphenol, butyl benzyl phthalate, pentachlorophenol, benzoic acid	13
EB3	Between 56/57 @ Mouth of Slip	Mercury, LPAH, HPAH, 2-methylnapthalene, dibenzofuran, di-n-butyl phthalate, bis(2EH)phthalate, pentachlorophenol, 4-methylphenol, benzyl alcohol, benzoic acid	11
EB4	Under Pier 56	Mercury, LPAH, HPAH, 2-methylnapthalate, dibenzofuran, bis(2EH)phthalate, 4-methylphenol, pentachlorophenol, benzoic acid	9
EB5	Between 54/55	Mercury, LPAH, HPAH, 2-methylnapthalene, dibenzofuran, butyl benzyl phthalate, bis (2EH)phthalate, 4-methylphenol, pentachlorophenol, benzoic acid	10
EB6-Surface	West end Pier 54	Mercury, chromium, LPAH, HPAH, 2-methylnapthalene, dibenzofuran, bis(2EH)phthalate, phenol, benzoic acid	8
EB6-Bottom	-	Mercury, LPAH, HPAH, 2-methylnapthalene, dibenzofuran, bis(2EH)phthalate, 4-methyl phenol, benzoic acid	8
EB7	Adjacent to Fire Boat Dock	Mercury, LPAH, HPAH, 2-methylnapthalene, dibenzofuran, bis(2EH)phthalate, 4-methyl phenol, benzoic acid	8
EB8	South of Passenger Ferry	Mercury, LPAH, dibenzofuran, 1,4-dichlorobenzene, bis(2EH)phthalate, TPCBs, phenol, 4-methylphenol, benzoic acid	9
EB9	Southwest Corner Pier 48	Mercury, LPAH, HPAH, dibenzofuran, bis(2EH)phthalate, benzoic acid	6

chemical = Also exceeds cleanup screening level

Table 7: Summary of metals and organics exceeding Ecology's Sediment Management Standards (Cleanup Screening Levels) in settling particulate matter from Elliott Bay.

Chemical	Samples*	Percent Exceeding	Location of Highest
Mercury	36/44	84%	EB-2
Benzoic Acid	19/41	46%	EB-2
LPAH	15/41	37%	EB-3
Dibenzofuran	14/41	34%	EB-4
Bis(2-ethyl hexyl) phthalate	13/41	32%	EB-8
4-Methylphenol	8/41	20%	EB-8
2-Methylnapthalene	6/41	15%	EB-4
Pentachlorophenol	5/41	12%	EB-1S
Phenol	3/41	7%	EB-8
Benzyl Alcohol	3/41	7%	EB-1B
1,4-Dichlorobenzene	1/41	2%	EB-8
Butylbenzylphthalate	1/41	2%	EB-5
Di-n-butylphthalate	1/41	2%	EB-3
Chromium	1/44	2%	EB-6S
Copper	1/44	2%	EB-2

*Samples=Number exceeding standards/total samples collected

Ecology Sediment Standards WAC 173-204, Cleanup screening levels and 57. The lowest number of exceedences of the CSL were typically observed in surface trap samples.

The distribution of mercury in SPM along the Seattle Waterfront is shown in Figure 6. Mercury was above the CSL in 84% of the samples analyzed indicating it is at problem levels throughout the study area. The only station where mercury did not exceed the CSL during the monitoring period was in the surface samples near the Seattle Aquarium (EB1). The average mercury concentration in SPM during the course of the study was 0.96 mg/kg dry, which is approximately 1.5 times higher than the CSL.

Figure 7 compares concentrations of LPAH, HPAH, Dibenzofuran, and Total PCBs in SPM to the SQS and CSL. Examination of these data indicates that the majority of SPM samples exceeded the SQS for LPAH (76%), HPAH (59%), and dibenzofuran (85%). The SQS for PCBs was exceeded in 10% of samples. In contrast to mercury, substantially fewer exceedences of the CSL were observed for these compounds. Of the four organics shown only LPAH (46%) and dibenzofuran (34%) were measured above the CSL.

Gross Sedimentation Rates

Sediment accumulation rates for the central Seattle Waterfront determined from sediment trap data are shown in Table 8. Two types of accumulation rates are listed. Mass accumulation (g/cm^2/yr) is the measured sediment flux into the traps, and accumulation rate (cm/yr) is calculated to represent the actual thickness of new sediment once the particulates have consolidated on the bottom. Both these values should be viewed as estimates of gross sedimentation (i.e., net sedimentation + resuspension). Calculations used to generate the reported sedimentation rates are shown below:

- Mass Accumulation (g/cm^2/yr)= [(P/A)/D] x Y
  P= Amount of material collected (dry grams)
  A= Collection area of cylinder (cm^2)
  D= Number of days sediment trap was deployed
  Y= Number of days in a year (365)

- Accumulation Rate (cm/yr)= Mass accumulation (g/cm^2/yr)/Dry density (g/cm^3)
  Dry density= [Wet density x (Bottom Sediment % solids/100)]
  Wet density= Estimated from Puget Sound Density Model using % solids data from in-situ bottom sediments (Crecelius, 1989)

Mass accumulation rates for bottom traps along the waterfront, on a dry weight basis, ranged from 0.3-1.8 g/cm^2/yr with a mean of 0.8±0.17 g/cm^2/yr. Based on means, the highest mass accumulation rates were consistently measured immediately south of the ferry terminal at station EB-8. A comparison of mass accumulation rates in surface and bottom traps is presented in

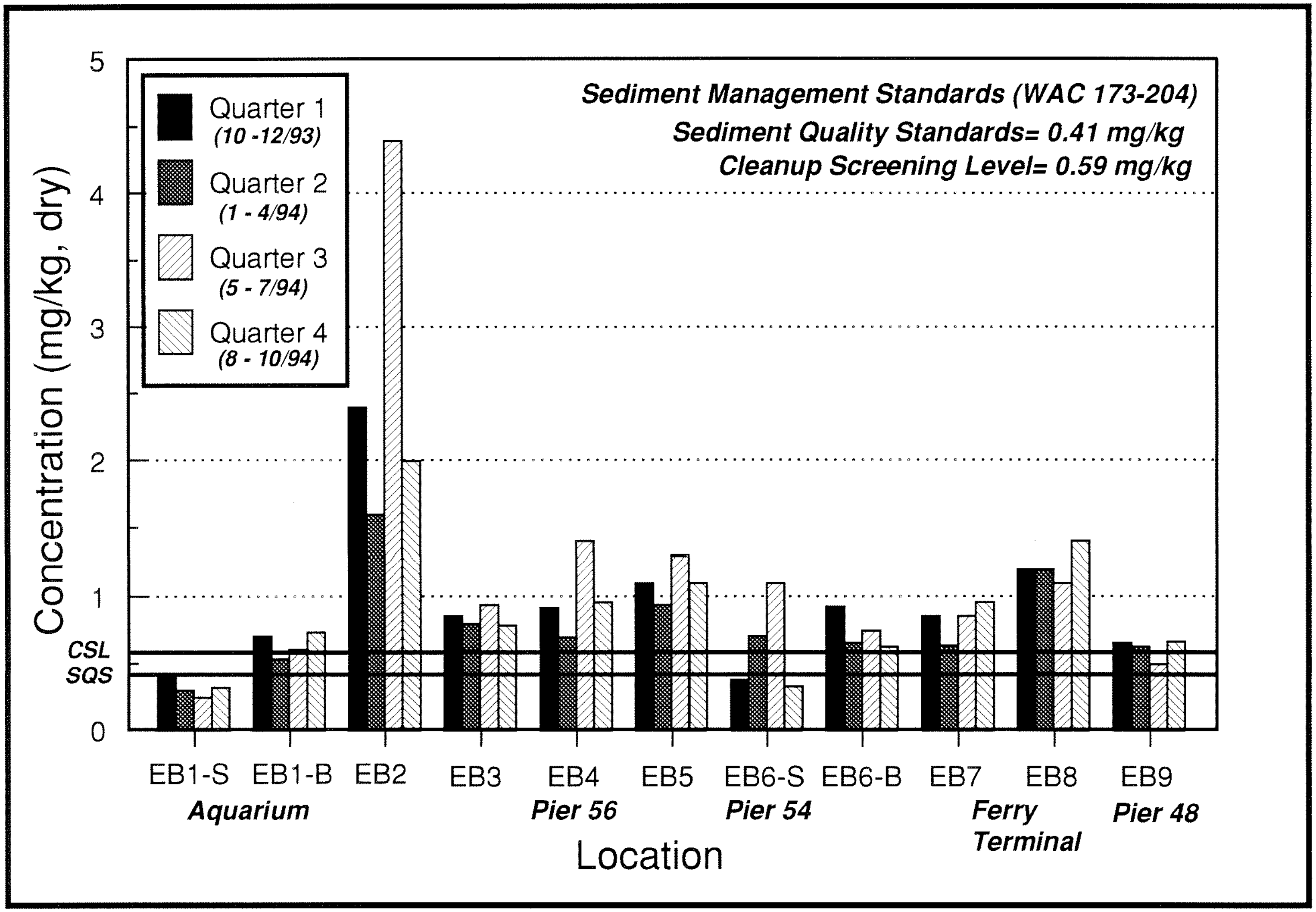

Figure 6: Mercury concentrations in settling particulate matter from the central Seattle Waterfront, October 1993 to October 1994.

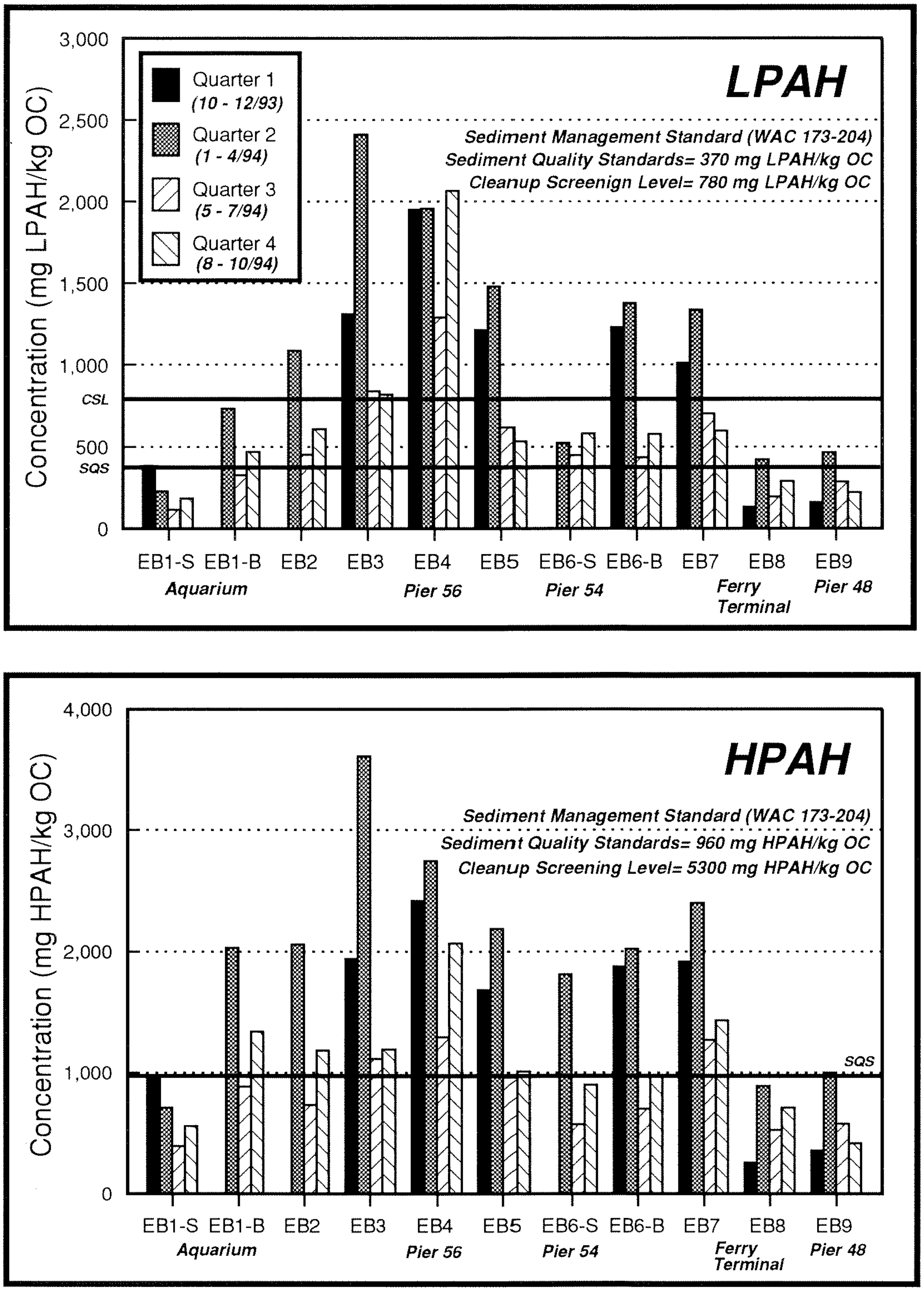

Figure 7: Comparison of Selected Organics in SPM to to Ecology's Sediment Management Standards.

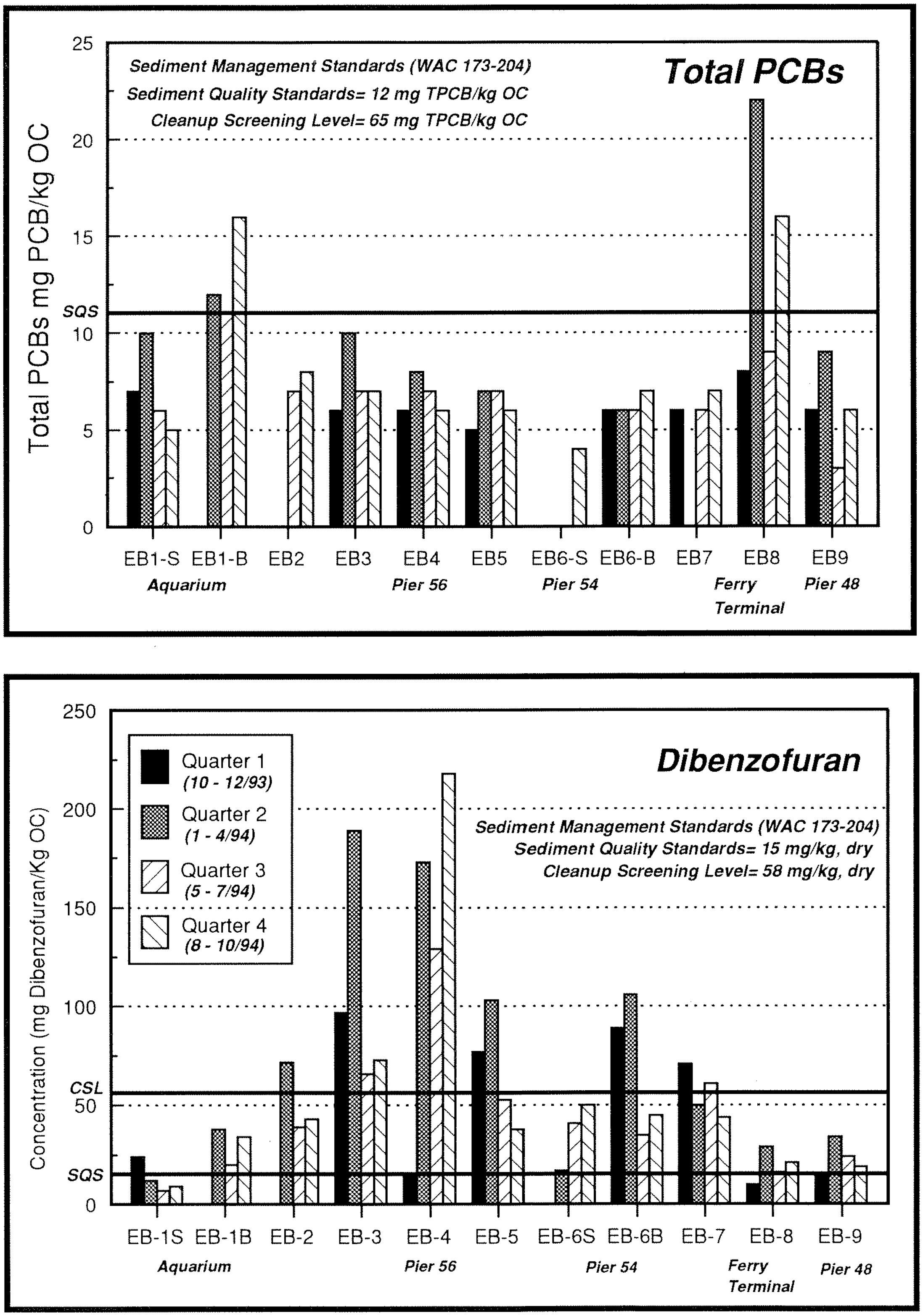

Figure 7(cont.): Comparison of Selected Organics in SPM to Ecology's Sediment Management Standards.

Table 8: Gross sedimentation rates for the central Seattle Waterfront from sediment trap data collected October 1993 to October 1994.

			Mass Accumulation (g/cm2/yr)		Accumulation Rate (cm/yr)	
Station	Quarter	N	Mean	Range	Mean	Range
EB1-S	1	4	0.5	0.4-0.5	1.0	0.9-1.2
	2	4	0.5	0.4-0.6	1.1	0.9-1.3
	3	3	0.6	0.6-0.7	1.3	1.2-1.5
	4	4	0.7	0.5-0.8	1.4	1.1-1.7
EB1-B	1	4	0.4	0.4-0.5	0.8	0.6-1.5
	2	4	0.6	0.5-0.7	1.3	1.0-1.5
	3	4	0.6	0.5-0.6	1.2	1.1-1.2
	4	2	0.5	0.5	1.1	1.1
EB2	1	1	-	0.4	-	0.5
	2	4	0.5	0.5	0.7	0.6-0.7
	3	4	1.1	0.9-1.2	1.2	1.2-1.4
	4	4	1.0	0.9-1.1	1.2	1.1-1.3
EB3	1	4	0.6	0.5-0.7	1.3	1.1-1.5
	2	3	0.6	0.6-0.7	1.5	1.4-1.6
	3	4	1.2	1.0-1.4	2.7	2.2-3.1
	4	4	1.0	0.9-1.1	2.4	2.1-2.6
EB4	1	4	0.6	0.5-0.6	1.8	1.6-1.9
	2	3	0.7	0.7	2.1	2.1-2.2
	3	4	1.1	1.1	3.4	3.3-3.4
	4	4	1.2	1.2-1.3	3.8	3.6-4.0
EB5	1	4	0.6	0.5-0.7	1.4	1.2-1.5
	2	4	0.6	0.6	1.3	1.3
	3	4	1.0	0.9-1.1	2.3	2.0-2.5
	4	4	0.9	0.8-1.0	2.2	1.9-2.3
EB6-S	1	1	-	0.1	-	0.2
	2	2	0.2	0.2	0.3	0.3
	3	3	0.7	0.6-0.7	0.9	0.8-1.0
	4	4	0.7	0.6-0.7	0.8	0.7-0.9
EB6-B	1	4	0.4	0.4	0.5	0.5
	2	4	0.4	0.3-0.5	0.5	0.3-0.6
	3	4	0.7	0.6-0.9	0.9	0.8-1.2
	4	4	0.7	0.6-0.8	0.9	0.8-1.0
EB7	1	4	0.6	0.5-0.6	1.8	1.6-1.9
	2	2	0.6	0.6	2.1	2.1-2.2
	3	4	0.8	0.7-0.8	2.6	2.5-2.7
	4	3	0.7	0.6-0.8	2.6	2.2-2.9
EB8	1	4	0.8	0.6-1.0	1.5	1.1-1.8
	2	4	0.6	0.5-0.7	1.0	0.8-1.2
	3	4	1.7	1.5-1.8	3.0	2.9-3.2
	4	4	1.5	1.4-1.6	2.7	2.5-2.9
EB9	1	3	0.5	0.5	0.6	0.6
	2	4	0.4	0.4	0.5	0.5
	3	4	0.6	0.6	0.8	0.7-0.8
	4	4	0.6	0.5-0.6	0.7	0.7
Overall	Surface	25	0.6	0.1-0.8	1.0	0.3-1.4
	Bottom	133	0.8	0.3-1.8	1.6	0.3-4.0

Quarter 1= Oct - Dec 93;Quarter 2= Jan - April 94

Quarter 3= May - July 94; Quarter 4= August - Oct 94

Figure 8. Surface rates were usually equal to or less than corresponding bottom rates. During the third and fourth quarters of monitoring the station at the west end of Pier 54 showed similar rates throughout the water column. No consistent pattern was observed in rates near Pier 59. Predicted accumulation rates on the bottom from bottom trap data ranged from 0.3 to 4.0 cm/yr with a mean of 1.6±0.88 cm/yr.

Gross accumulation rates from bottom trap data (3' above the bottom) are compared in Figure 9. Several patterns are evident in these data. The highest rates were typically measured during the third (May to July) and fourth (August to October) quarters of monitoring. Rates measured near Pier 59 and the west end of Pier 48 were fairly consistent and on the lower end of rates measured during the course of the study. At the remaining stations rates were seasonally variable, especially immediately south of the ferry terminal (EB8).

In general, areas with the most variable rates (Pier 56/57 and south of the Ferry Terminal) tended to correspond to locations that also had the highest amount of vessel traffic (see Figure 9). Conversely, areas which are least influenced by vessel traffic (near the Seattle Aquarium and the southwest end of Pier 48) did not exhibit the same degree of seasonal fluctuations in gross sedimentation rates that was observed at these other locations. The spatial and temporal patterns observed in gross sedimentation rates along the waterfront seem to suggest that vessel movements are affecting gross sedimentation by locally resuspending bottom sediments.

Vessel traffic along the central Seattle waterfront usually peaks during the summer tourist season (May through September). Some examples of tourist associated vessel traffic along the waterfront includes: harbor tours (operating out of both Pier 55 and Pier 57), fishing charters (Pier 54) and large vessels such as the Canadian Ferry "Royal Victorian" which makes daily runs to the north side of Pier 48 typically between May and September.

Results of ^{210}Pb analysis of the trap material also seem to support the idea that vessel movements are affecting gross sedimentation rates by locally resuspending bottom sediments. ^{210}Pb levels in bottom traps, shown in Figure 10, were at a minimum during the third quarter (May to July) of monitoring (Unfortunately, ^{210}Pb activities in the trap material was not determined during the fourth quarter of monitoring). During episodes when bottom sediments are being resuspended into the water column, ^{210}Pb activities in SPM near the bottom would be expected to drop because water column particulates which typically have higher ^{210}Pb activities are being mixing with lower activity bottom sediments suspended in the water column.

The data collected implies that vessel movements are playing an important role in resuspending bottom sediments along the central Seattle Waterfront, especially during the summer and early fall. Other widespread factors such as seasonal variations in plankton populations and discharge from the Duwamish River may also contribute to the increased sedimentation observed during the summer. However, the apparent connection between the amount of gross sedimentation and the level of vessel activity in the area points more toward vessels as the major factor controlling

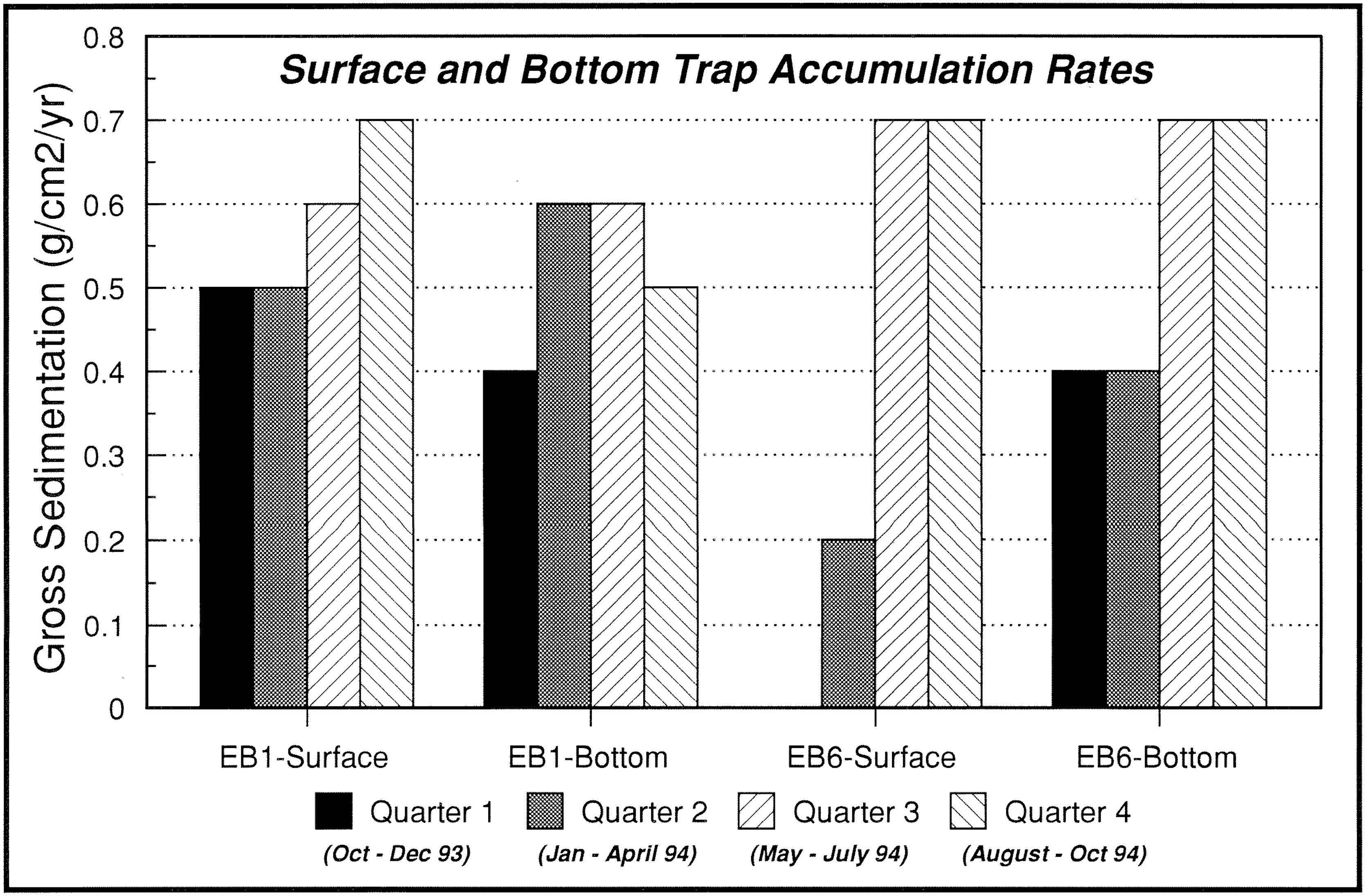

Figure 8: Comparison of sediment accumulation rates in surface and bottom traps.

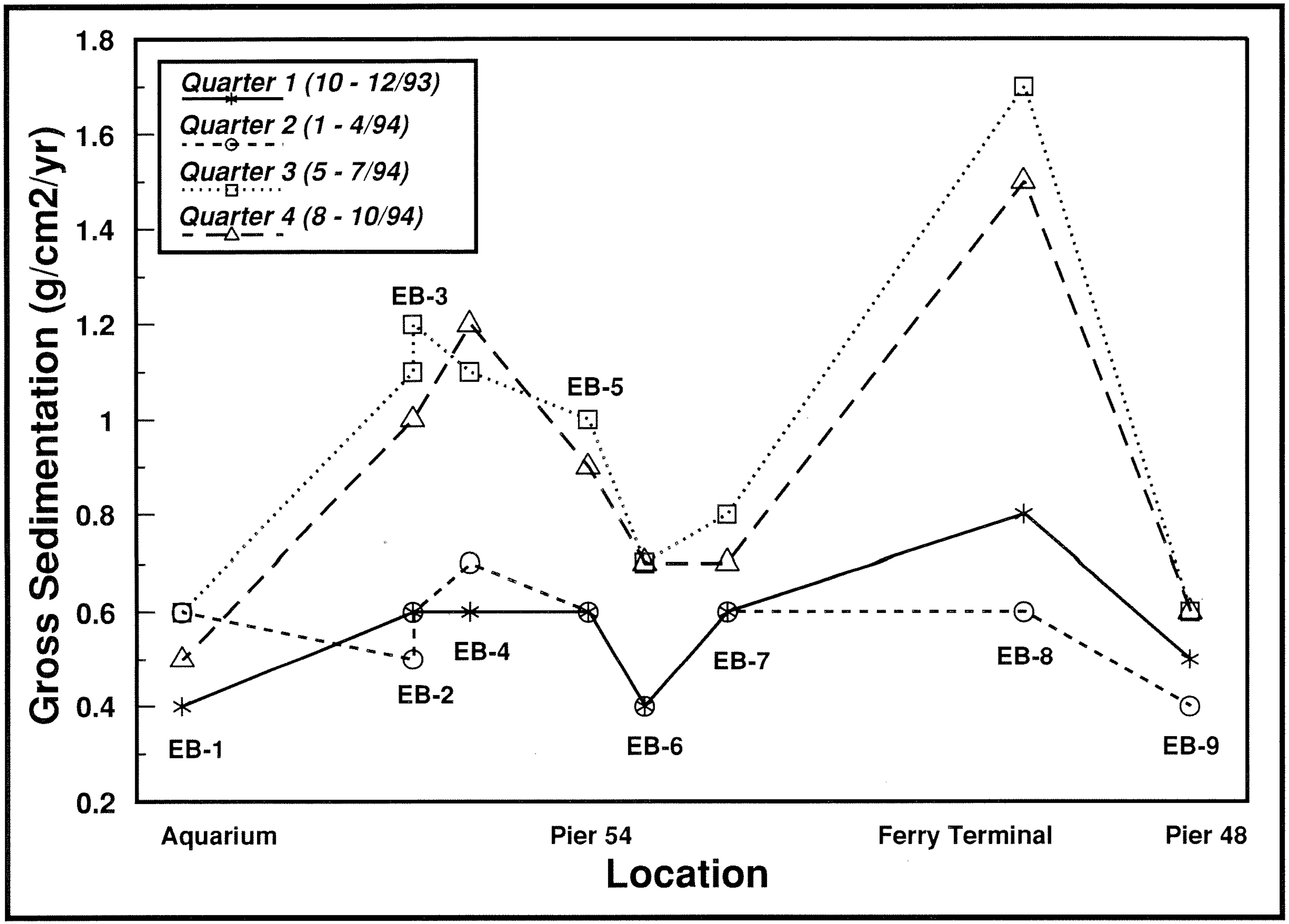

Figure 9: Comparison of gross sedimentation rates from sediment traps located 3 feet above the bottom along the central Seattle Waterfront.

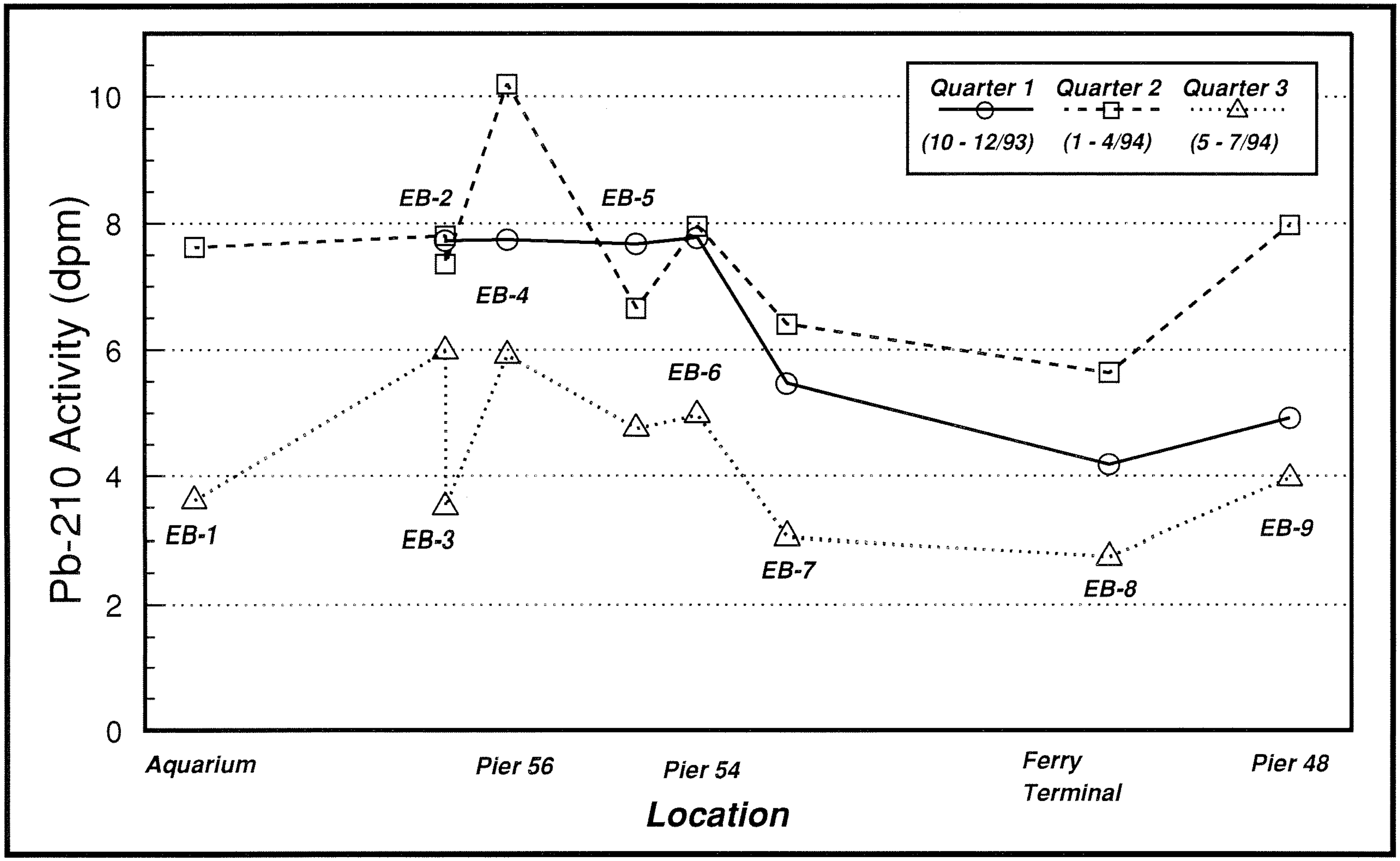

Figure 10: Comparison of Pb-210 levels in bottom traps from the central Seattle Waterfront between October 93 and July 94.

resuspension. Vessel traffic and its effects on resuspension of bottom sediments is discussed in more detail in Volume II.

Bottom Sediment

Nearshore Grain Size Mapping

The percent fines (<0.62um) content of bottom sediments (top 2 cm) in the study area is contoured in Figure 11. Examination of these data indicates that the majority of samples collected during the grain size mapping survey contained <50% fines. Areas immediately adjacent to the bulkhead line contained very little fine material. In addition, two sediment capping projects have also occurred in the last 6 years which have altered the grain size distribution of sediments in the area. These projects include the Ferry Terminal Cap which placed 10,000 yds^3 of material over 4 acres in 1989 and the Pier 53-55 cap which involved 20,000 yds^3 of material over 4.5 acres in 1992 (Romberg, 1995). Both projects used clean sand as a capping material.

Several localized areas were present that contained greater than 60% fines. The largest area is located between Piers 48 and 52. This area roughly corresponds to one of the current gyres previous discussed under net current circulation.

Deep Cores

Three cores were collected in June 1994 to evaluate net sedimentation rates using ^{210}Pb profiles and ^{137}Cs dating as a cross-check. Selected chemical analyses were also performed on these cores to evaluate subsurface contaminant profiles.

Net accumulation rates using ^{210}Pb profiles were calculated using two separate models (Boatman, 1995). The first, which has been used at a number of locations in Puget Sound is a simple burial and decay model which assumes a constant rate of supply of excess ^{210}Pb to the surface sediments (Krishnaswamy, et al, 1971). No evidence of a defined surface mixed layer was observed in any of the cores collected using the burial and decay model. Possible explanations for the lack of a sediment mixed layer could include; the presence of high chemical concentrations and/or more likely periodic disturbance of the surface sediments which prevents the establishment of a burrowing benthic community. Given the atypical nature of the profiles obtained with the burial and decay model, the data were also analyzed with a compaction/decay model. This model is based on a one-dimensional advection-diffusion equation, which considers sedimentation and compaction (Christensen, 1982).

Sedimentation rates for the waterfront determined from these models ranged from 0.1 - 0.72 g/cm^2/yr, with a mean of 0.28±0.26 g/cm^2/yr. In cores C1 (Between Pier 54 and 55) and C3 (North of Pier 48) rates from both models were in relatively good agreement, yielding net accumulation rates of 0.20±0.89 g/cm^2/yr (C1) and 0.11±0.11 g/cm^2/yr (C3), at each location

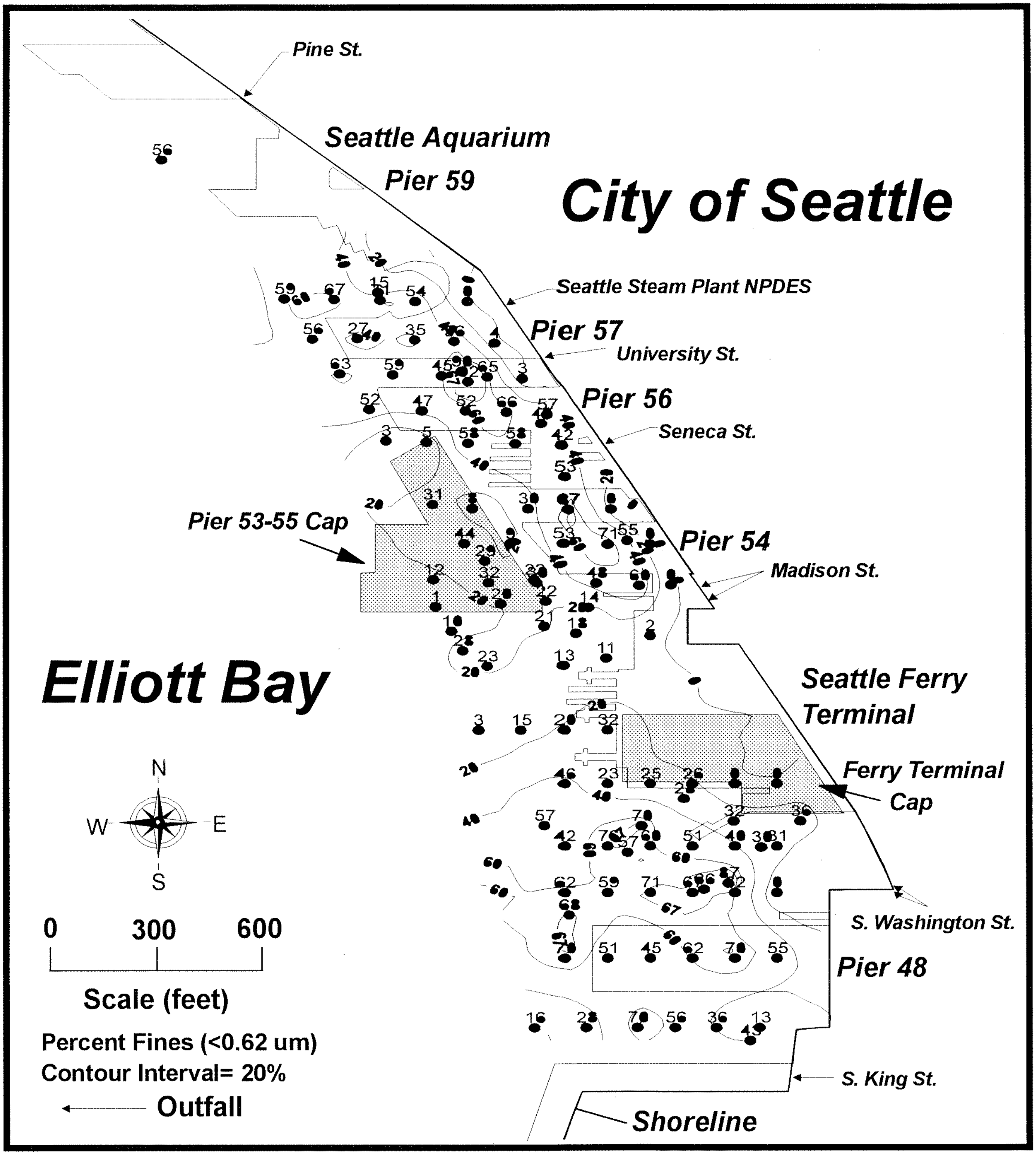

Figure 11: Bottom sediment percent fines contours for the Elliott Bay Waterfront Recontamination study area.

respectively. ^{137}Cs dating is also in good agreement with the assigned dates from ^{210}Pb profiles in core C1. No ^{137}Cs activity was noted in core C3, which suggests that the surface sediment layer has been removed from this location, probably through dredging. The average accumulation rate for the waterfront determined during the present study is in good agreement with other data collected in the vicinity of Pier 64/65 which reported a net accumulation rate of 0.26 ± 0.04 g/cm^2/yr (Hart Crowser, 1990).

Core C2 collected between Piers 56 and 57 exhibited a somewhat different accumulation pattern then the other two locations. Calculated accumulation rates and estimated dates for each section in core C2 are shown below. Dates for each core section were estimated by dividing the difference in depths between the midpoints of adjacent sections by the mean accumulation rate (cm/yr) of the sections. This yields the average total time to accumulate the given thickness between the midpoints of the sections.

Summary of calculated net accumulation rates and estimated dates for core C2.

Model Type	Depth (cm)*	Estimated Date	Accumulation Rate (g/cm^2/yr)
^{210}Pb Burial and Decay	2.8	1986	0.72
" "	13	1976	0.30
" "	23	1962	0.26
" "	34	1930	0.09
" "	45	1900	0.08
Compaction and Decay	66	1820	0.06
" "	87	1770	0.11
" "	110	1710	0.10
" "	130	1660	0.10
" "	150	1590	0.10
" "	170	1530	0.11
" "	190	1450	0.11
" "	210	1410	0.09

* Depth= Midpoint of section corrected for compaction

These data indicate that net sedimentation has been fairly constant up to as recent as 1962 (0.10 $g/cm^2/yr$) at this location. Since 1962, the accumulation rate has been increasing (0.28 $g/cm^2/yr$) with a large recent jump occurring after about the mid-1970s to the present value of 0.72 $g/cm^2/yr$. The higher rate for this location seems to be consistent with grain size information that suggests net deposition is occurring based on the presence of poorly sorted fine grained material (Boatman, 1995).

The results of chemical analysis of bottom cores from the central Seattle Waterfront are summarized in Table 9. Surface sediments (top 10 cm) from all cores were composed of primarily silt and clay size particles and which had relatively high TOC levels (7.0 to 7.7%). In general, cores from the northern portion of the study (C1 and C2) exhibited vertical contaminant profiles with peak concentrations occurring at depth. In contrast, maximum concentrations for most chemicals in core C3 (north of Pier 48) occurred in the top 7 cm of the core. The contaminant profile for core C3 is consistent with ^{137}Cs results that suggested the upper portion of the sediment record may have been removed.

Relatively high concentrations of mercury were present in all cores. This was especially true between Pier 56 and 57 (C2), where concentrations as high as 16 mg/kg occurred at a depth of 105-168 cm. Lead concentrations in the upper 7 cm of core C3 (north of Pier 48) was extremely high at 2100 mg/kg. This value is roughly 3.5 times higher then the next highest lead concentration measured during the present survey.

Vertical profiles of PCBs showed a similar pattern to metals. Cores from the northern portion of the study area had subsurface maximums, while the highest concentrations south of the ferry terminal were present in the upper 7 cm of the core. The highest Total PCB levels (8800 ug/kg, dry) were measured in the 21-42 cm layer of core C2 (between Pier 56 and 57). Dating information suggest that this layer was deposited sometime between the early 1900's and the early 1960's. PCBs were first commercially produced in 1929. Since that time they were widely used in industrial applications including: insulating fluids, plasticizers, in inks and carbonless paper, and as heat transfer and hydraulic fluids. Their manufacture was restricted by EPA in 1977 and banned in 1979 (Ecology, 1995).

Comparison to Sediment Management Standards

Individual contaminants in bottom cores are compared to the SMS in Table 9. Vertical profiles of copper, lead, mercury, and zinc are displayed in Figure 12. Similar patterns were observed for all of these metals in the sediment records. The highest concentrations occurred at depth, usually within the top 100 cm. One exception to this pattern was core C3 located north of Pier 48, which typically had the highest metals at the surface with concentrations declining with depth. This was especially true for lead which was exceptionally high (2100 mg/kg) in the top 3 cm. Concentration peaks for copper, lead, mercury and zinc between Piers 56 and 57, and lead and

Table 9: Comparison of metals and organics in bottom cores to Ecology's Sediment Management Standards.

Sample*			Grain Size															
Interval		TOC	Sand	Silt	Clay	Total Metals (mg/kg, dry)								PCBs (ug/kg, dry)				Total
(cm)	% Solids	(%)	(>62.5um)	(62.5-4um)	(<4um)	Cu	Pb	Ag	Hg	Zn	Al	Fe	Mn	1242	1254	1260	Total	PCBs*
Core #: C1 (Between Piers 54 and 55)																		
0-8	25	7.7	13	51	36	210	260 j	4.5	2.2	380 j	20000	31000	230	340 j	760	580	1700 j	8 j
8-16	31	-	-	-	-	280	330 j	4.7	2.5	420 j	23000	33000	270	230 j	1300	750	2300 j	10 j
16-32	33	-	-	-	-	290	480 j	3.7	5.5	590 j	22000	29000	230	500 j	2900	1480	4900 j	19 j
32-80	39	-	-	-	-	270	580 j	4.9	5.1	530 j	21000	27000	220	220 j	560	480	1300 j	6 j
80-128	44	-	-	-	-	180	510 j	5.1	3.4	400 j	22000	29000	250	100 u	100 u	100 u	100 u	-
128-140	49	-	-	-	-	90	280 j	0.9 j	2.9	280 j	25000	28000	300	79 u	79 u	79 u	79 u	-
Core #: C2 (Between Piers 56 and 57)																		
0-11	24	7.0	10	49	41	340	430 j	4.4	5.3	590 j	26000	30000	260	370 j	1900	2100	4400 j	30 j
11-21	27	-	-	-	-	300	540 j	3.8	7.0	710 j	24000	28000	240	680 j	2500	1300	4500 j	19 j
21-42	23	-	-	-	-	690	590 j	1.4 j	9.6	1000 j	46000	34000	210	1500 j	5500	1800	8800 j	26 j
42-105	21	-	-	-	-	300	400 j	6.2	12	1200 j	8500	13000	76	1400 j	4300	1100	6800 j	16 j
105-168	25	-	-	-	-	360	470 j	5.2	16	950 j	10000	20000	100	990 j	2700	1000	4700 j	14 j
168-206	29	-	-	-	-	1100	490 j	3.8	11	1700 j	11000	20000	130	300 j	150	580	1000 j	8 j
Core #: C3 (North of Pier 48)																		
0-7	58	7.3	34	46	20	160	2100 j	3.3	1.8	340 j	19000	28000	220	100 j	560	330	990 j	5 j
7-13	63	-	-	-	-	76	250 j	1.2 j	1.1	140 j	12000	32000	210	67 uj	56 j	47 j	100 j	1 j
13-26	62	-	-	-	-	68	140 j	0.53 j	1.2	110 j	11000	21000	160	71 u	71 u	71 u	71 u	-
26-65	65	-	-	-	-	45	290 j	0.3 u	0.82	230 j	13000	17000	140	56 u	56 u	56 u	56 u	-
65-117	68	-	-	-	-	24	7.4 j	0.3 u	0.054 j	34 j	12000	15000	120	44 u	44 u	44 u	44 u	-
117-143	68	-	-	-	-	23	6.3 j	0.3 u	0.038 j	29 j	8700	12000	110	62 u	62 u	62 u	62 u	-
143-172	66	-	-	-	-	24	4.8 j	0.3 u	0.036 j	34 j	9500	13000	110	58 u	58 u	58 u	58 u	-
172-199	65	-	-	-	-	30	4.8 j	2.9 j	0.052 j	35 j	10000	14000	120	72 u	72 u	72 u	72 u	-
SMS-Sediment Quality Standards						390	450	6.1	0.41	410	-	-	-	-	-	-	-	12*
SMS-Cleanup Screening Level						390	530	6.1	0.59	960	-	-	-	-	-	-	-	65*

Sample Interval= Depths corrected for core compaction

SMS= Ecology Sediment Management Standards (WAC-173-204)

*=Organic carbon normalized basis

▨ =Exceeds Cleanup Screening Level

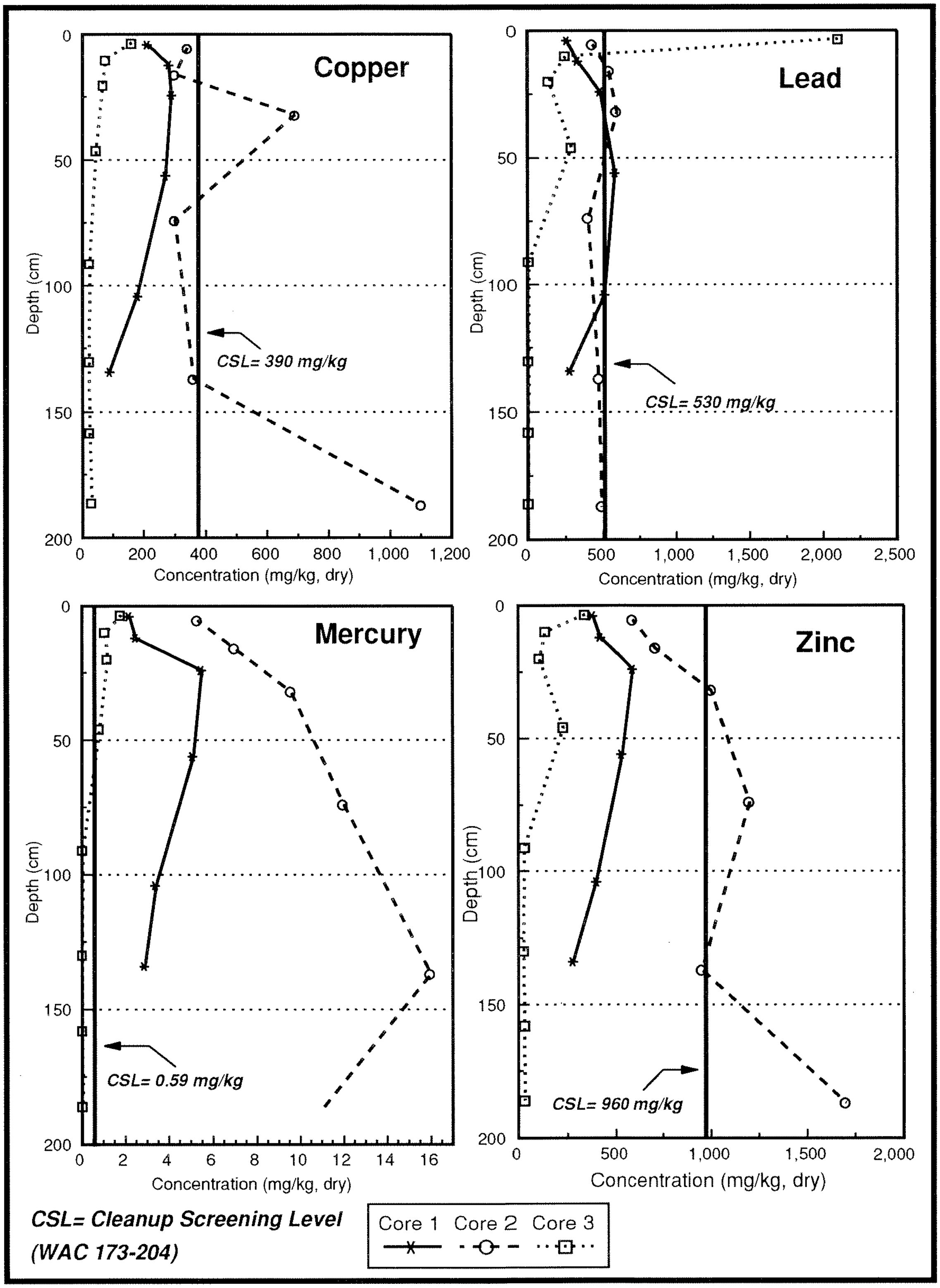

Figure 12: Copper, lead, mercury, and zinc profiles in bottom cores from the central Seattle Waterfront.

mercury between Piers 54 and 55 were above the CSL. Near surface concentrations of lead (top 3 cm) and mercury (top 50 cm) exceeded the at CSLs north of Pier 48.

Total PCB profiles displayed in Figure 13, showed the same general pattern as metals, with the highest concentrations occurring at depth. Again, an exception was noted in core C3 where PCB peaks occurred near the surface. Between Pier 56 and 57 was the only location where PCB levels exceeded the CSL of 65 mgPCB/Kg OC. PCB levels on a organic carbon normalized basis in core C2 reached a maximum of 130 mgPCB/Kg OC.

These data indicate that in the northern portion of the study area between Piers 54 and 57 any sediment cleanup activity involving sediment removal alone (i.e., dredging) would expose sediments with higher contaminant concentrations then currently exist at the surface. In contrast, at the location of core C3 south of the ferry terminal the danger of exposing more highly contaminated material does not appear to be a problem.

Comparison of Gross and Net Sedimentation Rates

To place sedimentation rates for the Seattle Waterfront into perspective, Table 10 summarizes rates reported for other parts of the waterfront and several waterways in Commencement Bay. The mean sedimentation rate of 0.7 g/cm^2/yr for the Seattle Waterfront determined from sediment traps (gross sedimentation) is in good agreement with the rate reported from the Pier 64/65 study (0.85 g/cm^2/yr). Compared to sediment trap data for Commencement Bay rates along the waterfront are approximately 2-5 times lower. Net sedimentation rates for the waterfront are similar between the present study and the Pier 64/65 study.

Comparison of sedimentation rates from sediment traps (gross sedimentation) and rates from ^{210}Pb dated cores (net sedimentation) have been used in other investigations to estimate bottom sediment resuspension rates (Baker, et al., 1991). Net and gross sedimentation rates from concurrent locations are compared below:

Summary of estimated resuspension rates for the central Seattle Waterfront from sediment trap and bottom core data (g/cm^2/yr).

Location	Gross	Net	Resuspension	Percent
Pier 54 and 55	0.78±0.21	0.20±0.89	0.58±0.91	74%
Pier 56 and 57	0.85±0.28	0.18±0.18	0.67±0.33	79%
Surface only	0.85±0.28	0.72	0.13±0.28	15%
N. of Pier 48	1.2±0.53	0.11±0.11	1.1±0.54	92%

Resuspension= (gross sedimentation - net sedimentation)
Percent= (resuspension/gross sedimentation) * 100

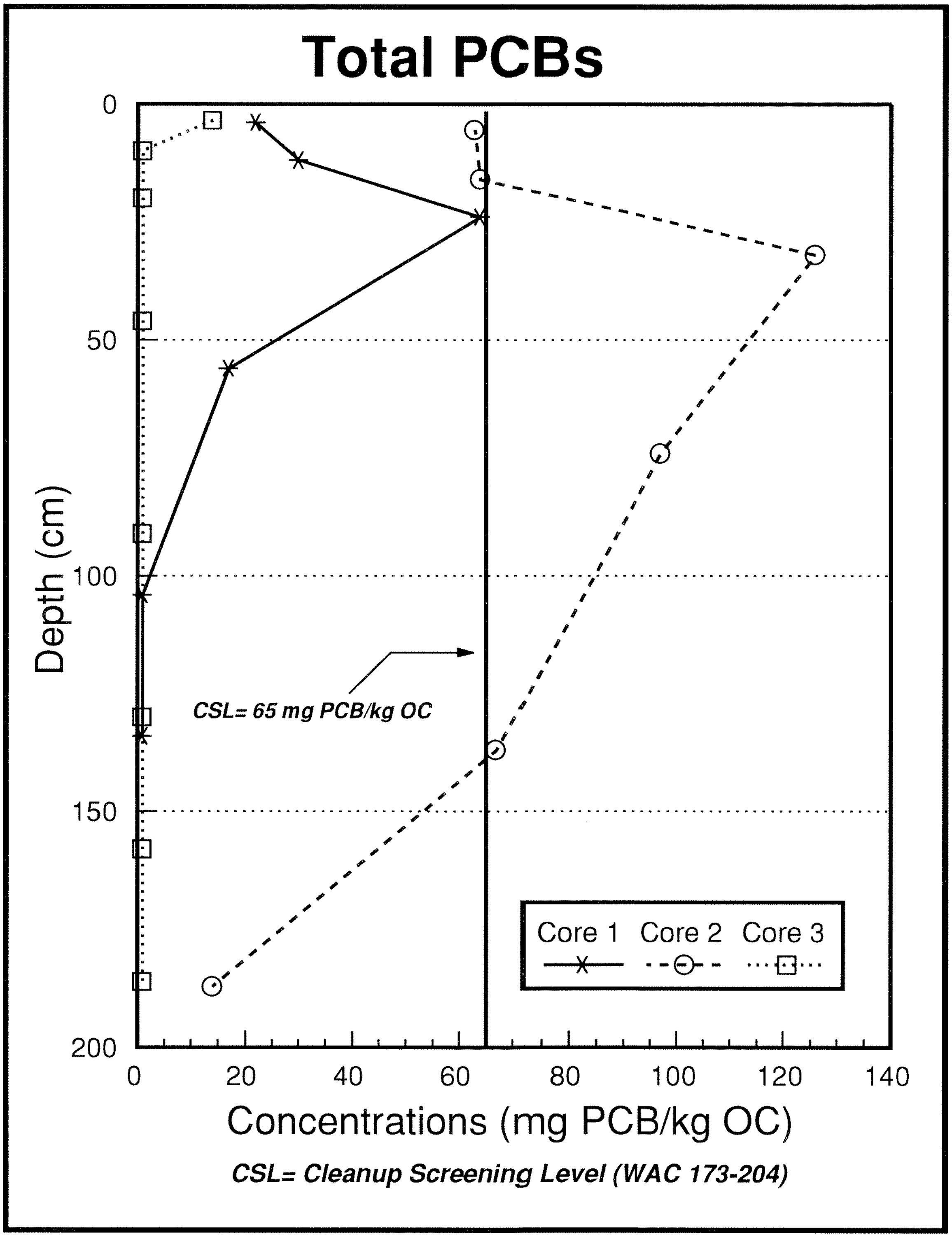

Figure 13: Organic carbon normalized PCB concentrations in bottom cores from the central Seattle Waterfront.

Table 10: Comparison of gross and net sedimentation rates for the central Seattle Waterfront (g/cm2/yr).

Source	Location	Mean	±	STD	Range
Gross Sedimentation					
Present Study	Seattle Waterfront	0.7	±	0.3	0.1 – 1.8
Hart Crowser, 1990	Pier 64/65	0.85	±	0.01	0.84 – 0.86
Norton, 1993	Thea Foss Waterway	1.7	±	1.1	0.2 – 5.0
Norton, 1992a,b	Hylebos Waterfront	2.1	±	0.8	0.7 – 3.8
	Sitcum Waterfront	3.5	±	1.2	2.1 – 5.7
Net Sedimentation					
Present Study	Seattle Waterfront	0.28	±	0.26	0.1 – 0.72
Hart Crowser, 1990	Pier 64/65	0.26	±	0.04	–

Gross rates determined from sediment trap data
Net rates determined from Pb–210 dated cores

Resuspension estimates for the Seattle Waterfront ranged from 0.13±0.28 to 1.1±0.54 g/cm^2/yr, with a mean of 0.62 g/cm^2/yr. These data suggest that as low as 15% (Pier 56/57- using the surface value in core C2 only) to as high as 92% (south of the ferry terminal) of the material collected by the traps in some areas, could be recent bottom sediments which have been resuspended. While the exact proportion of resuspended bottom sediment being collected by the traps is difficult to determine, it is fair to assume that the trapped material is representative of sediments which are mobile in the area.

Sediment resuspension rates for the Seattle Waterfront are similar to resuspension rates reported for Eagle Harbor (0.4 g/cm2/yr) and are somewhat lower than rates reported for other urban embayments in Puget Sound: Bellingham Bay= 3.6; Commencement Bay= 1.0-2.9 g/cm2/yr (Patmont and Crecelius, 1991; Norton, 1993).

As previously discussed a number of factors (net current velocities, spatial and temporal patterns in sediment accumulation and ^{210}Pb activities) suggest vessel activities along the waterfront as the major factor controlling the amount and timing of sediment resuspension. Resuspension and the potential for transport of contaminated sediments would be of the greatest concern in areas where new vessel activities are occurring above or adjacent to contaminated sediments. The design of any sediment remediation project along the Seattle Waterfront should consider vessel activities and their potential to redistribute contaminated sediments to be successful and cost effective over the long-term.

4.0 Conclusions

In general, the spatial distribution of contaminants measured in settling particulate matter (SPM) along the central Seattle Waterfront was in relatively good agreement with previous information on the area. Metals concentrations were fairly low and consistent during monitoring. An exception was mercury which exceeded Ecology's sediment Cleanup Screening Level (CSL) over a large portion of the study area (84% of the samples analyzed were >CSL). The average mercury concentration in SPM during the course of the study was 0.96 mg/kg, dry weight. This concentration is approximately 1.5 times higher than the CSL.

In contrast to metals, organics concentrations were variable both spatially and temporally along the waterfront. Peak concentrations of most organics tended to occur in the northern portion of the study area between Pier 52 (Ferry Terminal) and 57. Concentrations of 18 individual organics exceeded levels in SPM which would be expected to produce some adverse effects on biological resources (the Sediment Quality Standard- SQS). Twelve of these compounds also exceeded the CSLs.

Vertical profiles in bottom cores indicate that in the northern portion of study area (between Pier 52 and 57) concentrations of most contaminants typically peak at depth ranging from 16 to 42 cm. In contrast north of Pier 48 the highest concentrations were present in the top 7 cm. These data indicate that sediment cleanups in the northern portion of the study area that only involved dredging would probably expose more highly contaminated material then currently exists at the surface.

Net current speeds (surface and bottom) were weak along the waterfront being <5.0 cm/sec. The mean net speed for the entire study period was 1.3 cm/sec. Although, net speeds were weak a number of short term spikes were observed in the current records. These maximums ranged from 5.8 to 135 cm/sec. The occurrence of spikes in the records suggests that short term events (on the order of minutes) such as vessel movements are affecting near bottom current speeds.

Overall net current directions tend to be oriented parallel to the faces of piers. A convergent zone which moves water offshore to the west in the vicinity of Pier 52 is also present. This convergent zone located near Pier 52 appears to separate the study area hydrodynamically into a northern and southern region. The observed convergent zone is most likely the result of ferry operations at Pier 52. When docked, the ferries typically apply forward thrust to the stern propellers to hold the vessel in the berth during loading and unloading of cars and passengers. This causes an offshore current to be generated which moves away from Pier 52 to the west.

Gross (net + resuspension) sedimentation rates determined from bottom trap data ranged from 0.3-1.8 $g/cm^2/yr$ with a mean of 0.8±0.17 $g/cm^2/yr$. Net sedimentation rates for the waterfront ranged from 0.1 - 0.72 g/cm^2/yr, with a mean of 0.28±0.26g/cm^2/yr. Resuspension estimates for bottom sediments along the Seattle Waterfront ranged from 0.11±0.11 to 1.1±0.54 g/cm^2/yr.

Locations with the most variable gross sedimentation rates tended to corresponded to areas with the highest amount of vessel traffic. These data in conjunction with current velocity measurements and ^{210}Pb results suggest that vessel movements play an important role in resuspending bottom sediments along the central Seattle Waterfront, especially during the summer and early fall.

In general, cores from the northern portion of the study area between Piers 54 and 57 exhibited vertical contaminant profiles with peak concentrations occurring at depth. This was especially true for mercury between Pier 56 and 57, where concentrations as high as 16 mg/kg, dry weight occurred at a depth of 105-168 cm. In contrast, maximum concentrations for most chemicals in a core collected north of Pier 48 occurred in the top 7 cm.

The data collected during the field investigation portion of the waterfront recontamination study is further discussed in Volume II of this report. Particular attention in Volume II is given to implications of the data on sediment remediation strategies for the waterfront area.

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Appendices

Appendix A - Background Documents

Appendix B - Field Information

Appendix C - Quality Assurance Information

Appendix D - Individual Chemicals in Settling Particulate Matter and Bottom Cores, dry weight basis

Appendix A - Background information

Literature Search

Sampling and Analysis Plan

Modifications to the Sampling and Analysis Plan

ELLIOTT BAY WATERFRONT RECONTAMINATION STUDY

Literature Search

prepared by

Washington State Department of Ecology
Environmental Investigations and Laboratory Services Program

for

Elliott Bay/Duwamish Restoration Program

July 1993

INTRODUCTION

Recent studies have suggested that recontamination of bottom sediments along the central Seattle Waterfront may occur and could affect the success of sediment remediation projects in this area. As a result, the Elliott Bay/Duwamish Restoration Program Panel decided to conduct a resuspension/recontamination study in order to determine whether it is feasible to undertake sediment remediation projects along the central waterfront.

The first step in designing this study was to conduct a literature search which identifies existing information and ongoing monitoring programs whose data could be used in conjunction with the current study. The results of this review will be used to help design needed field activities for the resuspension/recontamination study to supplement existing information.

For the purposes of this review the outer limit of Elliott Bay was generally taken as a line between Duwamish Head and Smith Cove (Piers 90 and 91). The actual study area was understood to be the nearshore, subtidal Seattle Waterfront from approximately King Street to the north side of Pier 71. This area is shown in Figure A. An attempt was made to compile all sources of information since 1971, using existing figures and tables where possible. Information on the Duwamish River above the mouth and on land-based pollution sources was not included, although some information on these areas will be found among the references cited.

One hundred and four references were found on the subject areas of interest. Subject areas included: currents, distribution of suspended particulates, chemical analysis of suspended particulates, bottom sediment surveys, sediment trap studies, sediment accumulation rates, resuspension, and ongoing monitoring activities. The following pages present a synopsis of the information collected.

TABLE OF CONTENTS

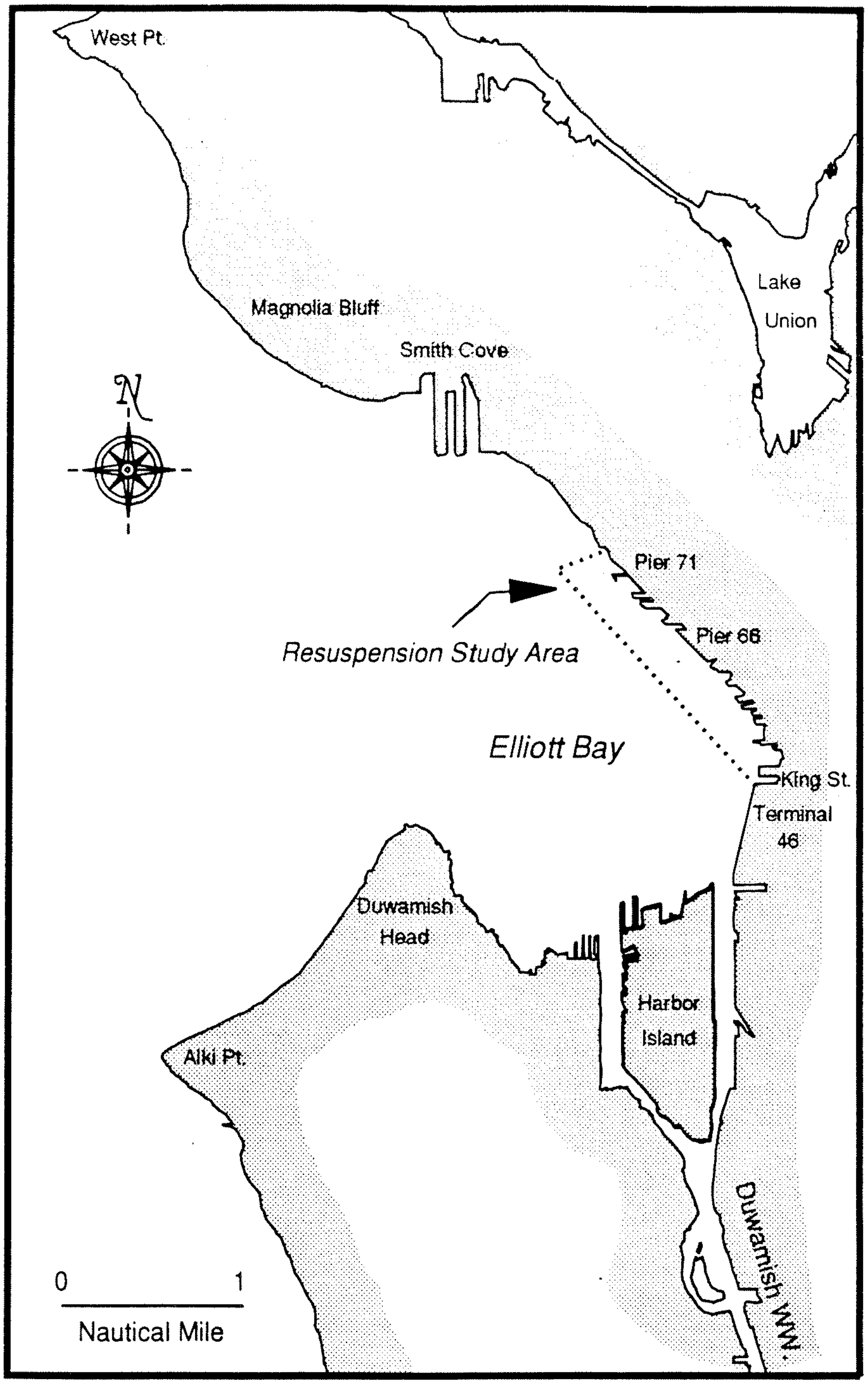


Figure A: Study Area, Elliott Bay Resuspension Study

I. CURRENTS

Most Useful References: 14, 18, 19, 83, 98, 100, 101, 104

Other References: 1, 2, 3, 4, 13, 16, 20, 21, 22, 23, 24, 36, 49, 56, 63, 74, 81, 97

Synopsis of Information Found: Early studies by Rogers (1955) and Winter (1977) using the UW Puget Sound hydraulic model suggested a clock-wise circulation pattern in Elliott Bay, with water generally exiting along Duwamish Head. When conditions of high runoff from the Duwamish River and weak tidal currents were modelled, flow was predominantly to the northwest past Smith Cove.

NOAA (Baker, *et al.*, 1983) conducted field studies during the summer of 1979 and winter of 1980 to describe the currents and hydrography of Elliott Bay for evaluating transport of dissolved and suspended matter. Figure 1 shows locations of current meters and CTD stations used in this study.

Sillcox, *et al.*, (1981) describes NOAA's observations on currents, temperature and salinity during 1979-1980. Findings generally contradicted those from the model. Surveys of temperature and salinity showed the Duwamish River plume was always on the north side of the bay. In both winter and summer most freshwater left the bay to the north. Residence time for water in the inner bay was inferred to be 1-to-10 days depending on depth and season. Winter (1977) calculated residence times of up to 3.5 days for dye moving north along the Seattle waterfront in the Puget Sound model.

Dexter, *et al.*, (1984) concluded the "primary influence of the river discharge is felt in the southern and southeast portions of Elliott Bay and along the Seattle waterfront." Normal seasonal flow of the Duwamish River is depicted in Figure 2 (Santos and Stoner, 1972). Most of the discharge is through the West Waterway. Curl, *et al.*, (1987) compared flows for the Duwamish River with the Denny Way and six other Elliott Bay combined sewer outfalls (CSOs) during eight days of rain between December 31 and January 5, 1986. They found the CSOs were only about 0.4% of river flow.

According to Sillcox, *et al.*, (1981) "Very weak speeds characterized all currents observed in Elliott Bay." Mean speeds were typically less than 5 cm/sec, although occasional instantaneous speeds of 30cm/sec occurred.

Records from current meters deployed in subsequent studies are in line with Sillcox, *et al.'s* conclusions with regard to current speed and direction in Elliott Bay. Chief among these are Dexter, *et al.*, (1984) who made two deployments over a PCB-contaminated dredge disposal site off the Duwamish River; URS Engineers and Evans-Hamilton (1986) who deployed 25 current meters in and around the Duwamish Head area for outfall siting studies for the Renton Sewage Treatment Plant; and 1985-1986 field studies by NOAA (Curl, *et al.*, 1987, 1988) using current meters at a deep-water site south of Pier 91 (site 1 in Figure 1).

Cox, *et al.*, (1984) have summarized Puget Sound current measurements from 1908-1980, including seven sites in Elliott Bay (station #159 - #165). URS Engineers and Evans-Hamilton (1984) synthesized the information from six of these sites to estimate circulation patterns for surface (0 - 50m) and bottom (50m - bottom) waters (Figures 3 and 4).

Three of the current meter sites indexed by Cox, *et al.*, are within the area of interest for the resuspension study. Site #159 in 43 meters of water off the Seattle Waterfront (47 36.7N x 122 21.4W) operated by the National Ocean Survey (unpublished) from March 25-29, 1946, recorded a net surface (2m) speed of 3.99 cm/sec and net direction of 318° true. The other two sites, #160 (Pier 46) and #161 (Pier 15) operated for less than one tidal day, so give no useful information (Patten, 1976).

No other instances of current meter measurements within the resuspension study area were found during the literature search. A draft report by Tomlinson, *et al.*, (1976) contains maps showing movements of dye released at the mouth of the Denny Way CSO.

Conclusion: The circulation pattern of Elliott Bay is well described but nearshore current speed information is generally lacking for the waterfront area.

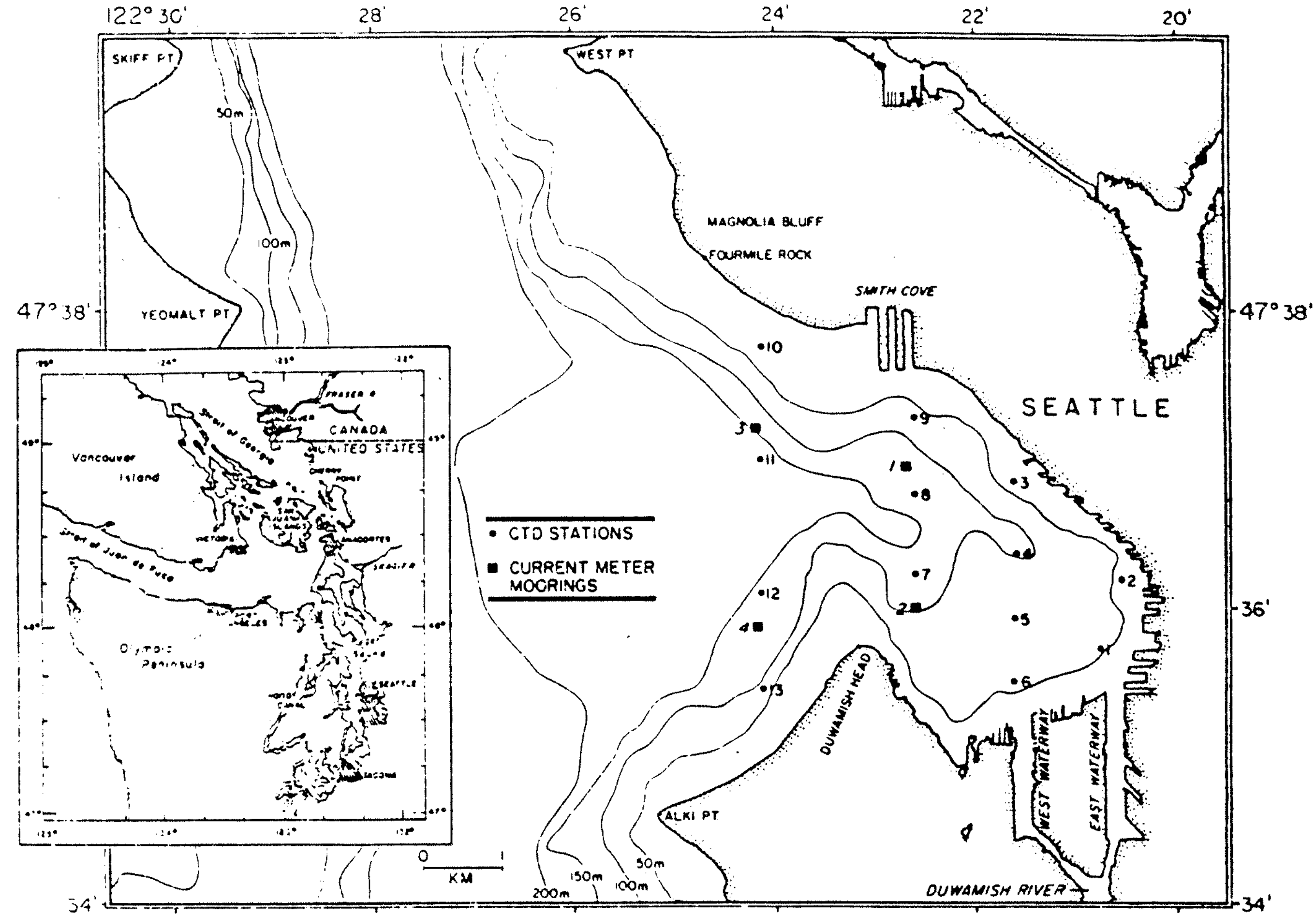
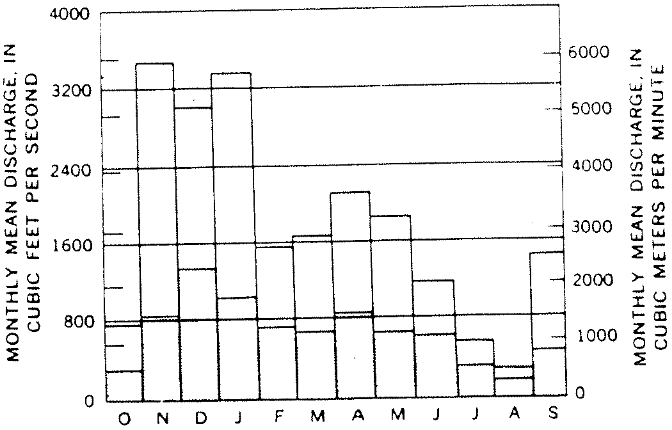
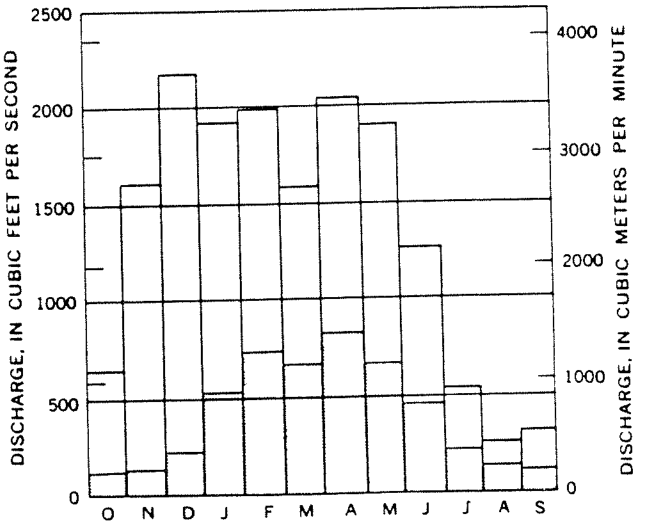


Chart of Elliott Bay showing bathymetry, station locations, mooring locations, and the mouth of the Duwamish River (West Waterway). Contour interval is 50 m.

Figure 1. Baker *et al.* (1983)

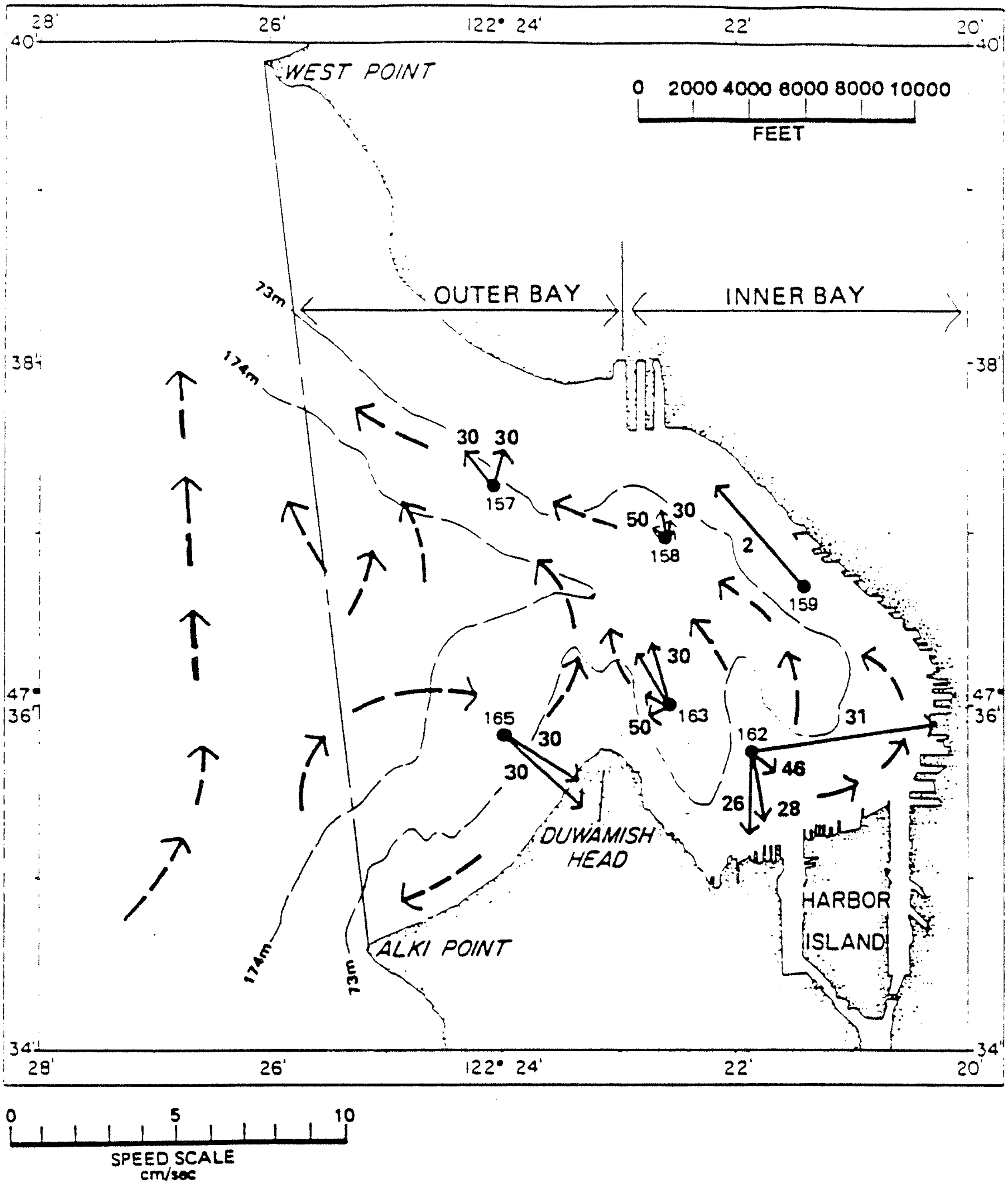


Comparison of monthly mean discharge of the Green River near Auburn for the driest year (1941, shaded bars) and wettest year (1959, shaded plus unshaded bars) during the period 1937–65.



Mean monthly (unshaded plus shaded bars) and minimum monthly (shaded bars) discharges of Green River near Auburn, 1937–65.

Figure 2. Santos and Stoner (1972)



Net velocities (⟶) in Elliott Bay in the depth range of
0 - 50m and inferred circulation patterns (--→)

Current meter site 158 ●

Current meter depth 30⟶
Arrow length proportionate to speed

METRO Municipality of Metropolitan Seattle

DATE	URS ENGINEERS	Evans-Hamilton Inc.	SCALE
BY	RENTON EFFLUENT TRANSFER SYSTEM		FILE NO.
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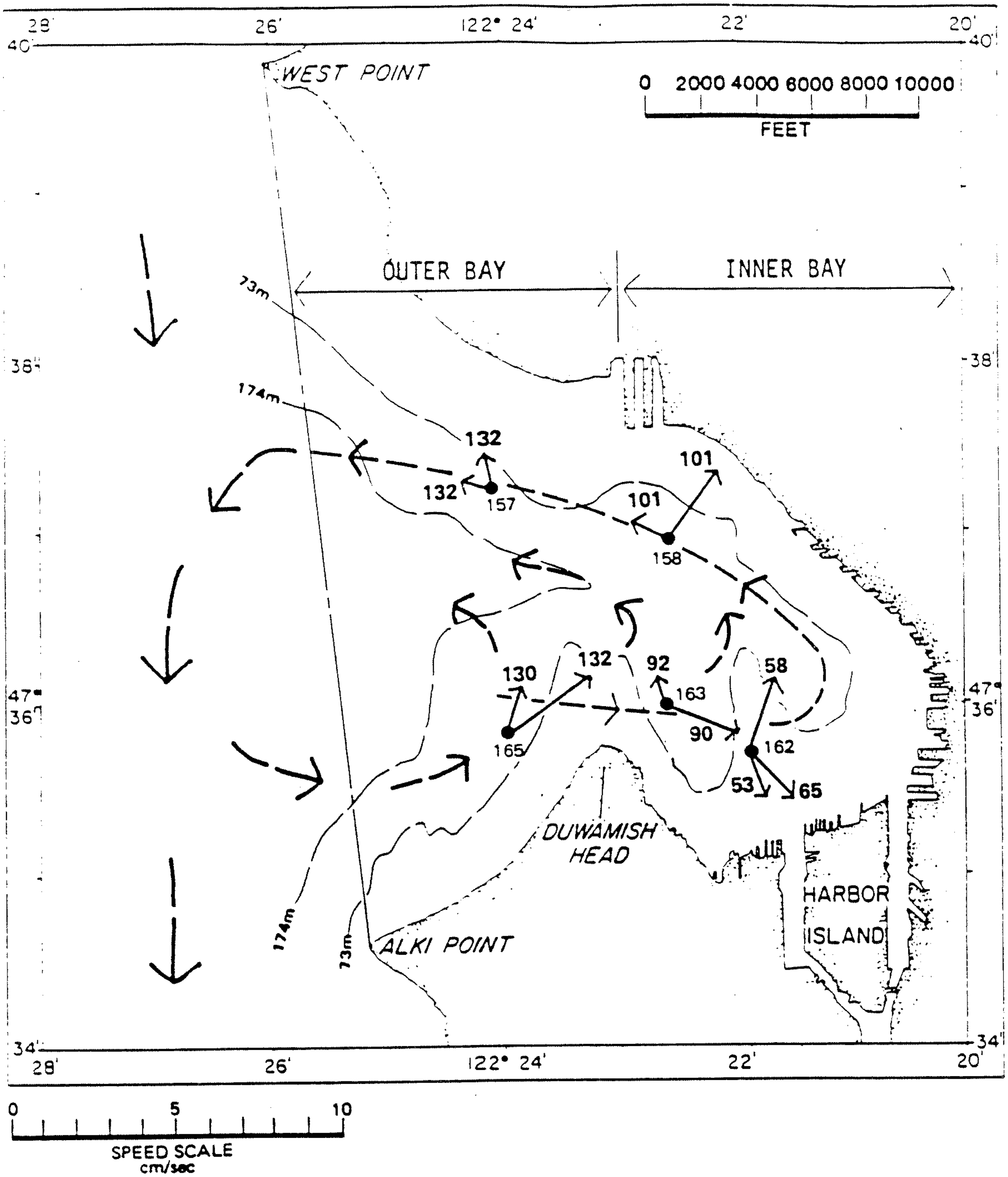
Figure 3. URS and Evans Hamilton (1984)



Net velocities (→) in Elliott Bay in the depth range of 50m - bottom at five locations (●). Numbers (157) denote sites and numbers (132) denote depth of observation in meters. Dashed line represents hypothetical trajectory of water particle.

METRO Municipality of Metropolitan Seattle

DATE	URS ENGINEERS	Evans-Hamilton Inc.	SCALE
BY	RENTON EFFLUENT TRANSFER SYSTEM		FILE NO.
APPROVED			SHEET OF

Figure 4. URS and Evans Hamilton (1984)

II. DISTRIBUTION OF SUSPENDED PARTICULATES

Most Useful References: 3, 4, 18, 19, 30, 32, 47, 98, 99

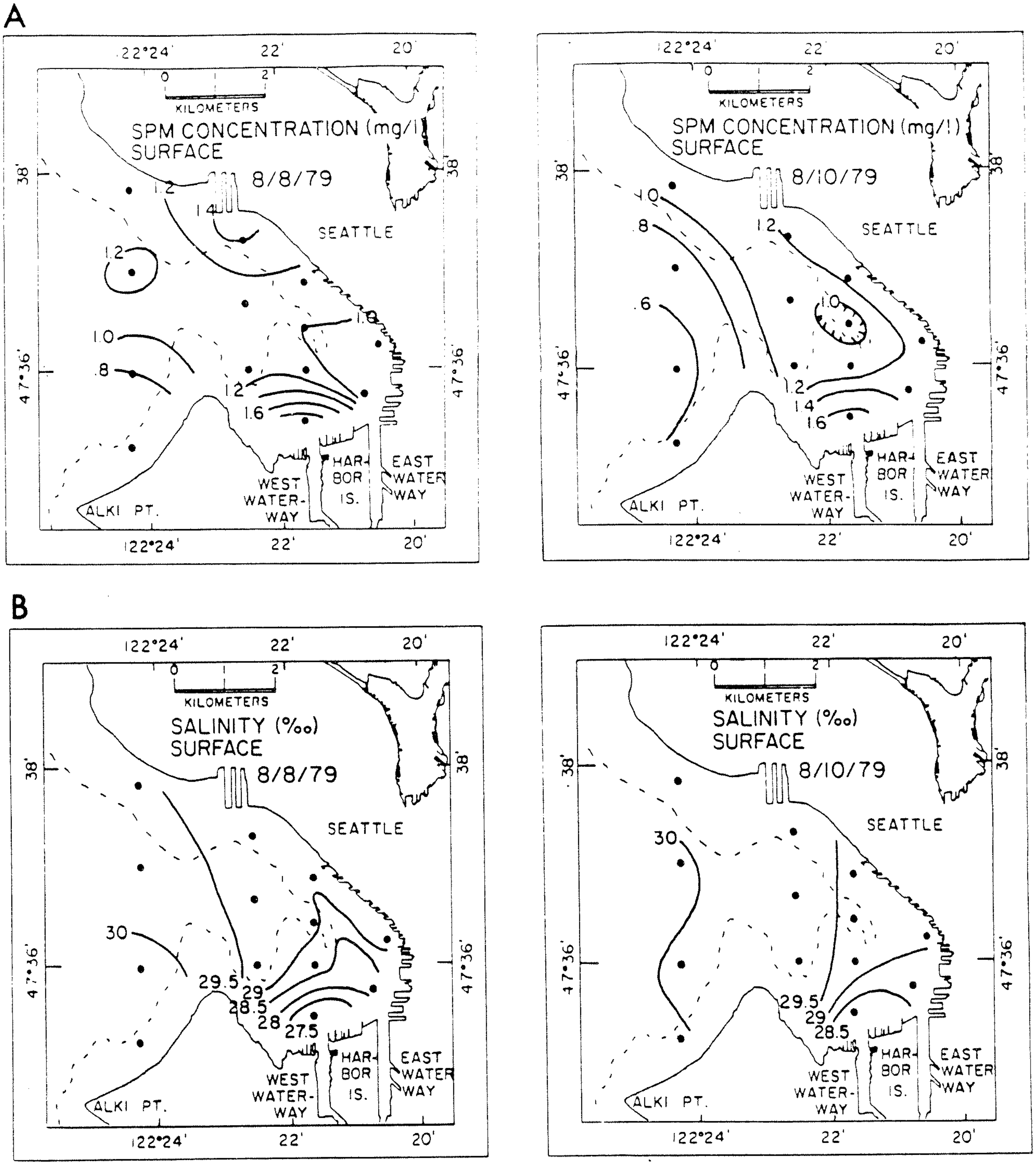
Other References: 17, 31, 37, 84, 101

Synopsis of Information Found: The horizontal and vertical distribution of suspended particulate matter (SPM) during NOAA's 1979-1980 field studies in Elliott Bay is described in Baker (1982) and Baker et al. (1983). These reports conclude the bulk of suspended particulate matter (SPM) occurs in a thin (<5m) surface layer from the Duwamish River plume and in a bottom nephloid layer in deep water areas (Figures 5 and 6). These reports also contain data on particle size distribution of SPM and organic content. Baker, *et al.*, (1983) conclude that, because of short residence time of Duwamish River water, the plume is a minor source of sediments to parts of Elliott Bay greater than 50m depth, but that "At shallower depths, shoreline sources and settling from the surface layer are probably the most important contributors to sedimentation." The distribution of SPM in Elliott Bay is also portrayed in Curl and Feely (1986), Curl, *et al.*, (1987, 1988), Feely, *et al.*, (1988), and Paulson, *et al.*, (1989), based on subsequent NOAA studies in 1985-1986 (Figures 7 and 8).

Tomlinson, *et al.*, (1980) studied the fate of particulates discharged by the Denny Way CSO. They had difficulty seeing the CSO plume because of a "massive," turbid plume from the Duwamish River, described as 1.5-3m deep and up to 1000m wide during storm events. The area "most heavily impacted" by the CSO plume extended 200-300m north and south of the discharge. Figure 9 shows a transverse section of the water column off the CSO. Helseth, *et al.*, (1979) and Stober and Chew (1984) contain hydrographic data that further demonstrate the Duwamish plume remains in the upper 5m along the Seattle waterfront.

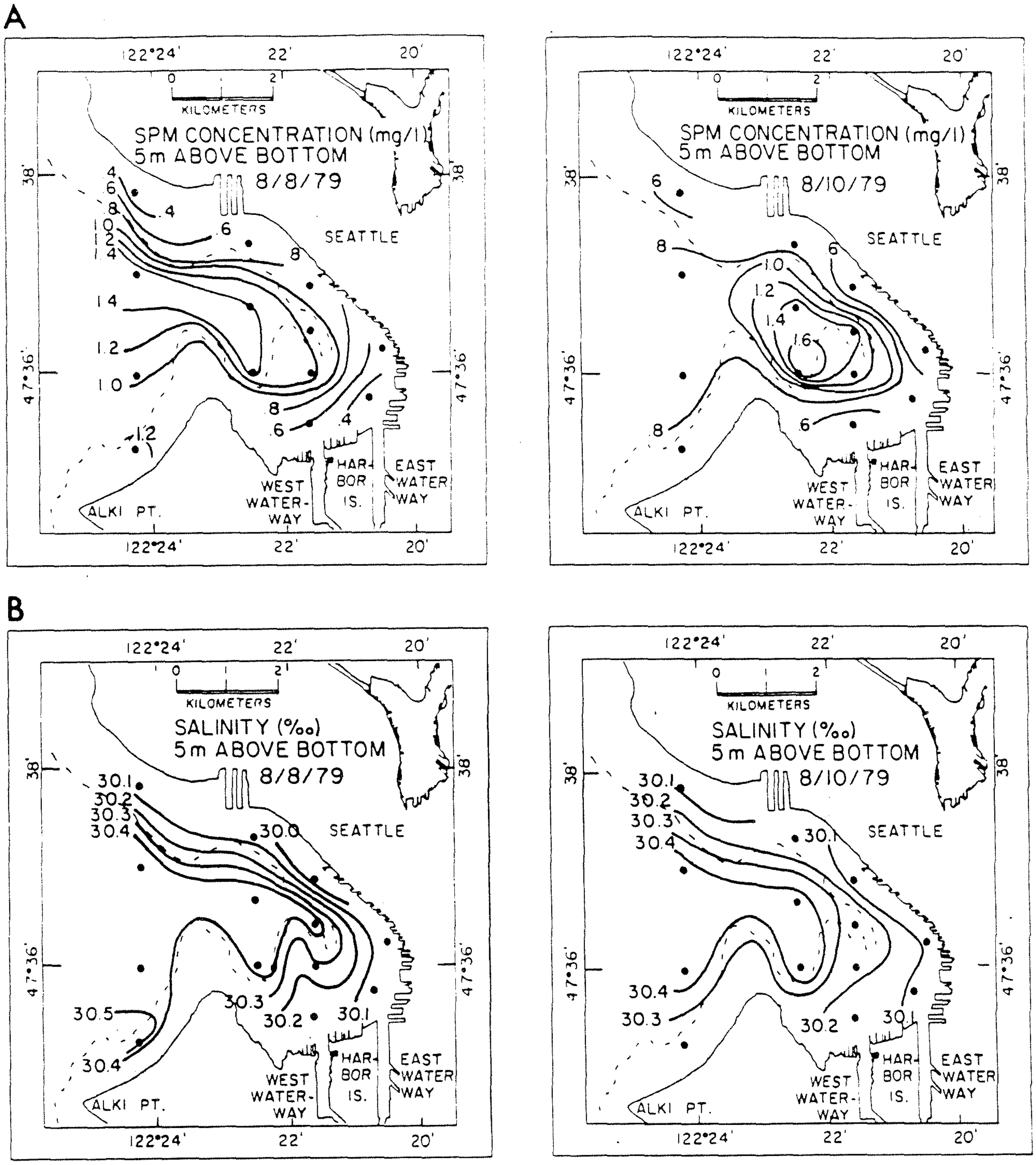
Sediment discharge by the Duwamish River is illustrated in Figure 10 (Curl, 1982). The season of maximum inputs to Elliott Bay is November through June.

Conclusion: The distribution of particulates in Elliott Bay has been described for a variety of conditions. The Duwamish River is expected to be the main influence on the study area, and may deposit sediments in nearshore areas along the waterfront.



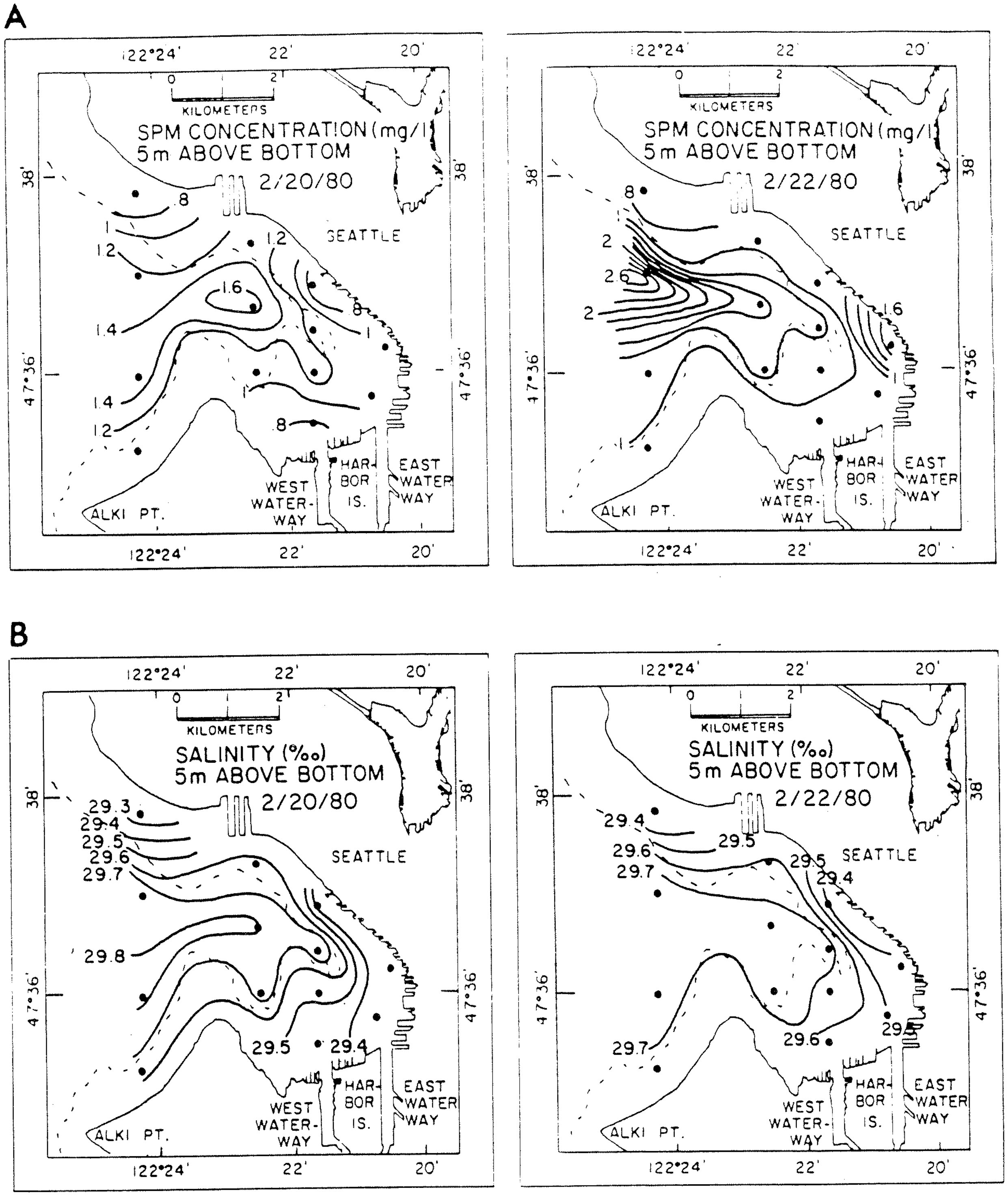
Areal maps of surface (A) SPM concentration and (B) salinity at 1 m during the August surveys. Contour interval is 0.2 mg/l for SPM, 0.5°/oo for salinity. Dotted line is the 100-m isobath.

Figure 5. Baker (1982)



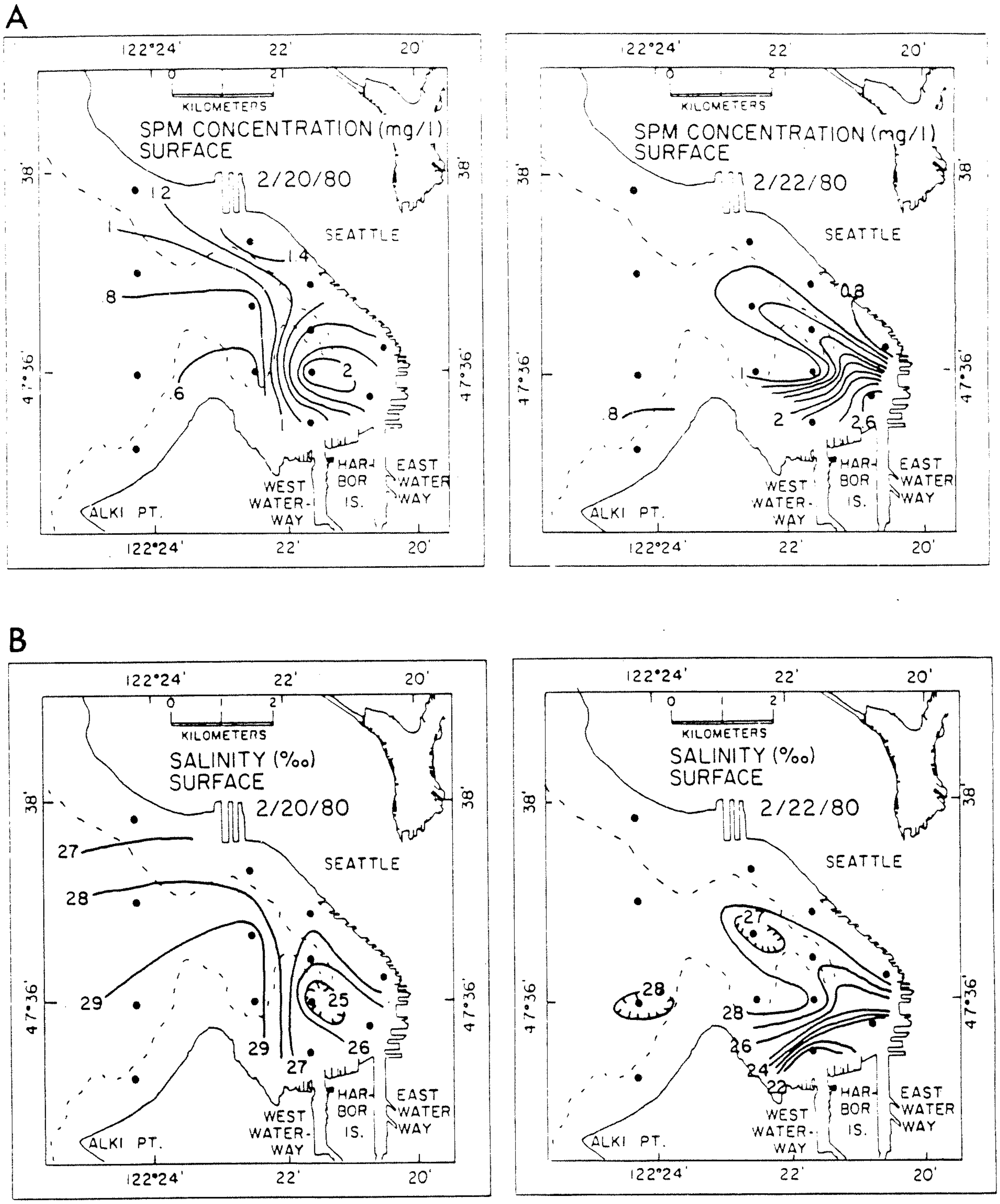
Areal maps of bottom (A) SPM concentration and (B) salinity during the August surveys. Contour interval is 0.2 mg/l for SPM, 0.1°/oo for salinity. Dotted line is the 100-m isobath.

Figure 5. Continued



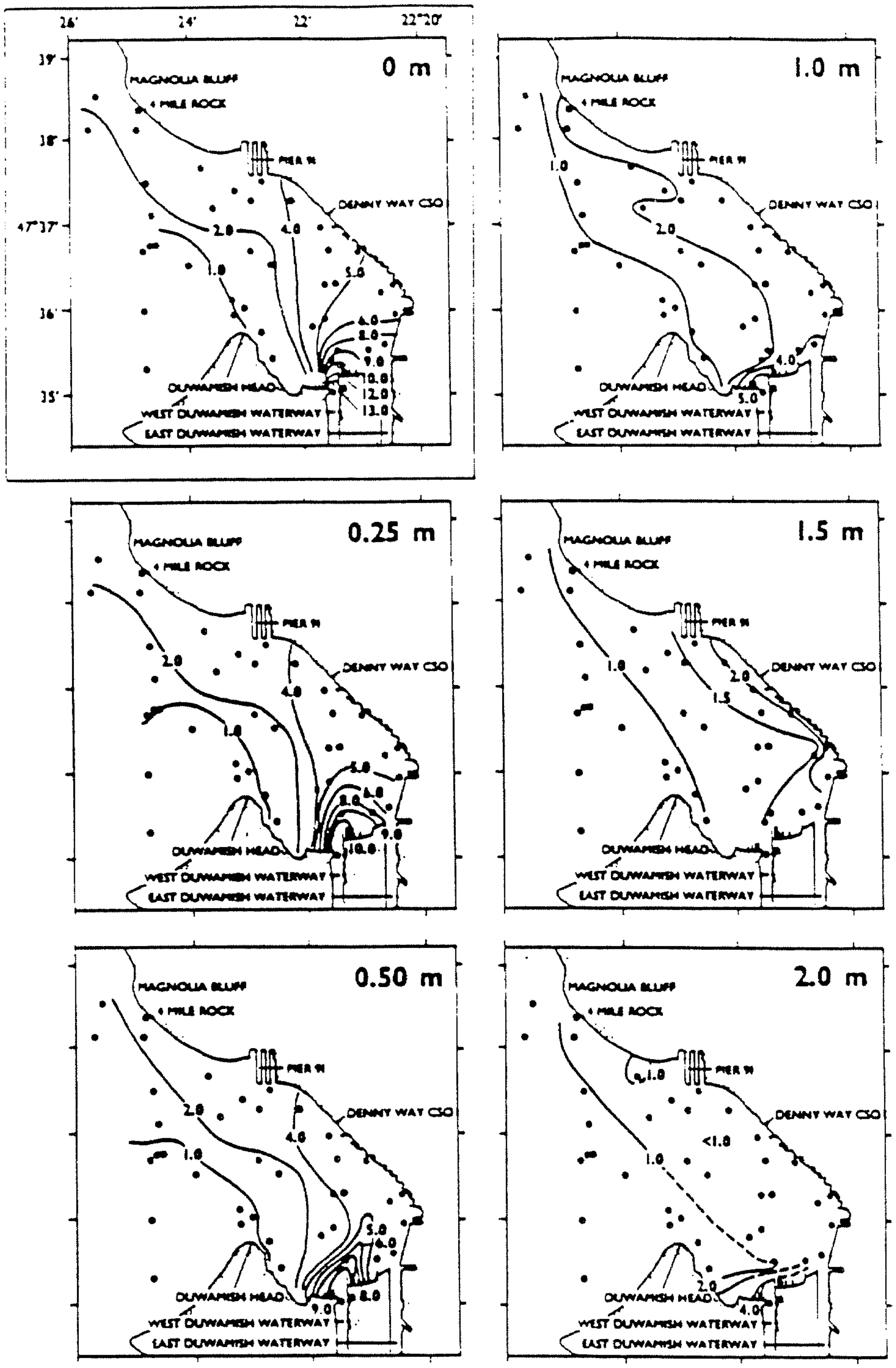
Areal maps of bottom (A) SPM concentration and (B) salinity during the February surveys. Contour interval is 0.2 mg/l for SPM, 0.1°/oo for salinity. Dotted line is 100-m isobath.

Figure 6. Baker (1982)



Areal maps of surface (A) SPM concentration and (B) salinity at 1 m during the February surveys. Contour interval is 0.2 mg/l for SPM, 1°/oo for salinity. Dotted line is 100-m isobath.

Figure 6. Continued



0 m

1.0 m

0.25 m

1.5 m

0.50 m

2.0 m

Near-Surface Concentrations of SPM (mg/l)
Elliott Bay
April 4, 1985

Figure 7. Curl *et al.* (1987)

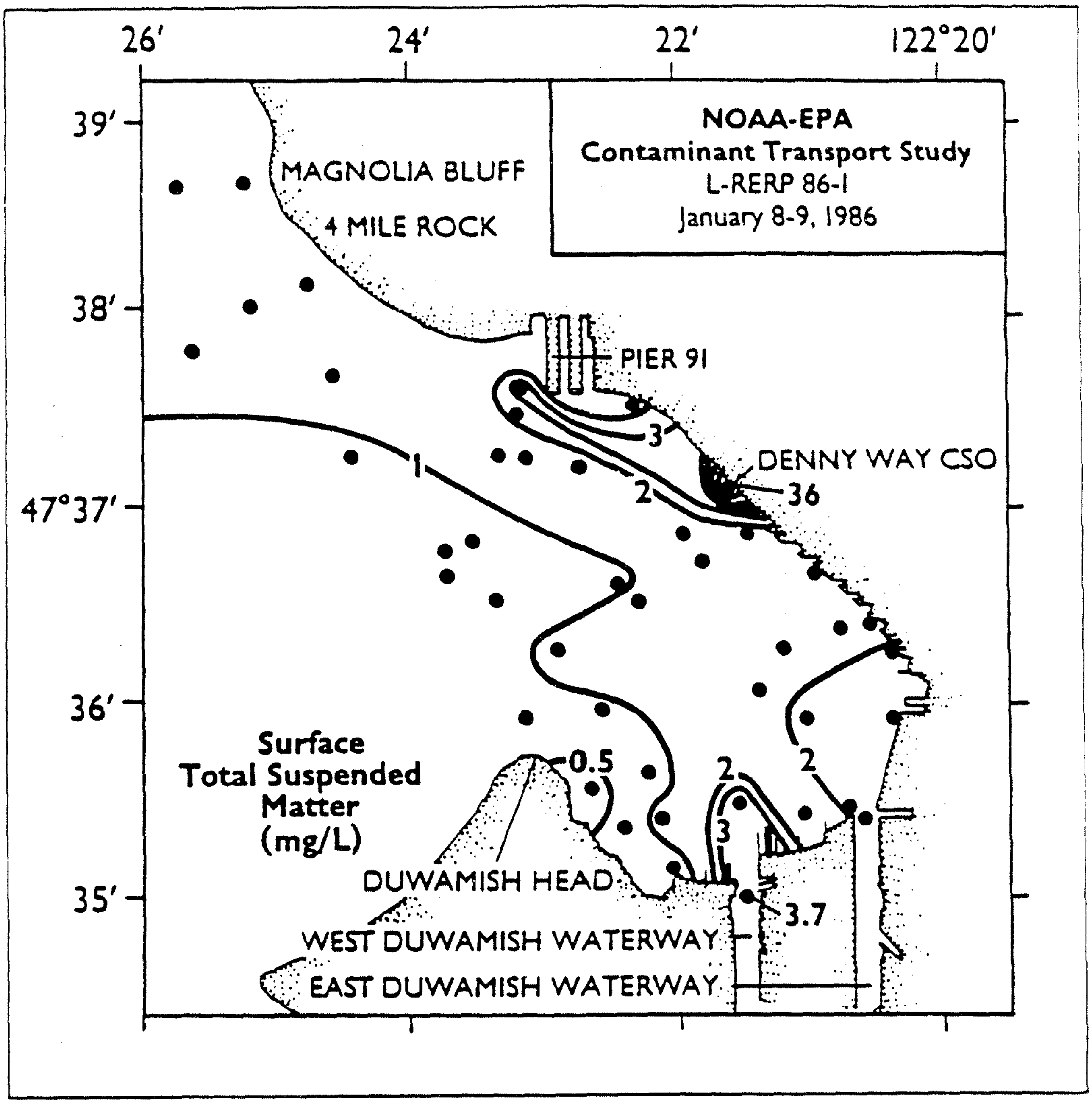
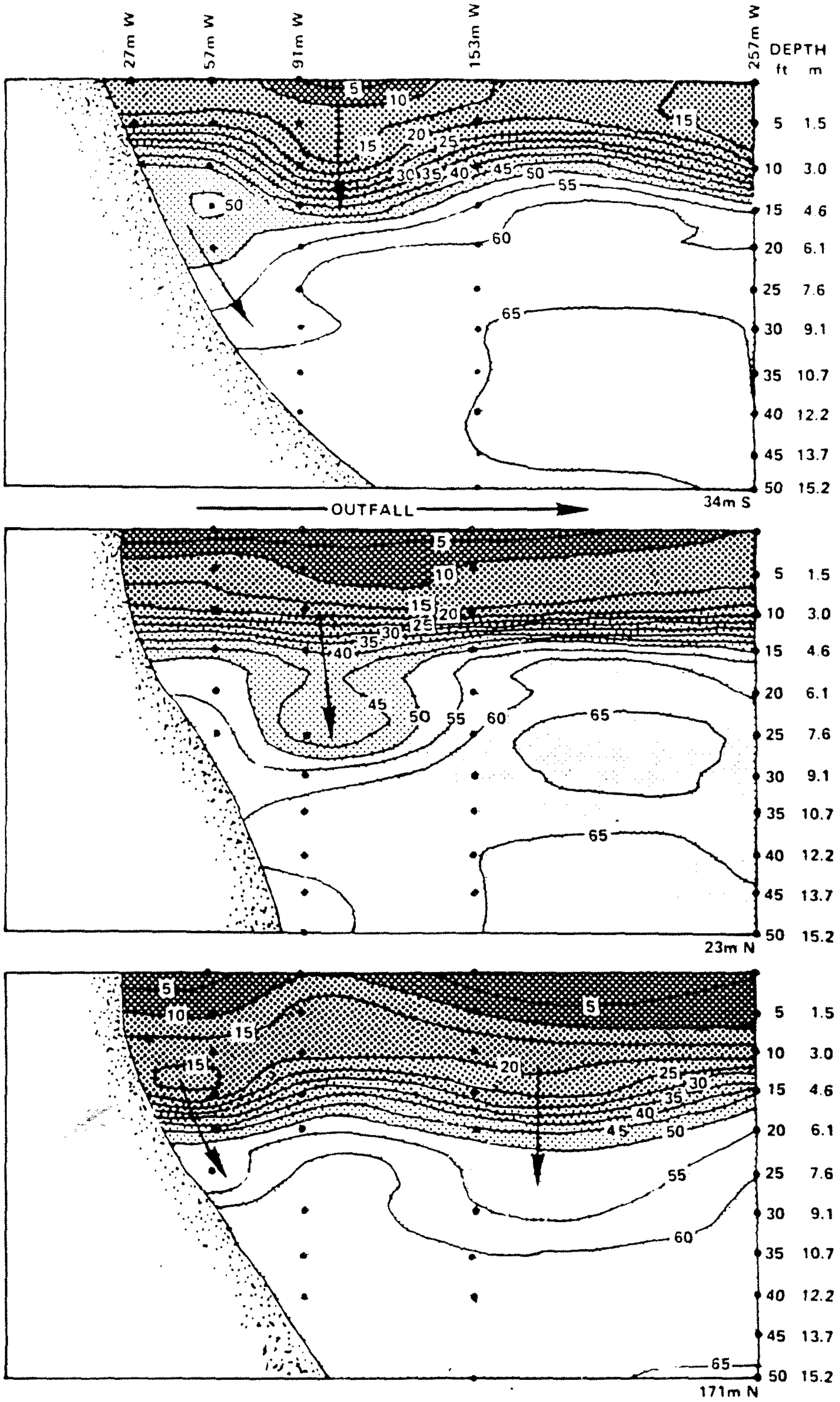
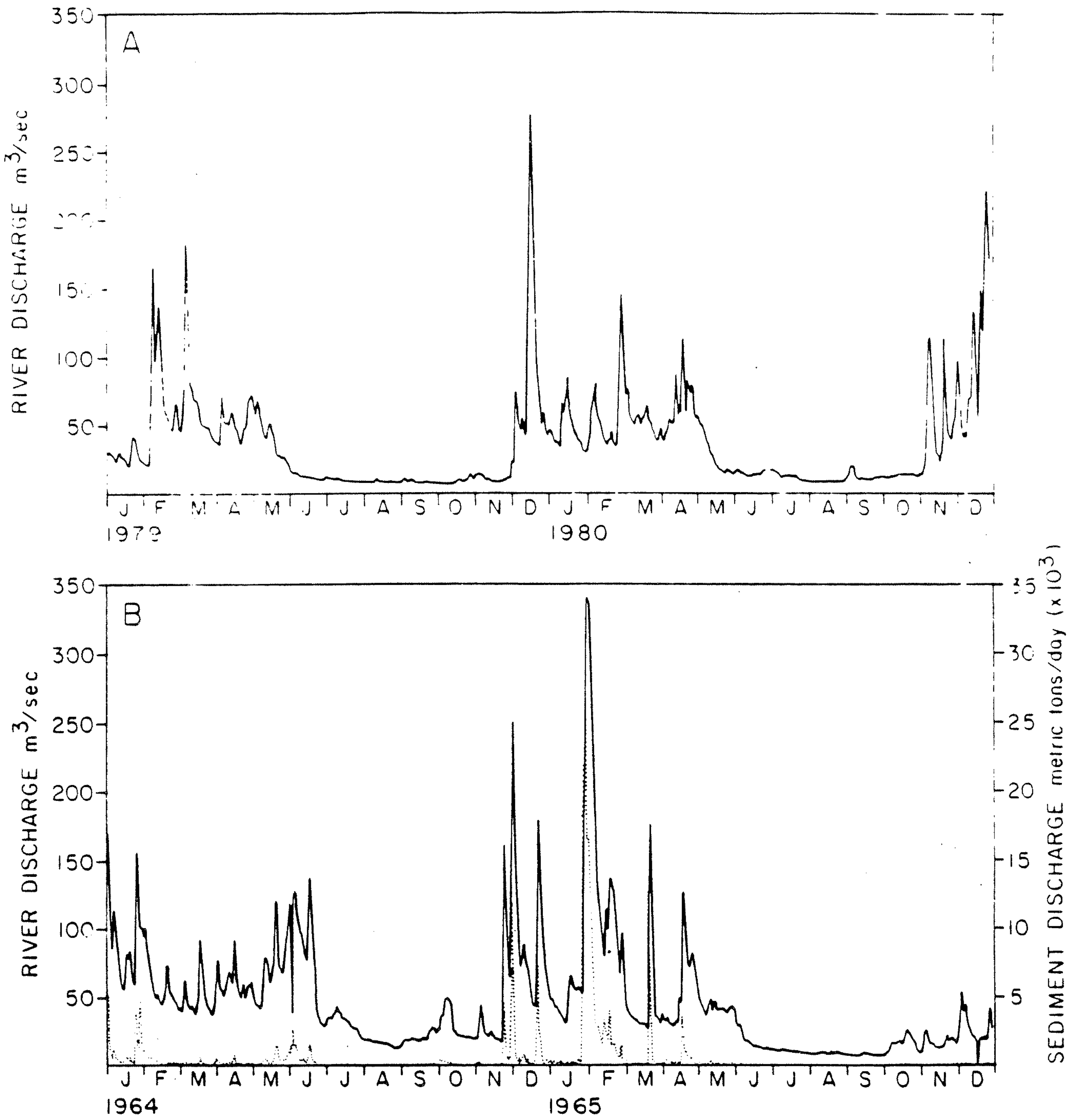


Figure 8. Curl et al. (1987)



Transverse sections of contours of percent light transmission around the overflow outfall of the Denny Way Regulator—2050-2243 hrs., 2/24/79. The perspective is that of a diver looking south along the shoreline with Elliott Bay to his right. The arrows indicate areas of particulate settling.

Figure 9. Tomlinson *et al.* (1980)



Water discharge data for the Duwamish River at Tukwila (period of record: 1979-1980). B. water (-----) and sediment (.....) discharge data for the Duwamish River at Tukwila (period of record: 1964-1965). Data obtained from U.S. Geological Survey, Water Resources Division.

Figure 10. Curl (1982)

III. CHEMICAL ANALYSIS OF SUSPENDED PARTICULATES

Most Useful References: 15, 18, 19, 31, 32, 47, 57, 58, 59, 71

Other References: 21, 34, 63

Synopsis of Information Found: Chemical analysis of Elliott Bay and Duwamish River SPM has been conducted by a number of investigators; most reports deal with metals. NOAA's metals data pertinent to Elliott Bay are compiled in reports by Paulson, *et al.*, (1991a,b). Paulson, *et al.*, (1989) contains a useful summary table of 1980-1985 NOAA data on iron, manganese, lead, zinc, and copper concentrations in SPM (Table 1).

Riley, *et al.*, (1980) collected SPM samples off Pier 54, the Duwamish West Waterway and upper end of Harbor Island in July 1979 and analyzed a range of trace elements (Figure 11, Tables 2 and 3). Concentrations of arsenic and antimony in Duwamish River SPM are reported by Crecelius, *et al.*, (1975) for samples collected in 1972-1973.

Massoth, *et al.*, (1980) made early observations of enrichment of iron, chromium, nickel, zinc and copper in Duwamish SPM due to flocculation of dissolved metals. They noted concentration gradients of metals decreased more rapidly with distance from the Duwamish mouth than did SPM gradients, this attributed to dilution with particulates from other sources. Massoth, *et al.*, and Feely, *et al.*, (1983) discuss the importance of manganese oxides precipitating onto SPM and scavenging metals from the water column in Elliott Bay.

Curl (1987), Feely, *et al.*, (1988) and Paulson, *et al.*, (1989) describe the distribution of particulate metals in Elliott Bay based on the NOAA 1985 and 1986 samples (Figure 12). Curl (1987) ranked metals sources to Elliott Bay from highest to lowest as the West Duwamish Waterway, the north end of Harbor Island, the Denny Way CSO and the Seattle waterfront including the King Street CSO. The East Duwamish Waterway was a source of SPM, but not a significant contributor of metals.

Feely, *et al.*, (1988) concluded that, because of the short residence time of Duwamish River water "under most flow conditions, the great majority of trace metal contaminants are transported out of Elliott Bay..." Feely, *et al.*, (1988) calculated vertical fluxes of SPM, iron, manganese and lead were only about 0.5 - 2.3% of the horizontal fluxes.

Relative few data were found on concentrations of organic compounds in SPM. Pavlou and Dexter (1979) and Dexter, *et al.*, (1984) contain data on historic levels of polychlorinated biphenyls (PCBs). Riley, *et al.*, (1980) analyzed saturated and polynuclear aromatic hydrocarbons (PAH) in the above mentioned SPM samples collected of Pier 54 and elsewhere (Table 4). Hamilton and Bates (1984) discuss possible sources of saturated hydrocarbons in Duwamish River particulates.

More recent data on PAH and selected chlorinated organics are reported for the NOAA SPM samples collected in 1985-86 (Curl, *et al.*, 1987, 1988). The areal distribution of total PAH, including a station at the Denny Way CSO, is shown in Figure 13. Curl, *et al.*, concluded the major sources of PAH during April 1985 were along the Seattle waterfront and - in contrast to findings for metals - that the Duwamish was not a major source at this time. During wetter conditions in January 1986, the Denny Way CSO and West Duwamish Waterway were the major sources of PAH to Elliott Bay. PCB concentrations were described as low; DDT, DDE and DDD were below detection limits (Table 5).

Conclusion: Substantial data exist on the elemental composition of suspended particulates but similar information is limited for organics. Major particulate sources of metals and PAH to the bay have been ranked qualitatively. The Harbor Island area may have the potential to contribute significant concentrations of metals to the waterfront area, while during most seasons of the year, the major sources of PAHs to the waterfront area may be local.

Elementral composition of suspended and settling particulates in Elliott Bay and the Duwamish River

Sample location		Fe (wt%)	Mn (ppm)	Pb (ppm)	Zn (ppm)	Cu (ppm)	*n*
Green-Duwamish River		6·25[a]	1150[b]	45[b]	150[b]	42[b]	5
Suspended sediments		±2·00	±332	±9	±84	±6	
(1980–1984; sal = 0)		(*n* = 7)					
Head of West Duwamish							
Waterway Suspended matter		7·72	1595	59	137	106	1
(April 1985; sal = 8·4)							
Elliott Bay		7·90	1700	86	183	113	14
Suspended matter		±1·06	±88	±36	±27	±11	
(April 1985; sal = 10–26)	RSTD	13%	5%	43%	15%	10%	
Elliott Bay							
Settling particulates (6 m)		4·25	553	100	—	52	1
(April 1985)							
Elliott Bay[c]		6·91	4100	370	300	127	18
Suspended matter		±2·00	±1700	±182	±85	±24	
(Feb 1980)	RSTD	29%	41%	49%	28%	19%	

RSTD: Relative standard deviation.

[a] Massoth *et al.*, 1982.

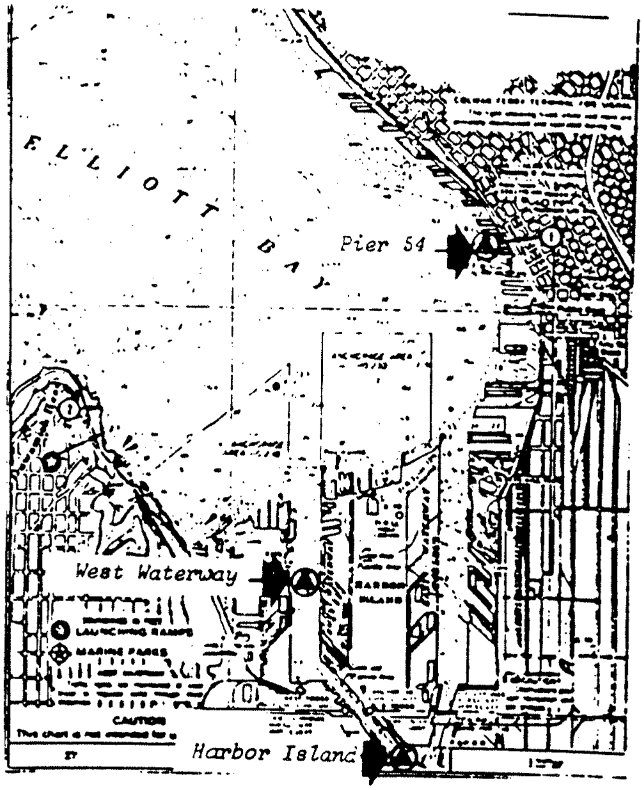
[b] Paulson *et al.*, 1988.

[c] Feely *et al.*, 1983.

Table 1. Paulson *et al.* (1989)

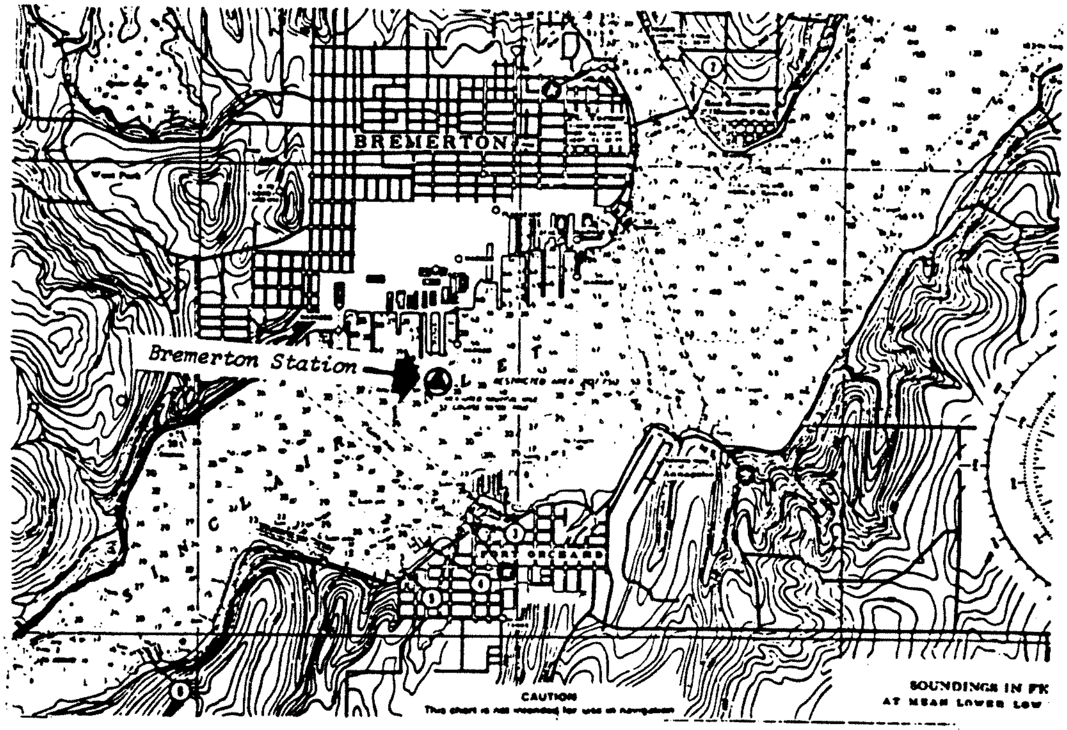
ELLIOT BAY AREA

Stations: *Pier 54*
Harbor Island
West Waterway



SINCLAIR INLET AREA

Bremerton Station



Maps of Elliott Bay area and Sinclair Inlet area showing locations of Pier 54, Harbor Island, West Waterway and Bremerton sampling stations.

Figure 11. Riley *et al.* (1980)

Concentration of Elements in Puget Sound Suspended Matter Collected July 1979 ppm Dry Weight
(mean values from duplicate samples, uncertainties of approximately ± 20% for σ)

ELEMENT	Pier 54	Harbor Island	West Waterway	Puyallup River	Hylebos Waterway	Blair Waterway	Bremerton	Olympia	Port Madison
As	<22	37	44	<22	94	52	31	<22	28
Br	58	78	75	179	303	95	126	34	214
Co	8.5	7.5	14	2.5	8.8	8.2	7.4	2.2	6.4
Cr	79	52	88	26	66	54	80	24	60
Cu	230	179	208	156	226	156	130	47	68
Eu	0.39	0.52	0.94	0.22	0.68	0.68	0.41	0.11	0.28
Mn	1850	1050	1090	373	581	660	1730	146	2090
Ni	82	39	44	47	55	28	58	12	55
Pb	380	338	448	153	250	111	146	26	97
Rb	27	33	39	25	18	37	24	8	<20
Sb	2.9	3.8	9.8	0.7	9.0	4.7	3.5	0.4	1.0
Se	2.3	1.1	1.2	0.5	1.6	1.2	1.7	1.5	1.8
Sr	205	213	213	262	370	328	<200	<200	<200
V	51	62	106	22	80	59	53	22	36
Zn	900	540	580	360	380	340	490	180	280

Table 2. Riley *et al.* (1980)

Concentration of Elements in Puget Sound Suspended Matter Collected July 1979 % Dry Weight
(mean values from duplicate samples, uncertainties of approximately ±20% for σ)

ELEMENT	Pier 54	Harbor Island	West Waterway	Puyallup River	Hylebos Waterway	Blair Waterway	Bremerton	Olympia	Port Madison
Al	3.7	7.1	6.6	6.3	8.1	6.1	4.2	0.2	1.4
Ca	0.7	1.6	1.5	2.3	2.2	2.6	1.4	0.6	0.8
Cl	0.30	0.83	0.43	4.8	0.74	1.2	1.5	0.53	2.9
Fe	4.0	5.9	5.4	1.9	3.9	3.3	2.8	0.5	1.4
K	0.33	0.78	0.76	0.86	0.89	0.86	0.52	0.15	0.37
P	0.75	1.0	0.59	0.66	0.62	0.67	0.67	0.48	0.72
S	0.55	0.38	0.30	0.49	0.44	0.54	0.55	0.53	0.66
Si	15	22	20	18	25	28	19	2	11
Ti	0.16	0.33	0.36	0.32	0.30	0.38	0.45	0.04	0.15

Table 3. Riley *et al.* (1980)

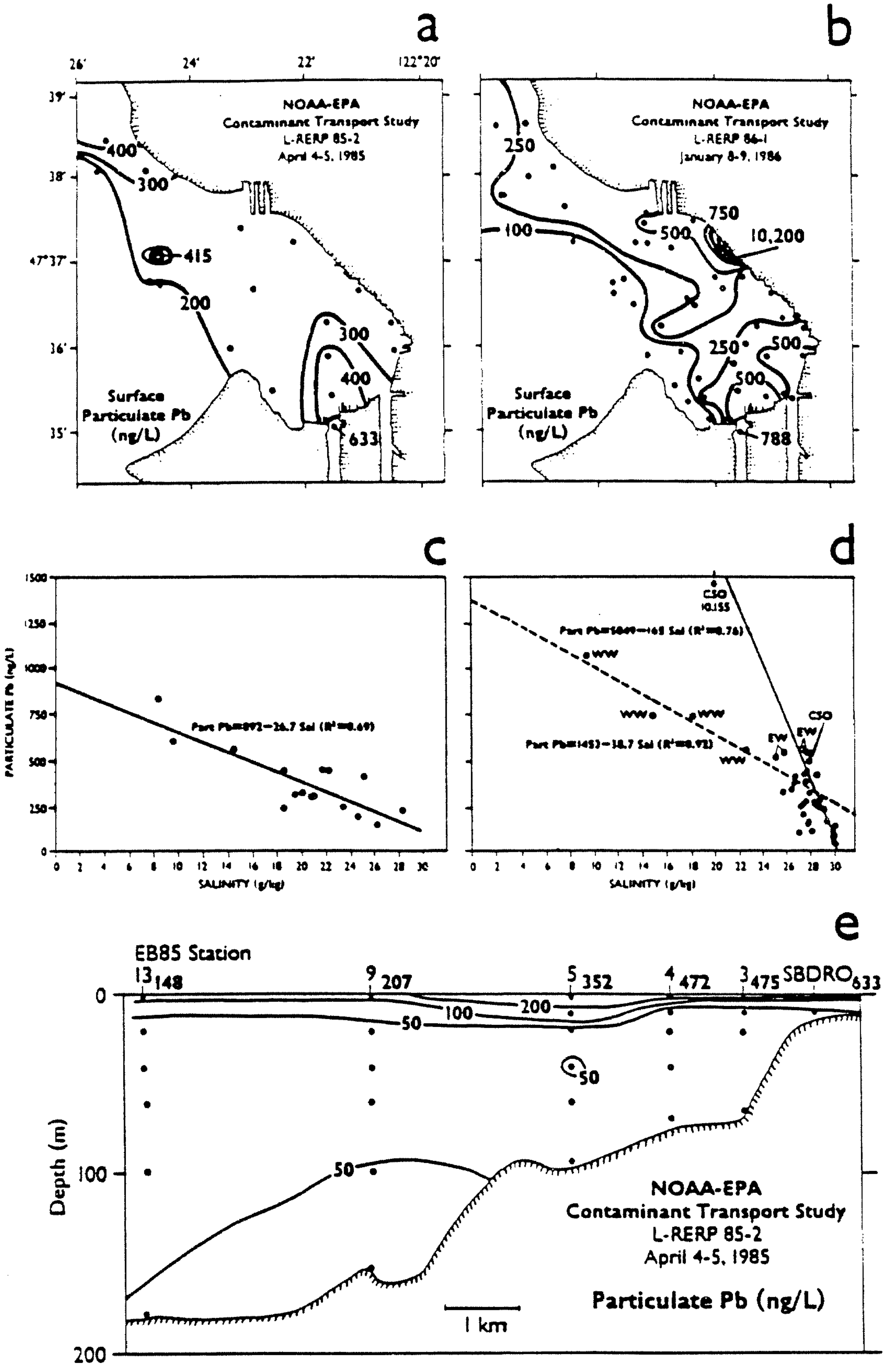


Figure 12. Curl *et al.* (1987)

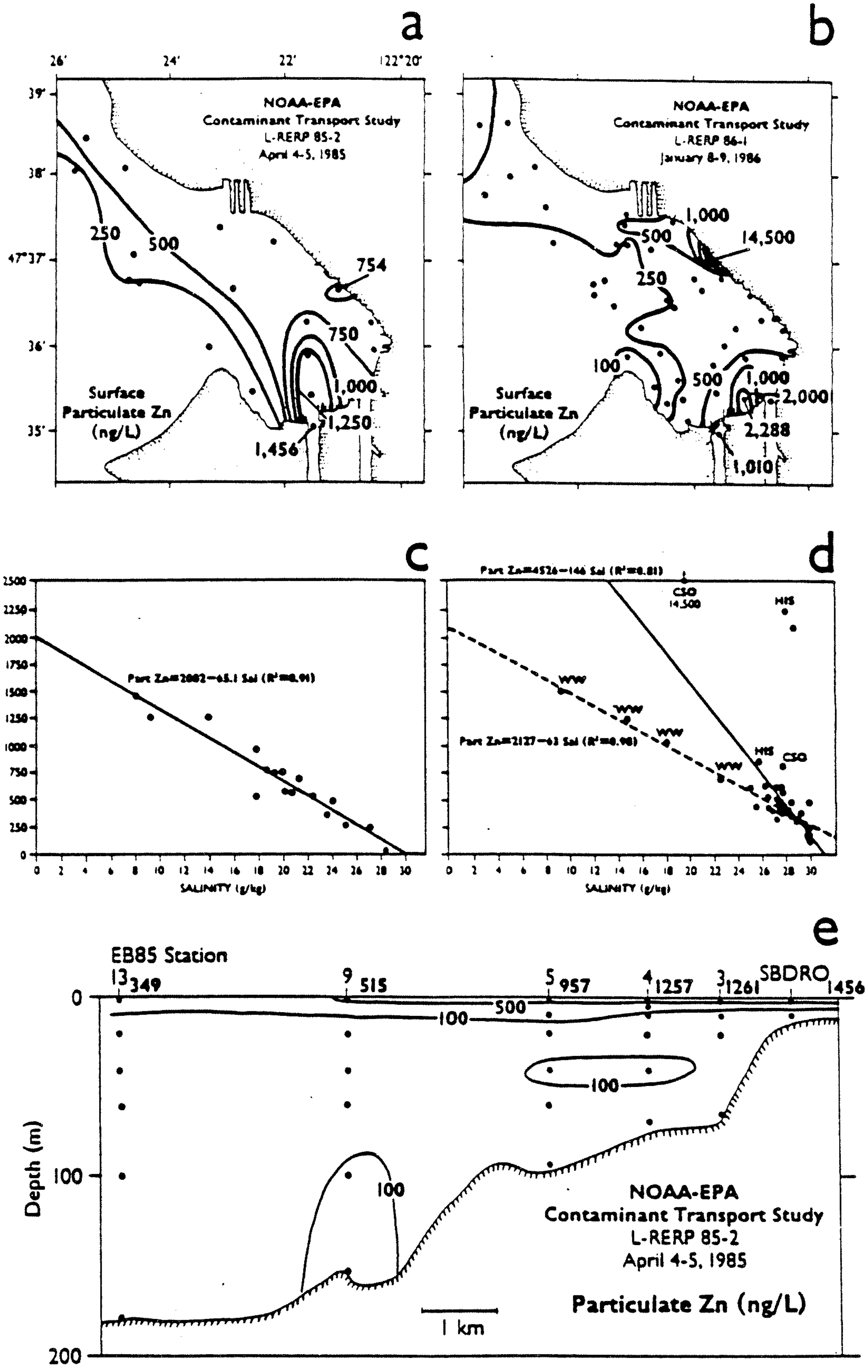


Figure 12. Continued

Concentrations of Aromatic Hydrocarbons Associated with Suspended Matter from Nine Sampling Sites in Puget Sound, $\overline{x} \pm$ SE, Parts Per Million (ppm) Dry Weight Sediment

Compound	Seattle P-54[1]	Seattle HI	Seattle WW	Bremerton SI	Tacoma PR	Tacoma HW	Tacoma BW	Olympia BI	Port Madison
Naphthalene	0.02 ± 0.01	0.02 ± 0.01	0.03 ± 0.01	0.03 ± 0.00	0.42 ± 0.14	0.05 ± 0.03	0.23 ± 0.08	0.02 ± 0.00	0.02 ± 0.01
2-MN[2]	0.02 ± 0.00	0.02 ± 0.01	0.02 ± 0.00	0.02 ± 0.01	0.03 ± 0.00	0.02 ± 0.01	0.01 ± 0.01	0.05 ± 0.03	0.01 ± 0.00
1-MN	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.01	0.03 ± 0.02	0.02 ± 0.00	0.02 ± 0.02	0.01 ± 0.01	0.19 ± 0.14	0.17 ± 0.21
2,6-DMN	0.02 ± 0.01	0.01 ± 0.01	0.01 ± 0.00	0.07 ± 0.04	<0.01	0.10 ± 0.11	0.05 ± 0.06	0.03 ± 0.03	0.10 ± 0.02
1,3-DMN	<0.01	0.01 ± 0.00	0.01 ± 0.00	0.02 ± 0.01	0.01 ± 0.01	0.14 ± 0.11	<0.01	0.02 ± 0.01	0.02 ± 0.00
2,3-DMN	0.01 ± 0.01	0.01 ± 0.00	<0.01	0.02 ± 0.00	<0.01	0.02 ± 0.03	0.02 ± 0.02	0.01 ± 0.01	0.01 ± 0.01
2,3,6-TMN	0.02 ± 0.00	0.01 ± 0.00	0.02 ± 0.00	0.13 ± 0.07	0.07 ± 0.03	0.73 ± 0.64	0.03 ± 0.05	0.04 ± 0.01	0.06 ± 0.09
Fluorene	0.05 ± 0.01	0.04 ± 0.06	<0.01	0.07 ± 0.10	0.04 ± 0.06	<0.01	<0.01	0.05 ± 0.01	0.01 ± 0.02
Phenanthrene	0.27 ± 0.03	0.14 ± 0.09	0.22 ± 0.04	0.10 ± 0.04	0.27 ± 0.06	0.62 ± 0.26	0.28 ± 0.13	0.12 ± 0.13	0.08 ± 0.02
Anthracene	0.18 ± 0.02	<0.01	0.08 ± 0.02	<0.01	<0.01	0.13 ± 0.18	<0.01	0.09 ± 0.04	0.41 ± 0.44
1-MP	0.01 ± 0.02	0.01 ± 0.01	<0.01	0.05 ± 0.02	0.06 ± 0.02	0.19 ± 0.26	0.22 ± 0.04	0.01 ± 0.01	0.05 ± 0.06
2-MP	0.04 ± 0.02	0.10 ± 0.08	0.08 ± 0.03	0.10 ± 0.00	0.22 ± 0.16	0.48 ± 0.68	0.45 ± 0.64	0.10 ± 0.14	0.34 ± 0.24
Fluoranthene	0.37 ± 0.05	0.25 ± 0.09	0.36 ± 0.11	0.54 ± 0.33	2.34 ± 0.44	0.83 ± 0.08	3.45 ± 1.62	0.08 ± 0.02	0.15 ± 0.00
Pyrene	0.49 ± 0.17	0.21 ± 0.20	0.58 ± 0.21	0.97 ± 0.49	3.94 ± 0.94	0.51 ± 0.71	2.94 ± 1.29	0.21 ± 0.09	1.05 ± 0.40
1-Me-Pyrene	<0.01	<0.01	<0.01	<0.02	<0.01	0.11 ± 0.15	<0.02	<0.01	<0.01
B(a)A	0.08 ± 0.00	0.03 ± 0.01	0.07 ± 0.02	<0.02	<0.01	0.01 ± 0.01	<0.01	<0.01	<0.01
Chrysene	0.13 ± 0.00	0.05 ± 0.00	0.12 ± 0.04	<0.01	<0.01	0.04 ± 0.06	<0.01	<0.01	<0.01
B(a)P	0.02 ± 0.03	<0.01	<0.01	<0.01	0.12 ± 0.17	0.04 ± 0.05	<0.01	<0.01	<0.01
Perylene	0.03 ± 0.04	<0.01	<0.01	<0.01	0.18 ± 0.26	0.06 ± 0.09	<0.01	<0.01	<0.01
TOTAL	1.76 ± 0.07	0.90 ± 0.15	1.6 ± 0.50	2.1 ± 0.73	7.71 ± 0.93	4.08 ± 1.02	7.67 ± 1.37	1.01 ± 0.62	2.48 ± 0.05

[1] P-54 = Pier 54, HI = Harbor Island, WW = West Waterway, SI = Sinclair Inlet, PR = Puyallup River, HW = Hylebos Waterway, BW = Blair Waterway, BI = Budd Inlet

[2] MN = methylnaphthalene, DMN = dimethylnaphthalene, TMN = trimethylnaphthalene, MP = methylphenanthrene, 1-Me-Pyrene = 1-methylpyrene, B(a)A = Benz(a)anthracene, B(a)P = Benz(a)pyrene

Table 4. Riley *et al.* (1980)

PAH CONCENTRATIONS IN ELLIOTT BAY

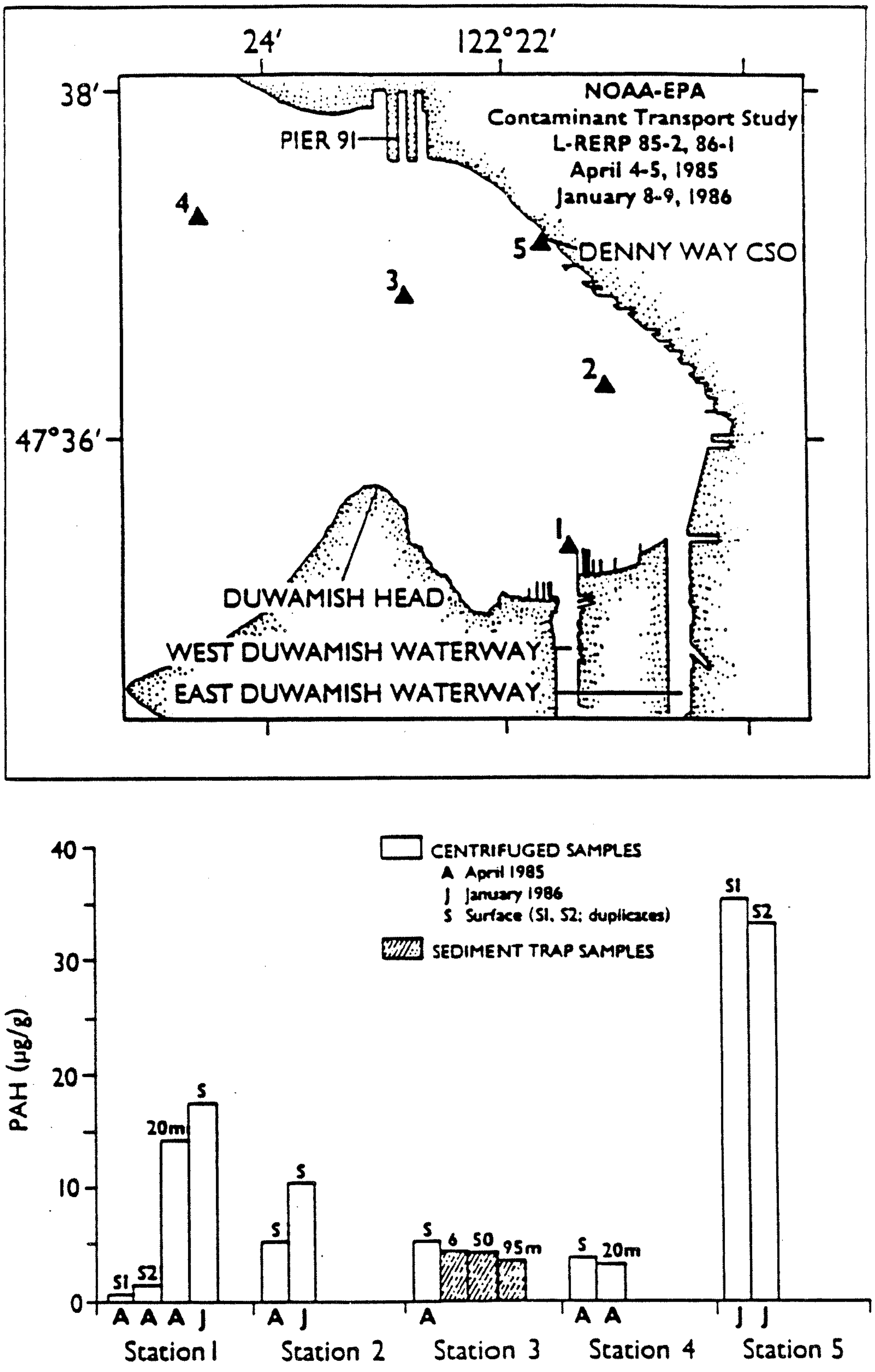


Figure 13. Curl *et al.* (1987)

TRACE ORGANICS
(in total ng/g)
COLLECTED BY CENTRIFUGE 1/86

SAMPLE NAME	S1SURF1	S1SURF2	S2SURF	S3SURF
DATE/TIME	10886, 1250	10886, 1250	10986, 0950	11086, 0915
LATITUDE	47°37.1'N	47°37.1'N	47°35.0'N	47°36.6'N
LONGITUDE	122°21.6'W	122°21.6'W	122°21.5'W	122°21.3'W
LOCATION	ELLIOTT BAY	ELLIOTT BAY	ELLIOTT BAY	ELLIOTT BAY
VOL SAMPLED	140L	193L	510L	525L
Phe	15000	14000	1100	950
Ant	3000	2700	380	420
MPh	24000	22000	1300	960
Fla	12000	13000	3600	2100
Pyr	9400	9000	3400	1800
Ret	<320	<310	230	260
BAA	2100	1900	950	730
Chr	2900	2500	1600	1100
BFl	3100	2000	3100	2200
BEP	1400	1200	1400	720
BAP	1800	1300	1200	790
IPy	1400	1100	1200	670
BPe	1400	1100	1100	620
DDE	<8.8	<12	<2.1	<1.6
DDT	<35	<50	<8.5	<6.5
DDD	<35	<50	<2.1	<6.5
CL2	<8.5	<12	<2.1	<1.6
CL3	<8.5	32	<2.1	<1.6
CL4	<14	25	<3.4	<2.6
CL5	86	25	28	10
CL6	160	19	84	59
CL7	100	36	59	29
CL8	<14	<20	11	<2.6
CL9	<28	<40	<6.8	<5.2

Table 5. Curl et al. (1987)

IV. BOTTOM SEDIMENT SURVEYS

Most Useful References: 22, 36, 49, 50, 69, 77-79, 90, 92-94

Other References: 9, 12, 15, 16, 21, 25, 26, 28, 29, 39, 41, 42, 45, 46, 51, 62, 72-75, 83-89, 91, 93-96, 103

Synopsis of Findings: Dexter, *et al.*, (1981) reviewed results of sediment surveys in Elliott Bay from reports published up to 1980. More recently, Tetra Tech (1986) evaluated approximately 70 reports on chemical contaminants in Elliott Bay. Seven reports were selected by Tetra Tech for a detailed analysis of sediment chemistry: Romberg, *et al.*, (1984), Malins, *et al.*, (1980, 1982), Dexter, *et al.*, (1984), Stober and Chew (1984), and EPA (1982, 1983). Station locations of these studies are in Figure 14.

Based on elevations above reference areas, Tetra Tech concluded the Seattle Waterfront between Pier 91 and Terminal 37 was among the most contaminated areas of Elliott Bay for LPAH, HPAH and PCBs. Copper, lead and zinc were also high, especially along the south waterfront area (Pier 70 to Terminal 37). The contamination between Pier 91 - Pier 70 was primarily at sampling stations clustered around the Denny Way CSO. This contaminated area extended a "few thousand feet along the beach and offshore from the end of the pipe." Figures in the Tetra Tech report show the spatial distribution of grain size, total organic carbon (TOC), and selected contaminants in the bay (e.g., Figure 15).

Following the above review, a 1985 field investigation of the nearshore Elliott Bay/Duwamish River was conducted to identify problem sediments in shallow water areas (< 20m) between Alki Point and West Point (PTI and Tetra Tech, 1988). The "Seattle South Waterfront" from Pier 70 to Terminal 37 (Figure 16) corresponds to the resuspension study area. Sampling sites near the Denny Way CSO were limited to one intertidal station (NS-01) because of the extensive data available in Romberg, *et al.*, (1984). Figure 17 shows Tetra Tech's sampling sites.

The Seattle South Waterfront, North Harbor Island and West Waterway were the most contaminated areas. Results of sediment chemistry are summarized with bar graphs (Figure 18). Contour maps using codes for concentration levels compare survey results with historical data (e.g., Figures 19 and 20). A modified excerpt from PTI and Tetra Tech (1988) summarizes findings for the Seattle South Waterfront (see pages 248-251 for complete text):

"The sediments were highly contaminated throughout and had more chemicals exceeding HAET (highest apparent effects thresholds) than in any other problem area. Superimposed upon the high levels of certain problem chemicals (e.g., PAH and mercury) were maximum concentrations of different problem chemicals occurring at a number of non-adjacent stations. These patterns suggested that multiple local sources were present, perhaps in conjunction with a more diffuse source for compounds such as PAH.

PAH were the most commonly occurring problem chemicals and exceeded the HAET at 14 of 15 stations. HAET for other organic compounds (e.g., PCBs, 1,4-dichlorobenzene and chlorinated pesticides) and a number of metals (including cadmium, copper, lead, zinc, mercury and silver) were exceeded at least once. The highest concentrations of many problem chemicals occurred at Stations SS-08 (Pier 63-64) and SS-09 (Pier 65-66). Although these stations were not located near obvious potential sources, a number of stations are near CSOs: SS-03 (King St.), SS-04 (Washington St.), SS-05 (Madison St.), SS-06 (University St.), and SS-11 (Vine St.). Sediments throughout the problem area tended to be fine-grained and rich in organic matter.

Concentrations of PAH decreased in either direction from the extremely high concentrations at Station SS-08 (Pier 63-66) (roughly 0.38 percent DW of the EPA priority pollutant hydrocarbons) and tended to correlate well with TOC. Detection limits for low molecular weight PAH (LPAH) were very high at Station SS-12 (Pier 70-71), which may explain why HAET for PAH were not exceeded at this station.

The most elevated metals in this area had similar overall distribution patterns. For the metals of highest concentrations, concentrations were relatively constant and elevated throughout the area, with pronounced maxima at non-adjacent stations (typically SS-03 (Pier 42), SS-09 (Pier 65-66), and historical TPSS Station S0090 (Romberg, *et al.*, 1984). Examples of these distributions include mercury, zinc, lead, cadmium and arsenic. Copper distributions were somewhat more variable but maximized at SS-03 and SS-07 (Pier 57-59). Notably, chromium and nickel concentrations maximized at Station SS-10 (Pier 66-67) and were the highest values observed in the study. Chromium and nickel were near or below reference levels at other stations in the problem area.

PCB concentrations were generally elevated but patchy. 1,4-dichlorobenzene exceeded HAET at Stations SS-09 (Pier 65-66) and SS-03 (Pier 42), but high detection limits occurred at other stations. Benzyl alcohol exceeded HAET at Station SS-03 (Pier 43)."

An evaluation of potential sources of sediment contamination followed the 1985 survey (Tetra Tech, 1988a). Most of the material in this useful report was outside the scope of the literature search. It contains figures showing locations of nearshore sediment sampling stations from previously mentioned surveys along the Seattle Waterfront (Figures 21 and 22).

Tetra Tech (1988b,c) evaluate sediment remediation and recovery off the Denny Way CSO and Slip 4 in the Duwamish River. These reports contain figures showing the areal distributions of mercury, zinc, fluoranthene, chrysene, butyl benzyl phthalate, bis(2-ethylhexyl)phthalate and PCBs in sediments off the Denny Way CSO based on surveys by Malins, *et al.*, (1980), Romberg, *et al.*, (1984), Romberg, *et al.*, (1987) and PTI and Tetra Tech (1988). A summary of station locations is shown in Figure 23. Mercury concentrations are summarized in Figure 24.

METRO (1989, 1990) describe intertidal and subtidal sediment sampling at three areas along the Seattle Waterfront in 1988 and 1989: the Northern Region near the old Union Oil fuel dock on Pier 71 and the area proposed for Denny Way CSO capping project in 1990; and Central and Southern Regions where development was planned and the site of the first capping project at the Washington State Ferry Terminal in 1989 (Figures 25-29). The ferry terminal and Denny Way capping projects are described. The report also has data on METRO sediment station LTDF01 which is sampled annually for priority pollutants (Figure 30)

METRO (1990) concludes "The highest sediment concentrations found in 1988 and 1989 were from the central waterfront, followed by areas to the south and north of the central waterfront. In the central and southern waterfront areas, the highest sediment chemistry values occurred at the shore end of the slips, with lower values near the mouth and even lower values farther offshore."

Monitoring of the Pier 53-55 cap and surrounding areas (Romberg 1993a,c) has shown that concentrations of metals and PAHs nearshore under the piers is higher than cleanup standards and are similar to (but in some cases higher than) the contamination present prior to placing the Pier 53-55 cap. In addition, sampling subsequent to a recent release of PAHs at the DOT ferry terminal shows that the area of the former wing wall is heavily contaminated with a creosote-like material and that nearby areas, including areas of the Pier 53-55 cap have been recontaminated above cleanup standards for PAHs by this material. The source of this material may have been numerous creosoted pilings or weathered material from a historic creosoting plant at this location.

Hart Crowser (1990) did a sediment quality assessment between Pier 62 and 66 for a marina development at Pier 64/65 by the Port of Seattle. They reviewed existing data (including unpublished Port of Seattle data not obtained for the present literature search), collected surface sediments and cores, and deployed sediment traps to assess the need for and general scope of sediment remediation. Figures 31-34 show sampling locations and contours for lead and PAH.

With regard to surface sediments, Hart Crowser concluded that no significant differences in contaminant concentrations existed alongshore within the study area (Pier 62 - 66); concentrations of lead and PAH declined with distance from shore indicating sources close to shore; and other chemicals such as mercury, zinc and PCBs did not vary with distance off shore indicating regional sources.

Vertical profiles were interpreted as showing that lead and zinc inputs have been slowly reducing over time, there was an abrupt reduction in PCB sources (highest concentrations of PCBs were found in the deepest samples; 40-50 cm), and existence of a PAH source close to the shoreline -- possibly from creosoted pilings and urban runoff.

Sumeri and Romberg (undated) describe the Denny Way sediment capping project and include core data on zinc, mercury and fluoranthene (Figures 35, 36). Craig Homan provided selected figures (37 - 41) from an upcoming METRO report on the cap.

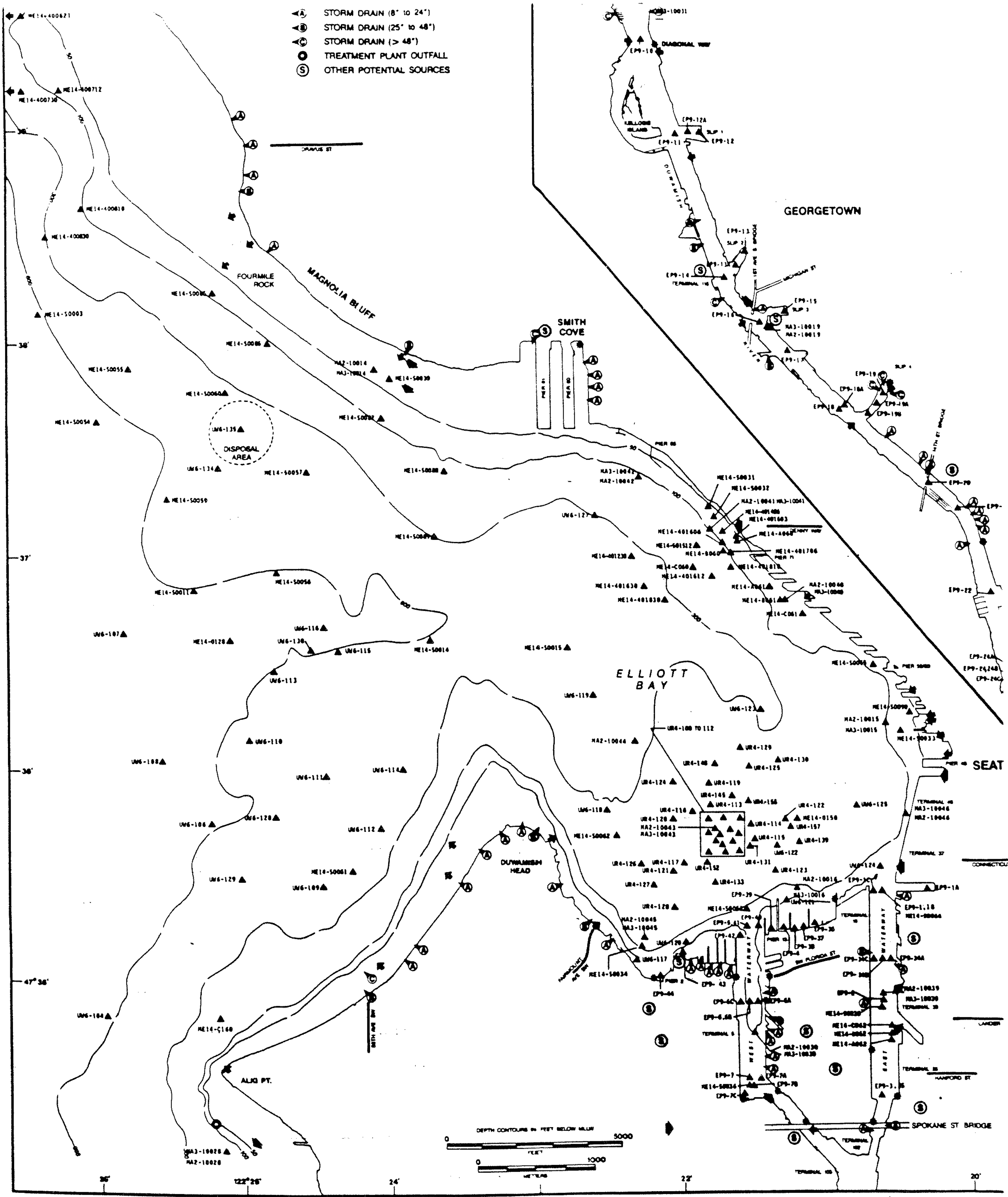
Krone, *et al.*, (1988, 1989) report data on tributyltins at three stations along the Seattle Waterfront.

Weston (1993) report and map extensive sediment chemistry data from the Harbor Island remedial investigation, including sites along the mouth of the Duwamish River. Cubbage (1989) analyzed sediment chemistry at the mouth of the West Waterway as part of an investigation of PAH near the Wyckoff wood treatment plant. Data have also been collected by the Port of Seattle at Terminal 3 (unpublished). These results show highly contaminated areas of sediment surrounding Harbor Island, adjacent to Terminal 3, and offshore of the Wyckoff facility.

Sediments surrounding Harbor Island are characterized by high levels of cadmium, mercury, and tributyltin. PCBs also exceed cleanup standards over a large area, and are highest in East Waterway. Localized areas with high levels of antimony, arsenic, chromium, copper, lead, and zinc are found near the shipyards, including Terminal 3. Isolated areas with heavy petroleum contamination were found near certain CSOs and at the north end of Harbor Island. Contamination offshore of the Wyckoff facility is typical of the wood treating chemicals creosote and pentachlorophenol.

A number of additional references contain physical/chemical data on Elliott Bay sediments but are of limited use for the resuspension study because of location, small sample size, old information, or other reasons: Army Corps Engineers, *et al.*,, (1988a,b); Bates, *et al.*, (1979); Chapman, *et al.*, (1982, 1983); Cooper Consultants (1986); Evans-Hamilton Inc. (1988a,b); Gamponia, *et al.*, (1985); Harper-Owes (1983); NOAA (1988); Paulson, *et al.*, (1991a); PTI (1988, 1989); Striplin, *et al.*, (1991, 1992, 1993); Tatem and Johnson (1978); Tetra Tech (1990); and Varanasi, *et al.*, (1988).

Conclusion: Substantial amounts of recent data on sediment chemistry in the resuspension study area are contained in the reports by PTI and Tetra Tech (1988), METRO (1989, 1990) and Hart Crowser (1990).



Sediment Chemistry: Sampling stations for selected data sets in Elliott Bay and the lower Duwamish River

▲ SAMPLING STATION

Figure 14. Tetra Tech (1986)

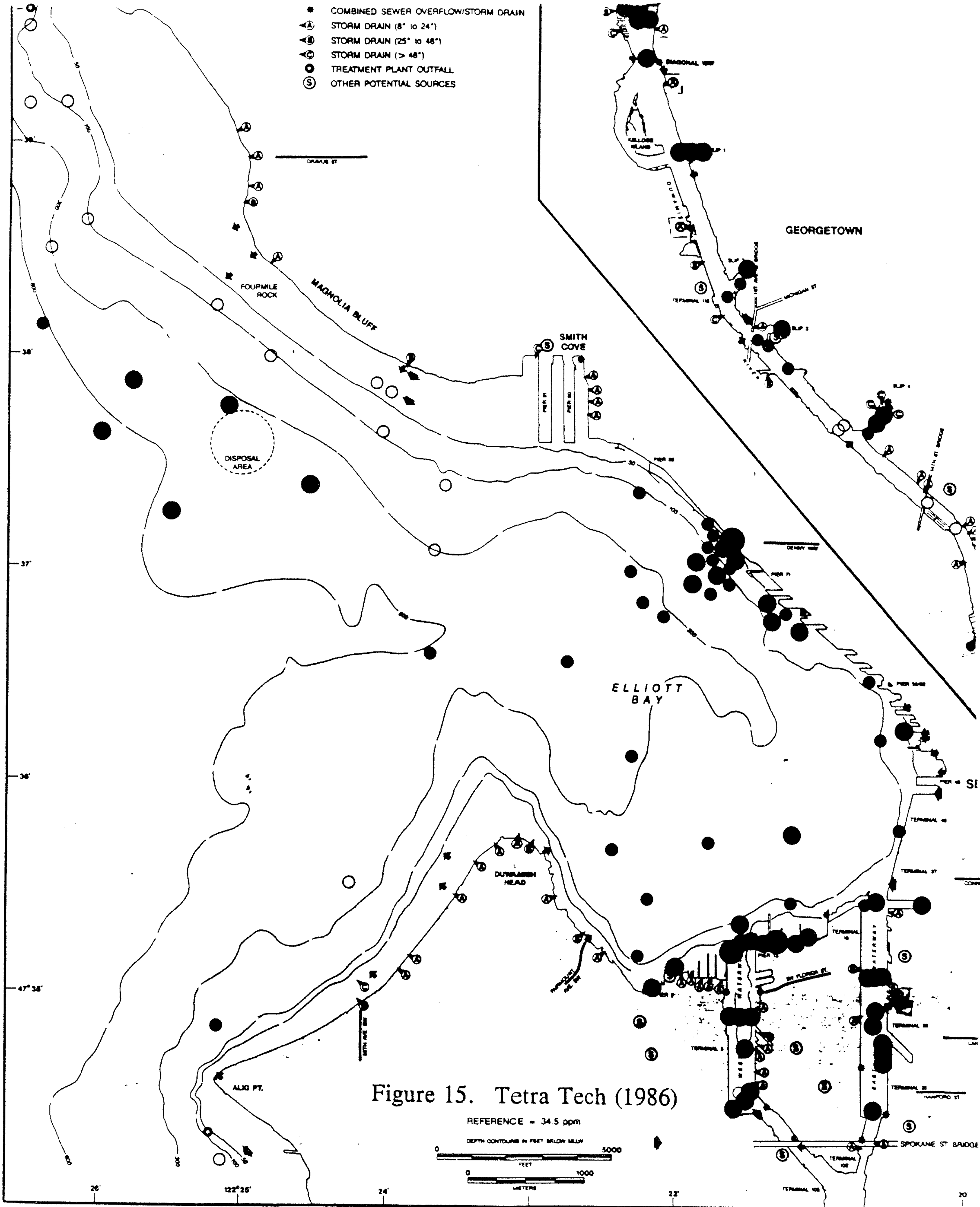
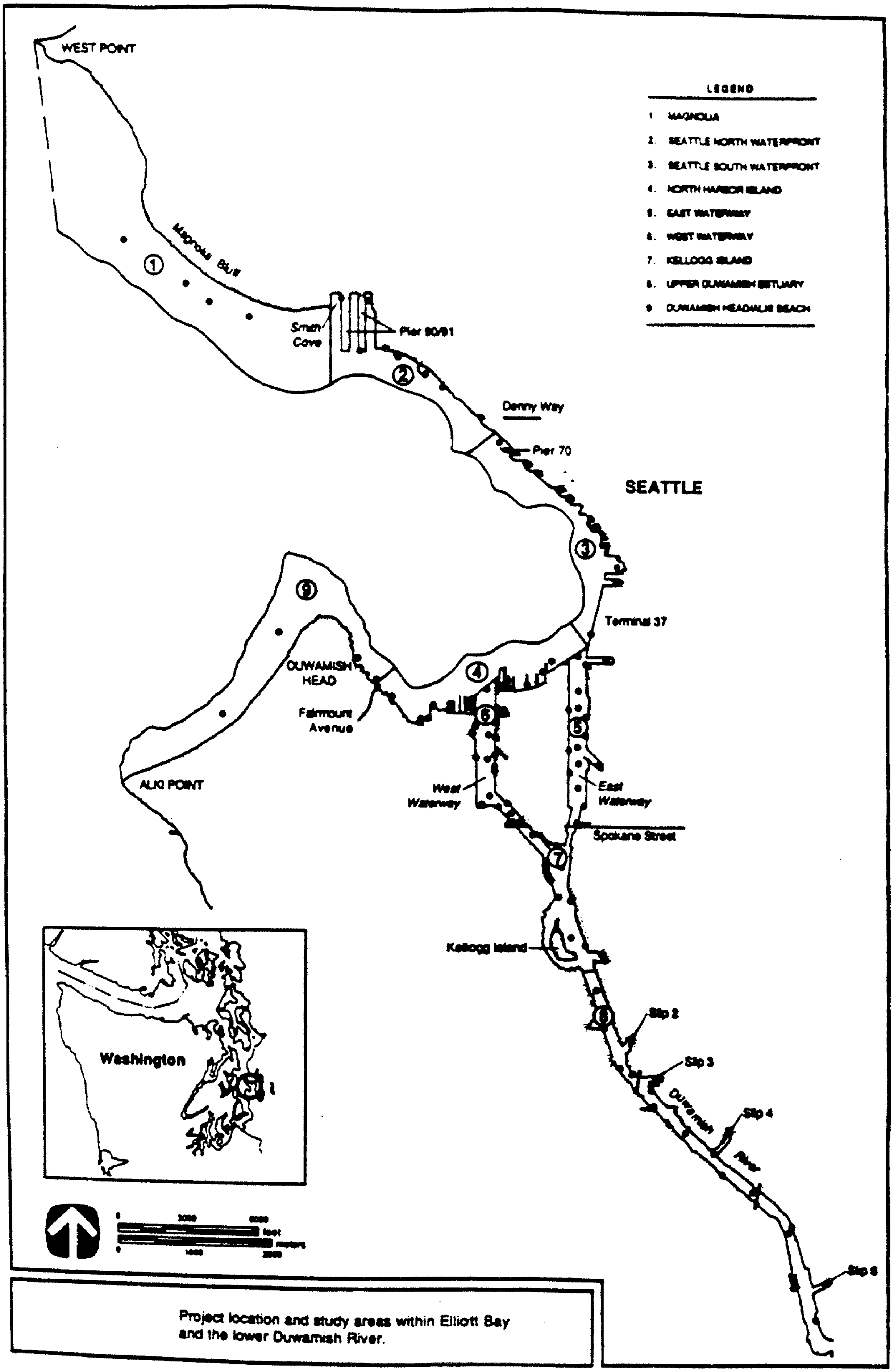


Figure 15. Tetra Tech (1986)

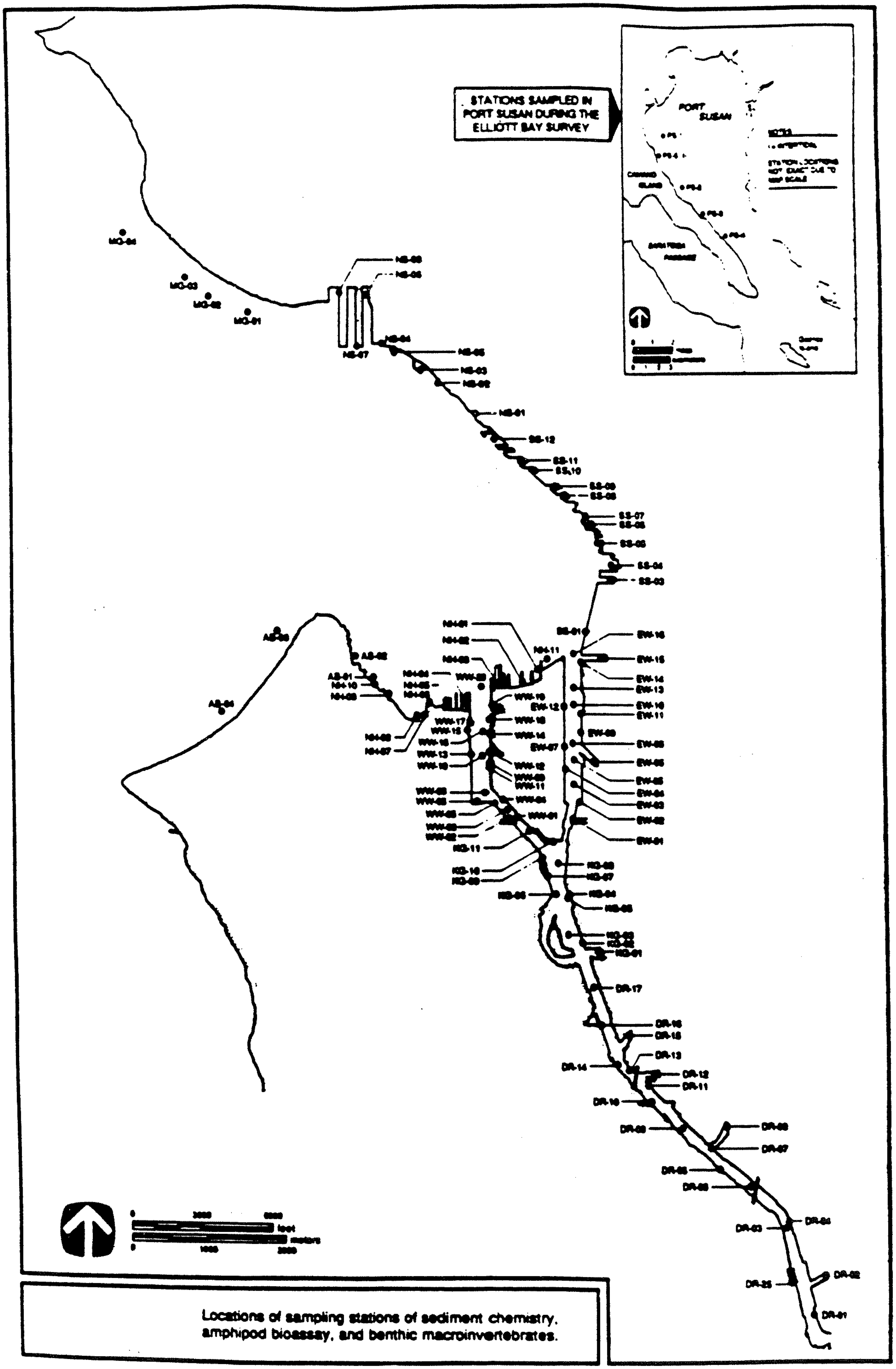
Sediment Chemistry: Elevations above reference for copper, lead, and zinc in Elliott Bay and the lower Duwamish River

○ NOT SIGNIFICANT
● SIGNIFICANT, <10 X REFERENCE
● SIGNIFICANT, 10 - 100 X
● SIGNIFICANT, 100 - 1000 X
● SIGNIFICANT, ≥1000 X



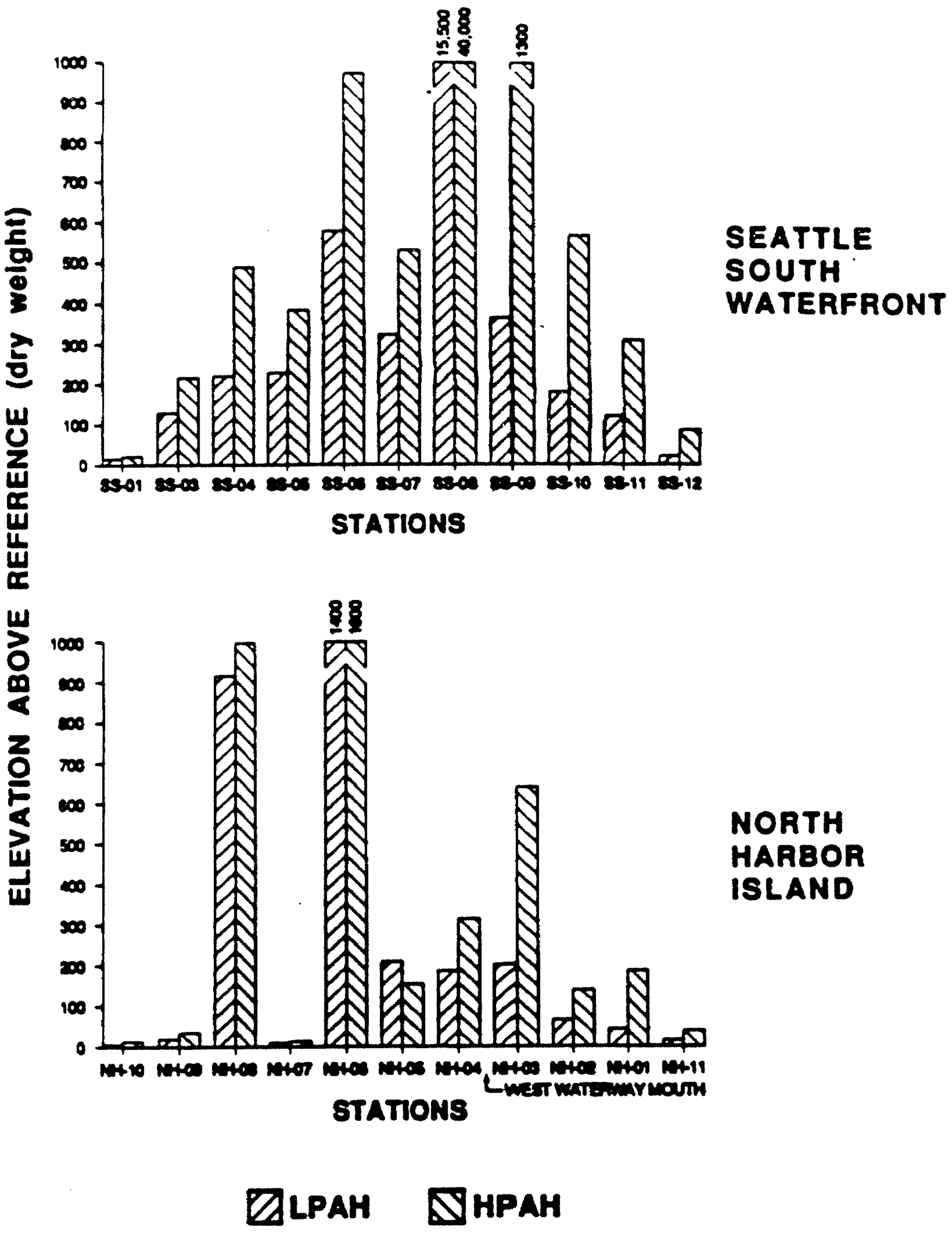
Project location and study areas within Elliott Bay and the lower Duwamish River.

Figure 16. Tetra Tech (1988)



Locations of sampling stations of sediment chemistry, amphipod bioassay, and benthic macroinvertebrates.

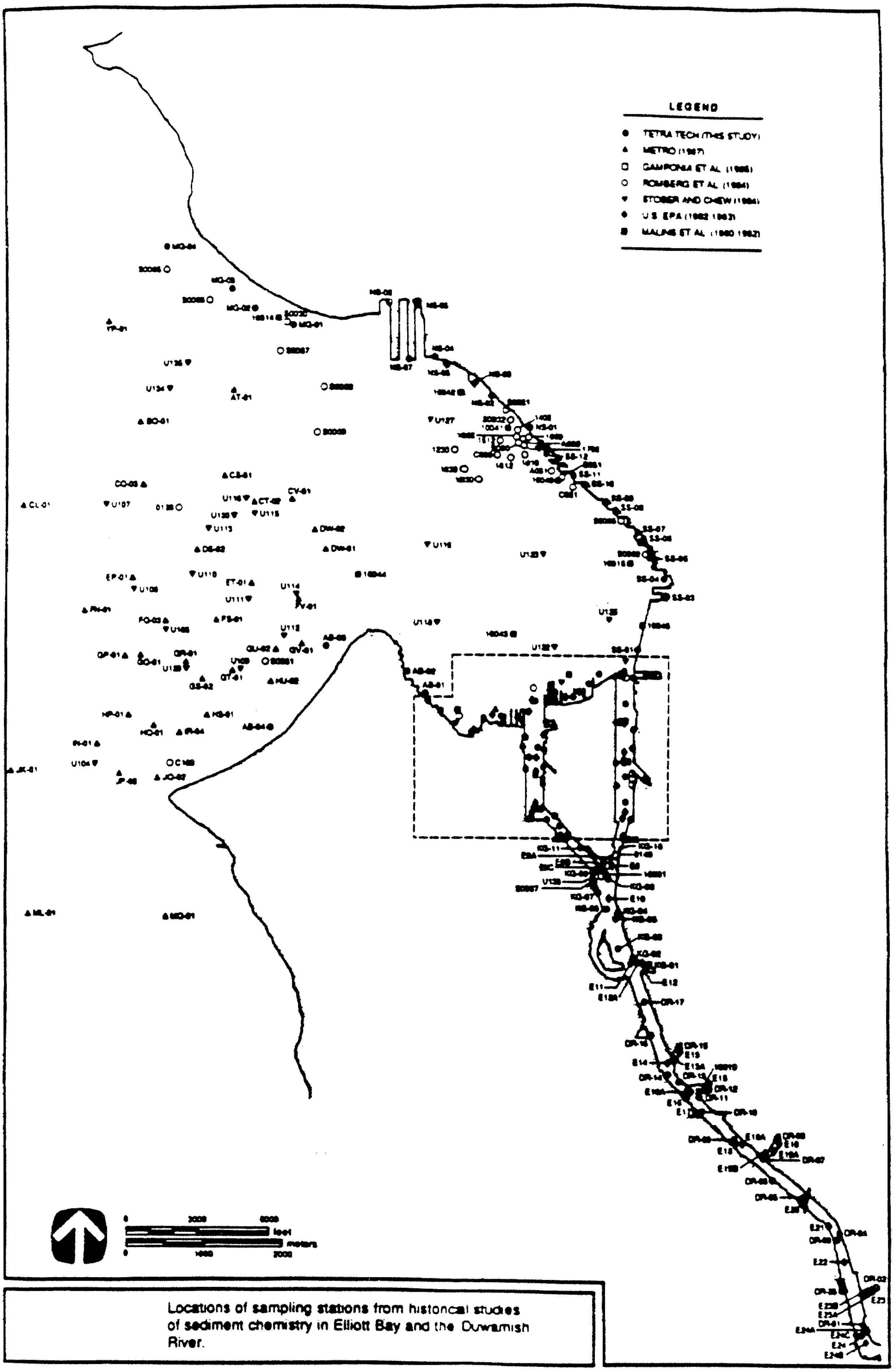
Figure 17. Tetra Tech (1988)



Carr Inlet Reference = 41 µg/kg DW (LPAH) and 79 µg/kg DW (HPAH).

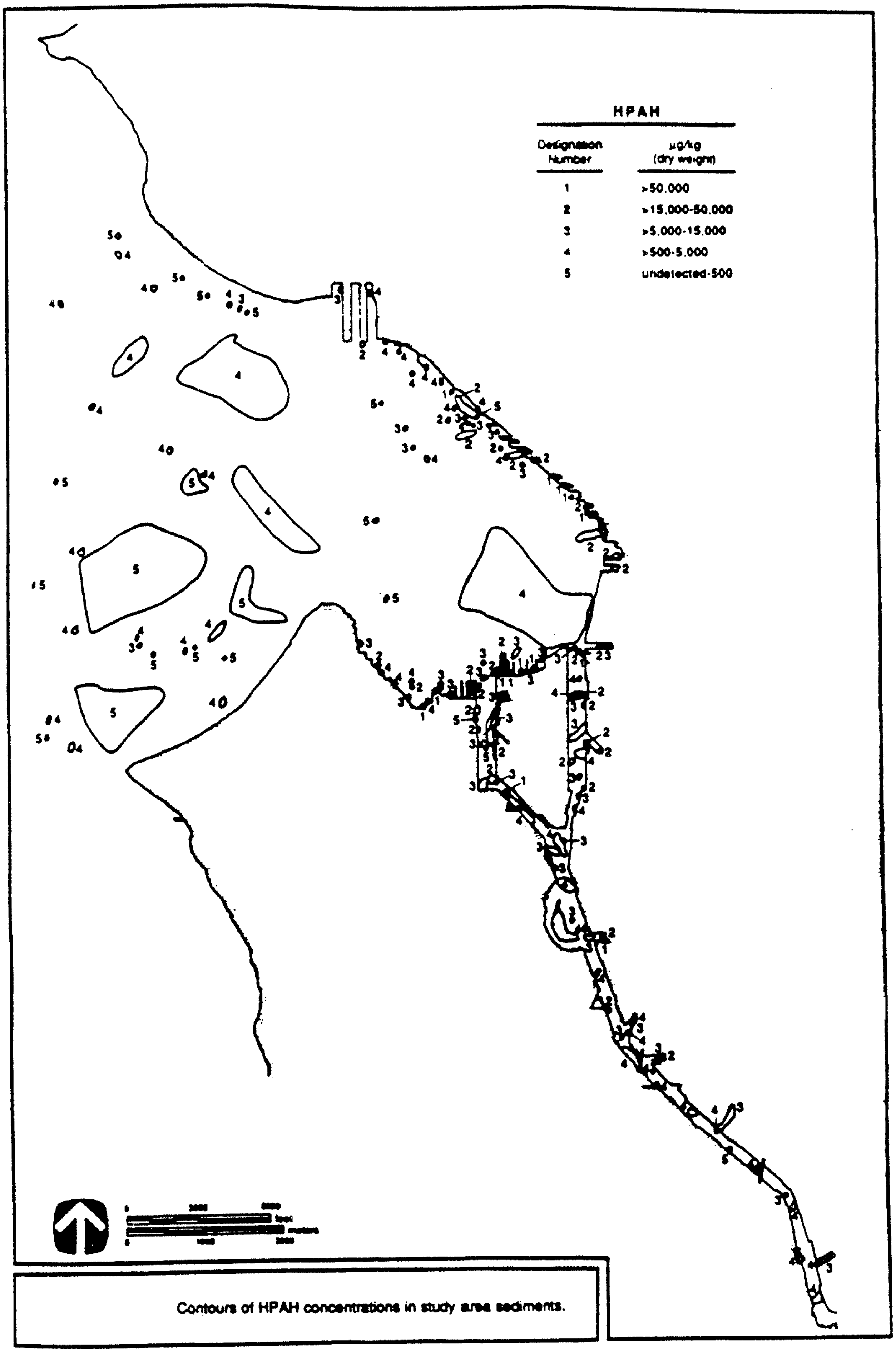
Elevations above reference (EAR) of LPAH and HPAH at individual stations in the most contaminated study areas.

Figure 18. Tetra Tech (1988)



Locations of sampling stations from historical studies of sediment chemistry in Elliott Bay and the Duwamish River.

Figure 19. Tetra Tech (1988)



Contours of HPAH concentrations in study area sediments.

Figure 20. Tetra Tech (1988)

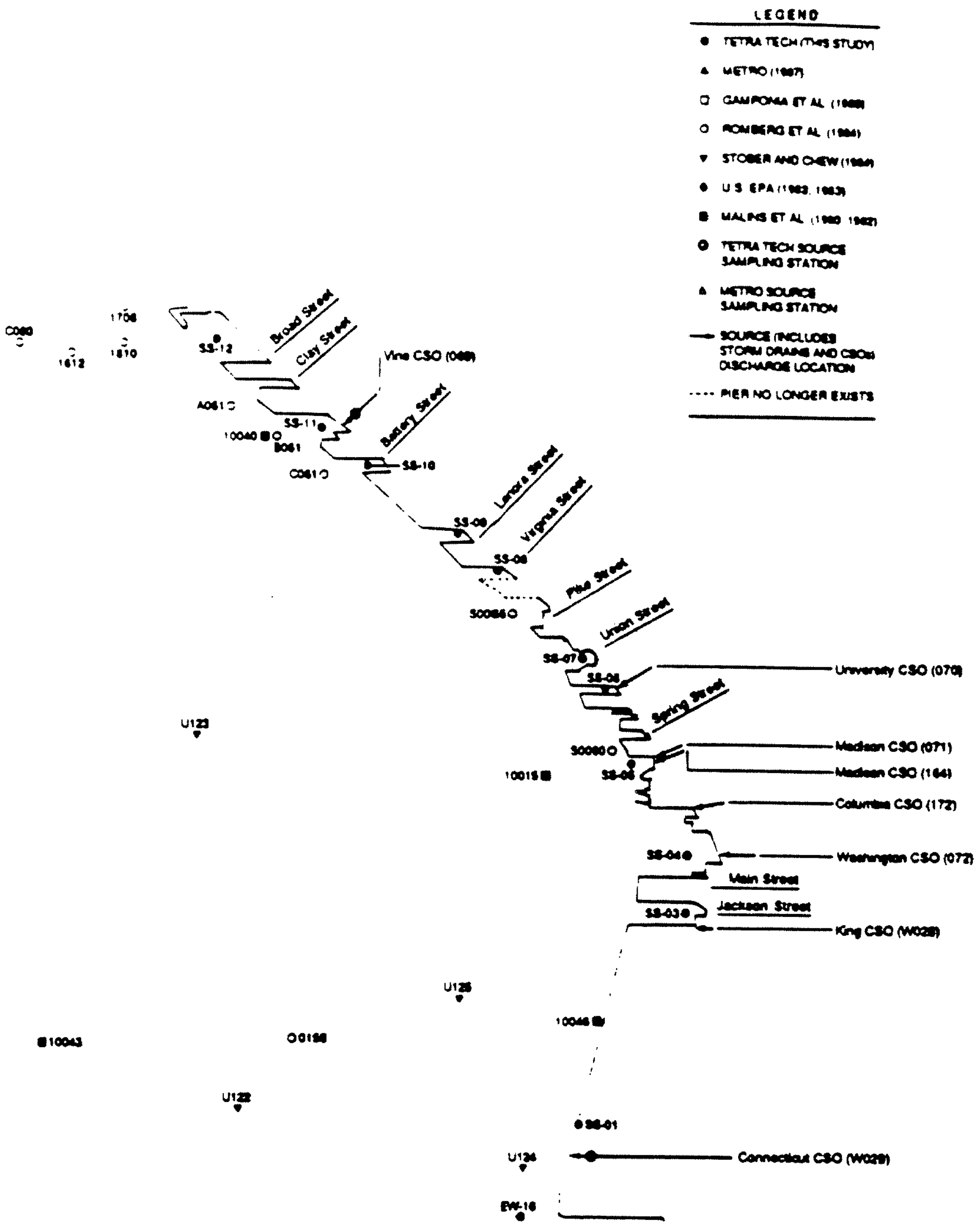


Figure 21. Tetra Tech (1988a)

Locations of offshore and drain sampling stations, CSOs, and storm drains in the Seattle South Waterfront study area.

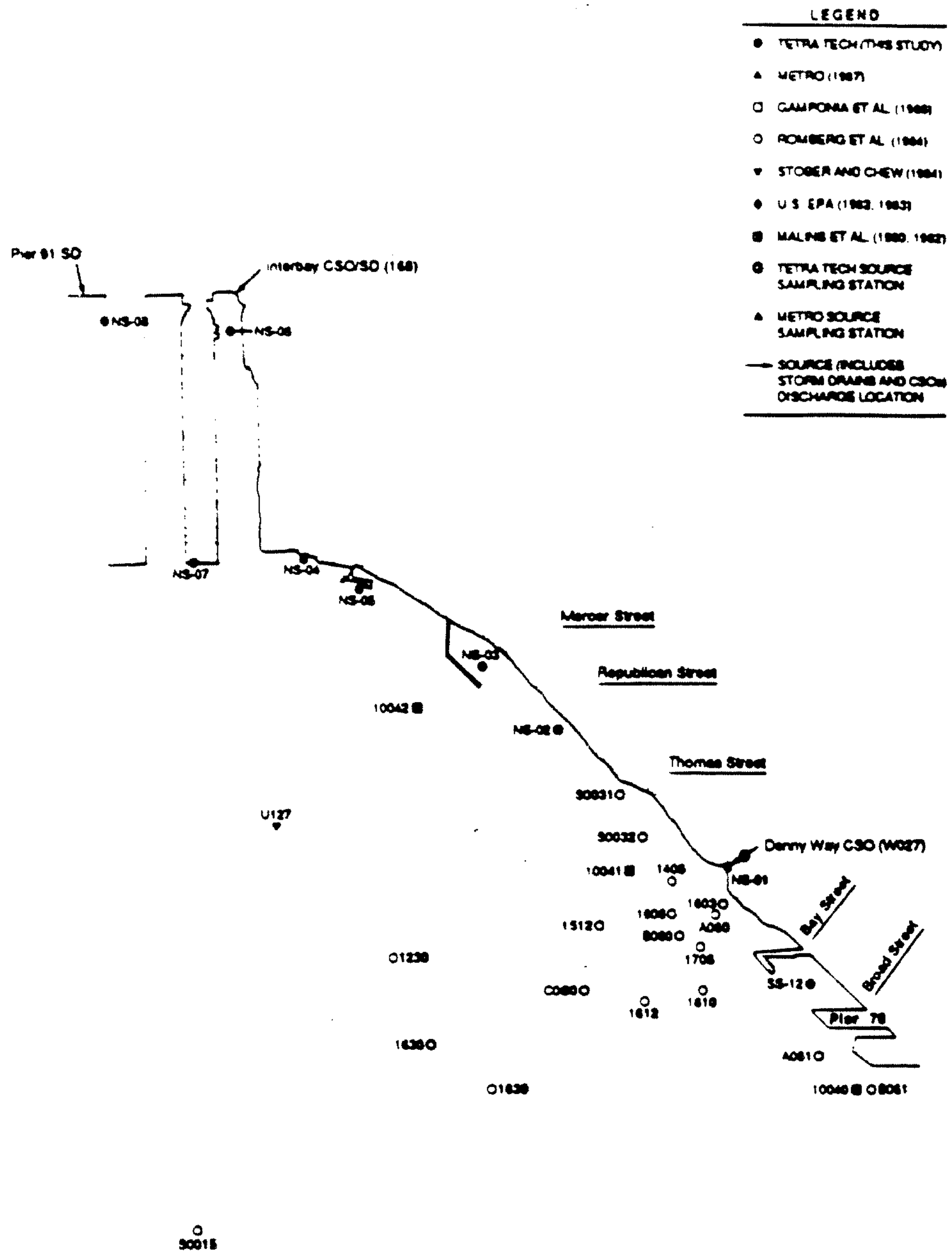
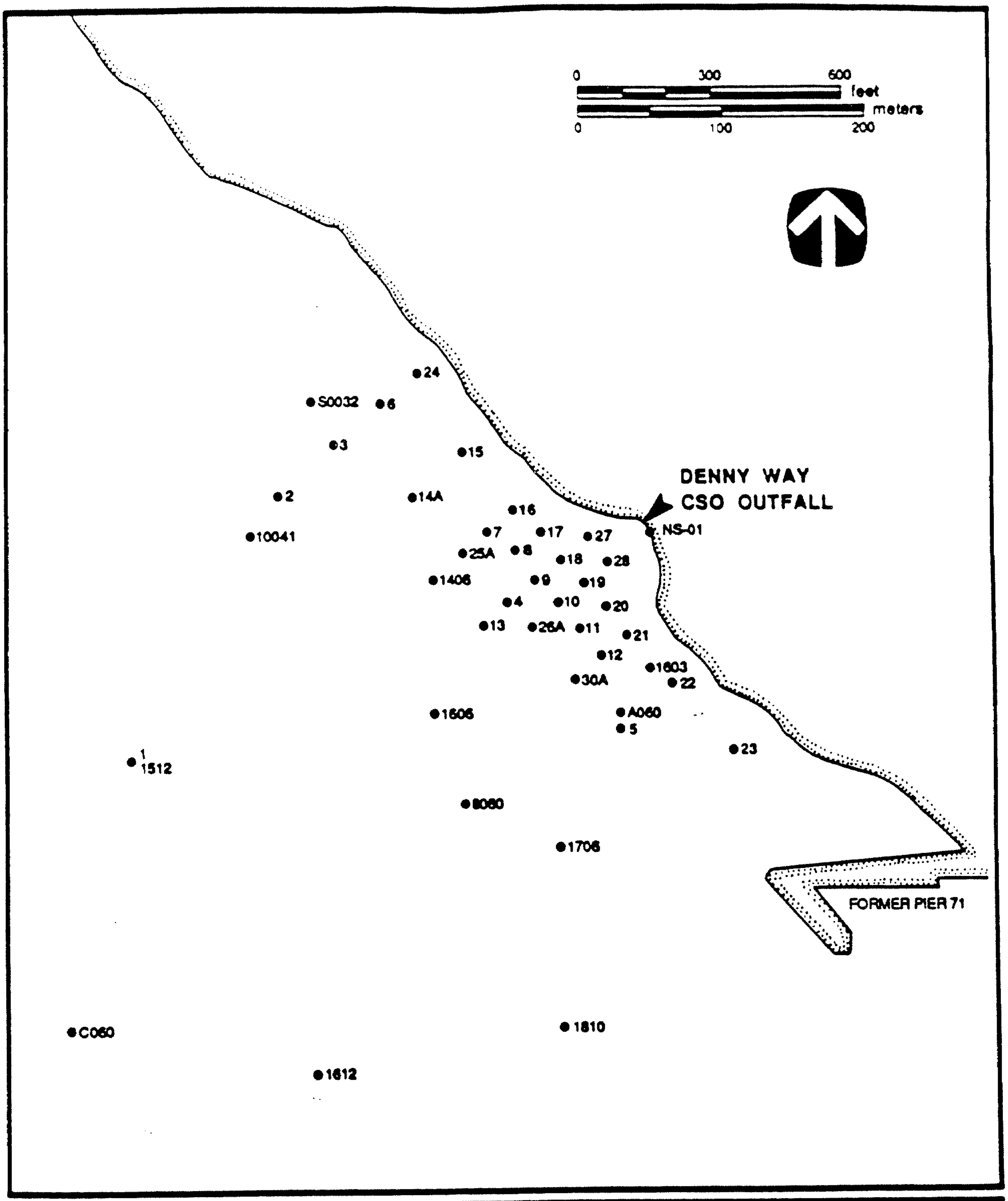


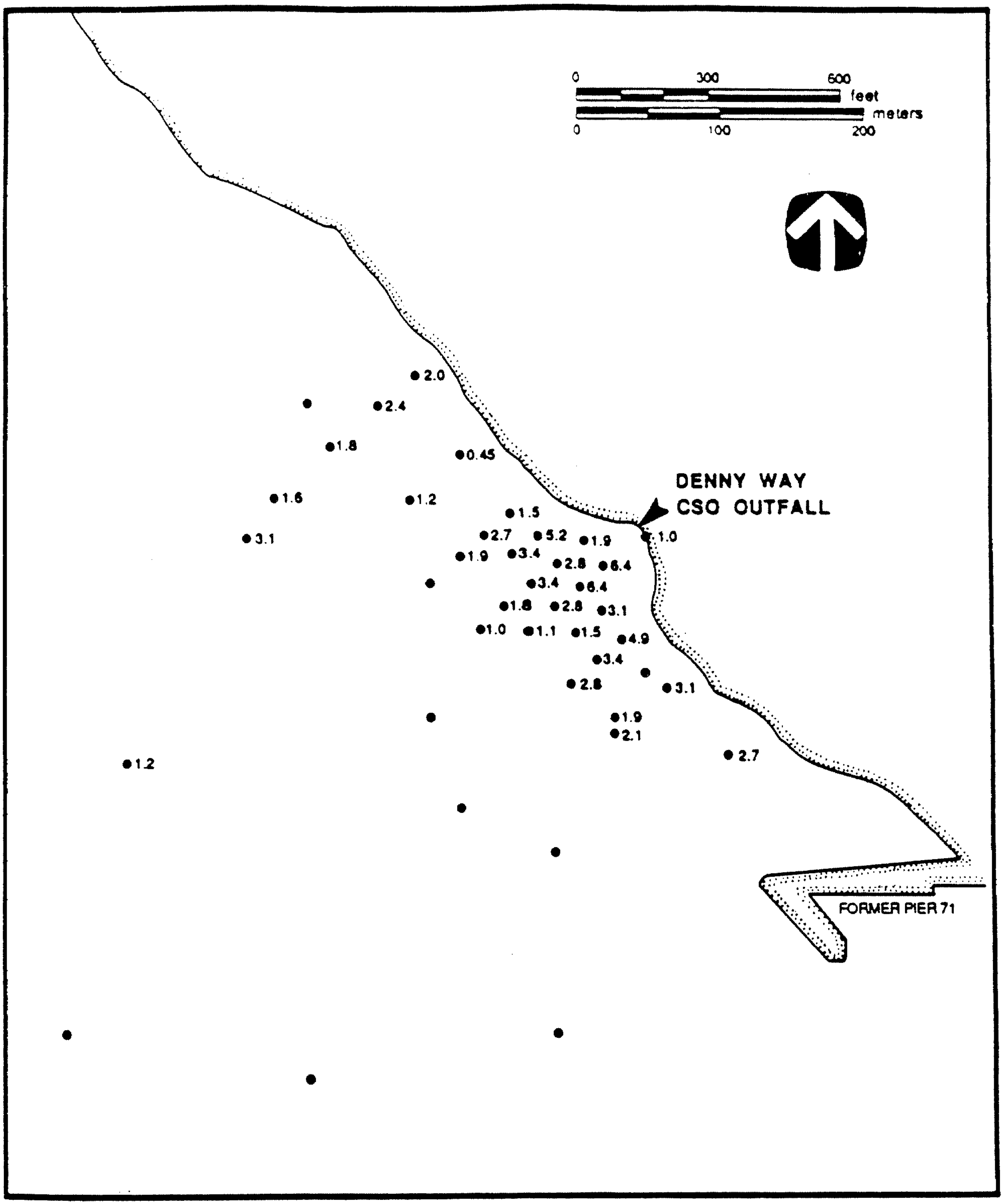
Figure 22. Tetra Tech (1988a)

Locations of offshore and drain sampling stations, CSOs, and storm drains in the Seattle North Waterfront study area.



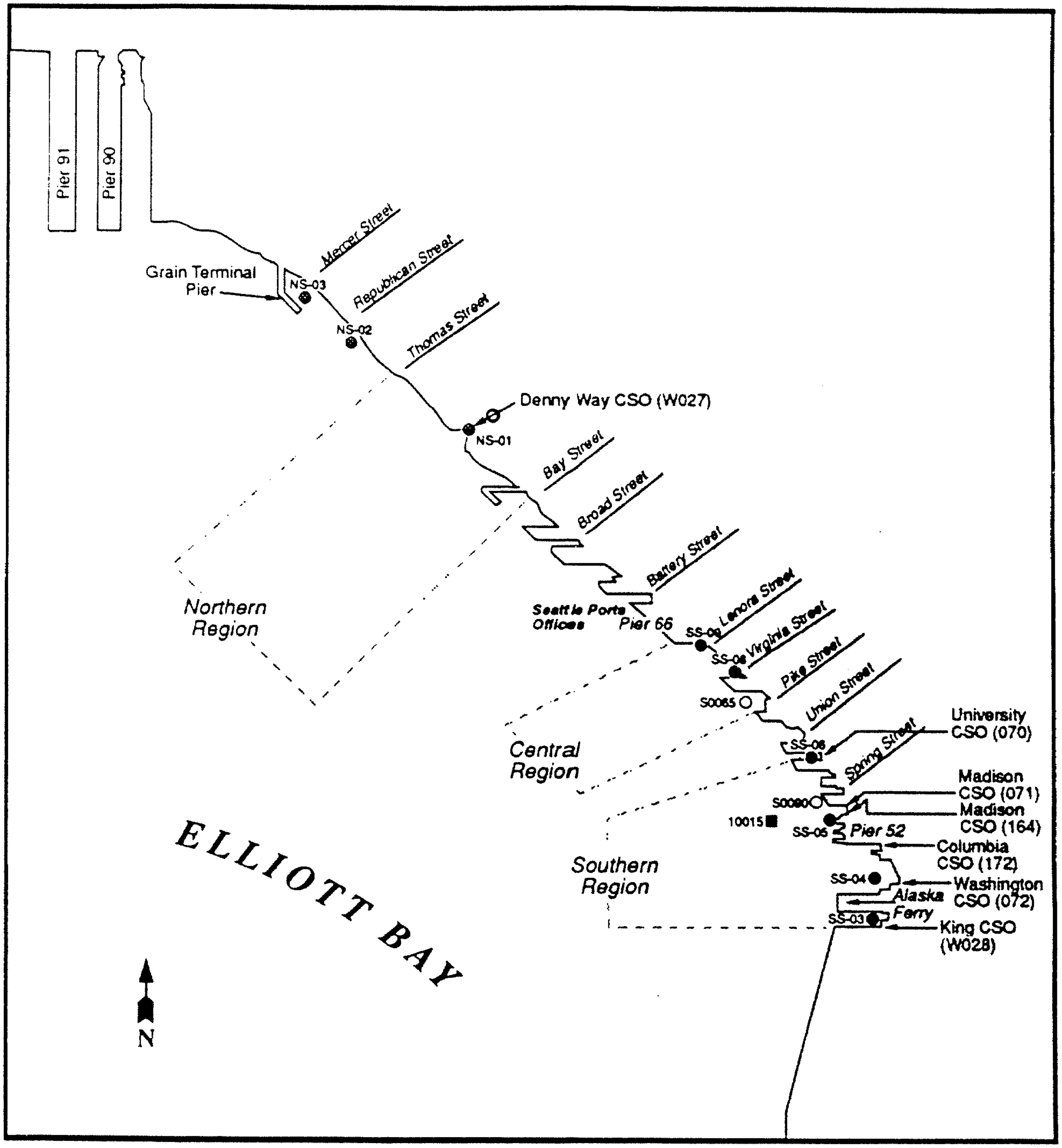
Sampling station locations in the Denny Way CSO problem area.

Figure 23. Tetra Tech (1988b)



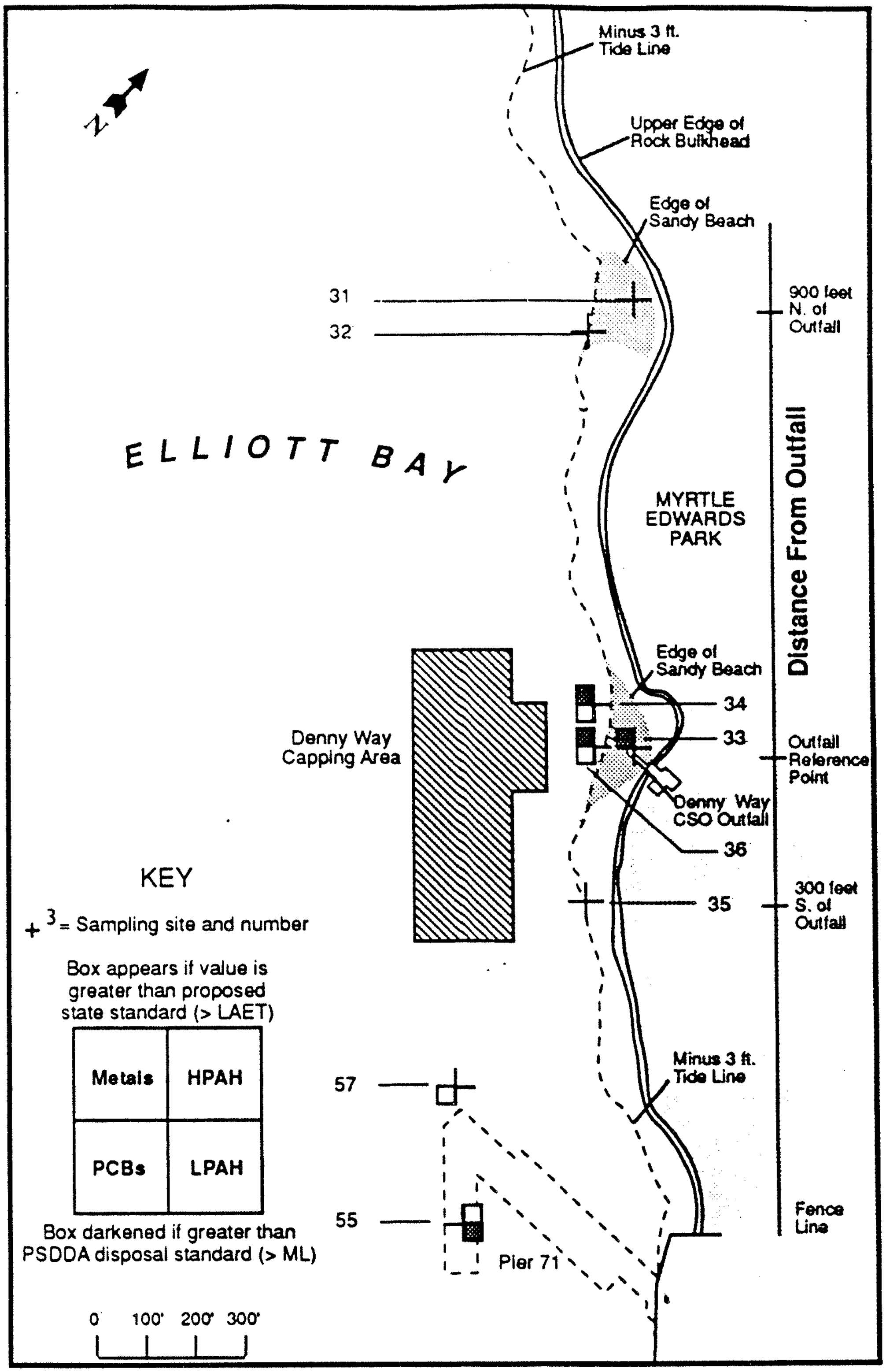
Areal distribution of mercury concentrations in Denny Way surficial sediments, corrected for background concentration and normalized to the target cleanup goal (C_O'/C_G').

Figure 24. Tetra Tech (1988b)



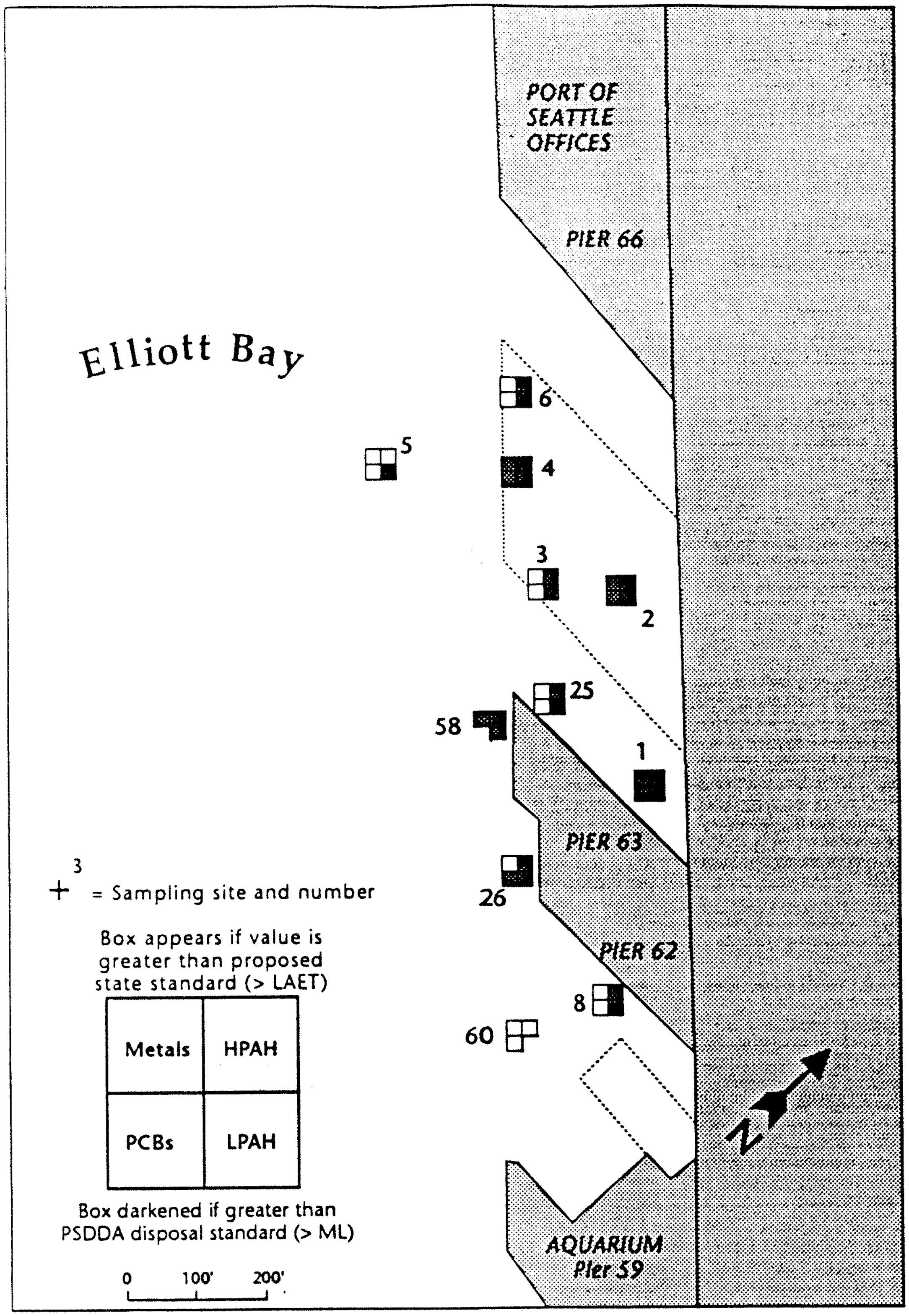
Eastern Elliott Bay Shoreline Showing the Northern, Central, and Southern Regions Where Metro Collected Additional Sediment Samples in 1989

Figure 25. METRO (1989)



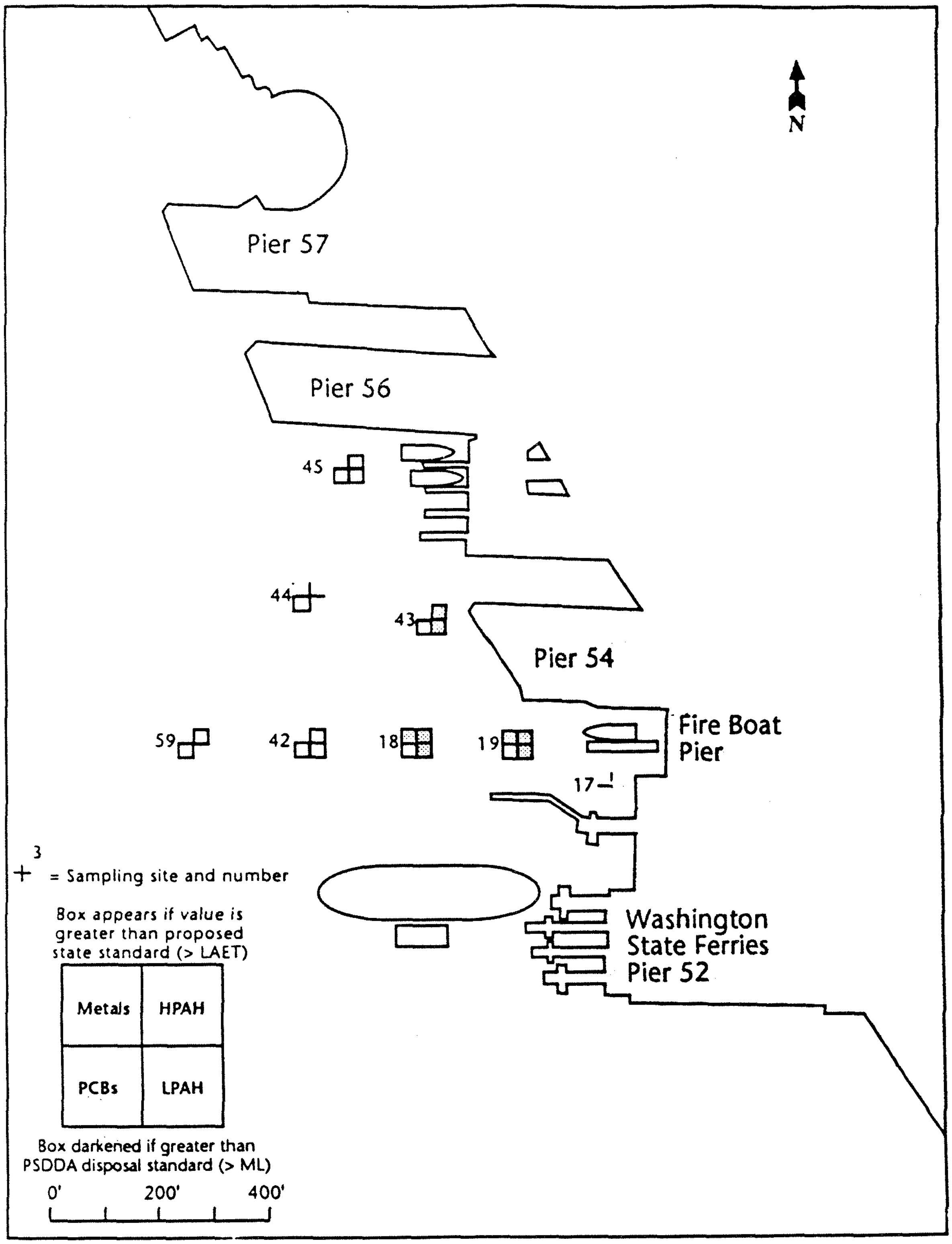
Northern Sampling Region, Illustrating Chemical Quality of Intertidal Sediments Collected at Sampling Sites 31 - 36 (sampled in 1988) and subtidal Sites 55 and 57 sampled in 1989

Figure 26. METRO (1989)



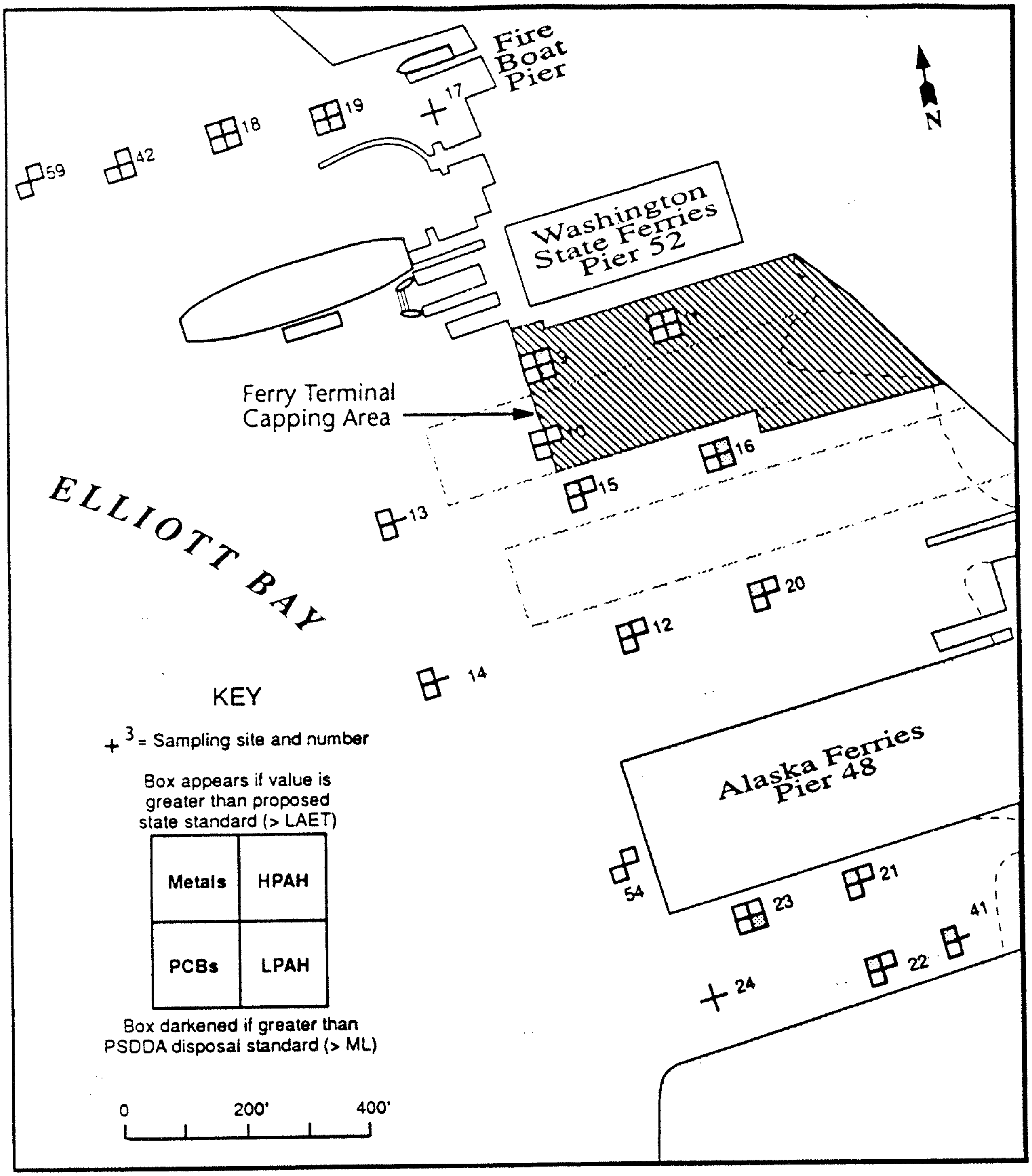
Central Sampling Area, Illustrating Chemical Quality of Subtidal Sediments Collected at Sampling Sites 1 - 6, 8, 25, 26 (sampled in 1988) and 58 and 60 (sampled in 1989)

Figure 27. METRO (1989)



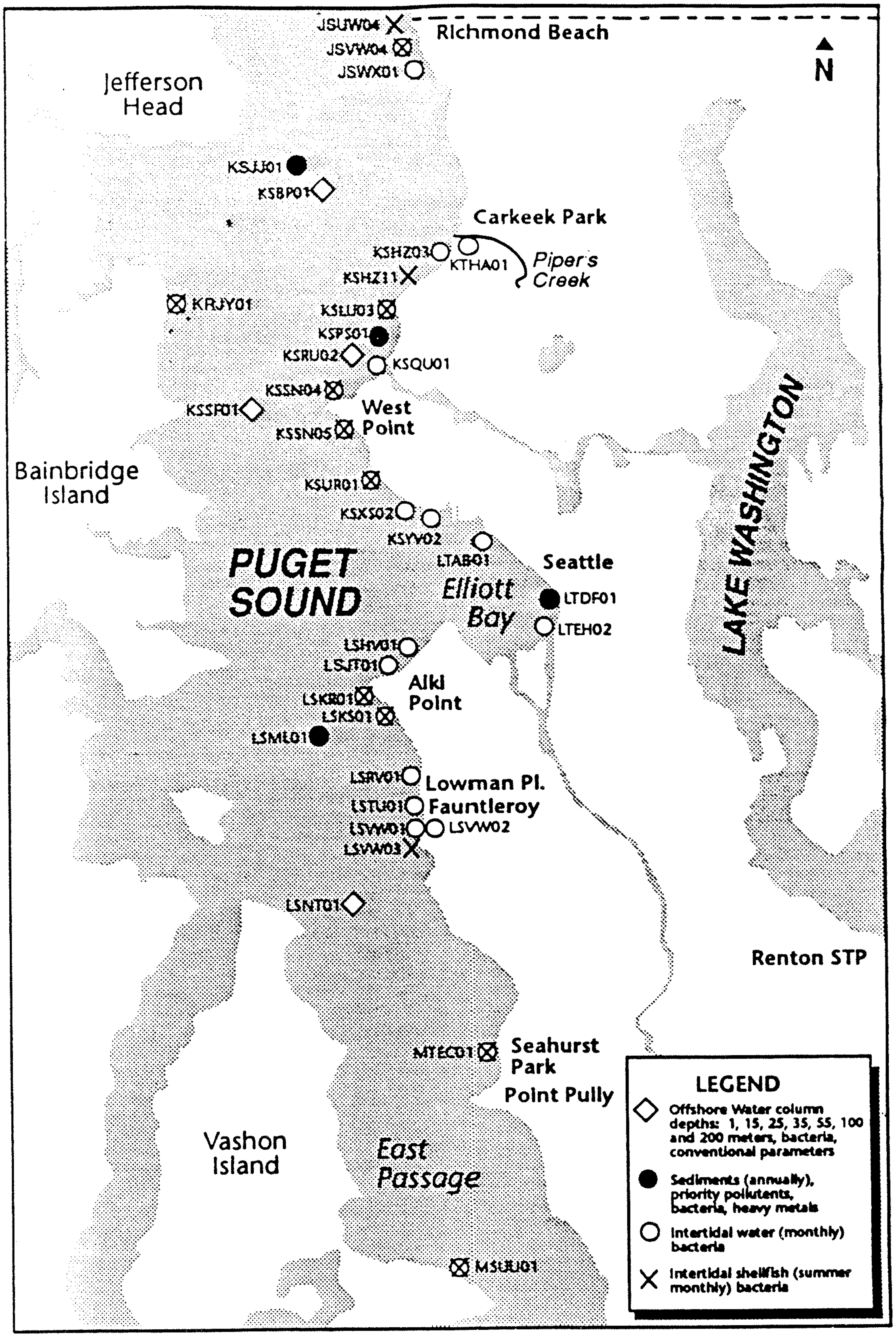
Southern Sampling Region, Illustrating Chemical Quality of Subtidal Sediments Collected at Sampling Sites 17 - 19 (sampled in 1988) and 42 - 45, and 59 (sampled in 1989)

Figure 28. METRO (1989)



Southern Sampling Region, Illustrating Chemical Quality of Subtidal Sediments Collected at Sampling Sites 9 - 24 (sampled in 1988) and 41 and 54 (sampled in 1989)

Figure 29. METRO (1989)



Metro's Puget Sound Ambient Monitoring Program

Figure 30. METRO (1989)

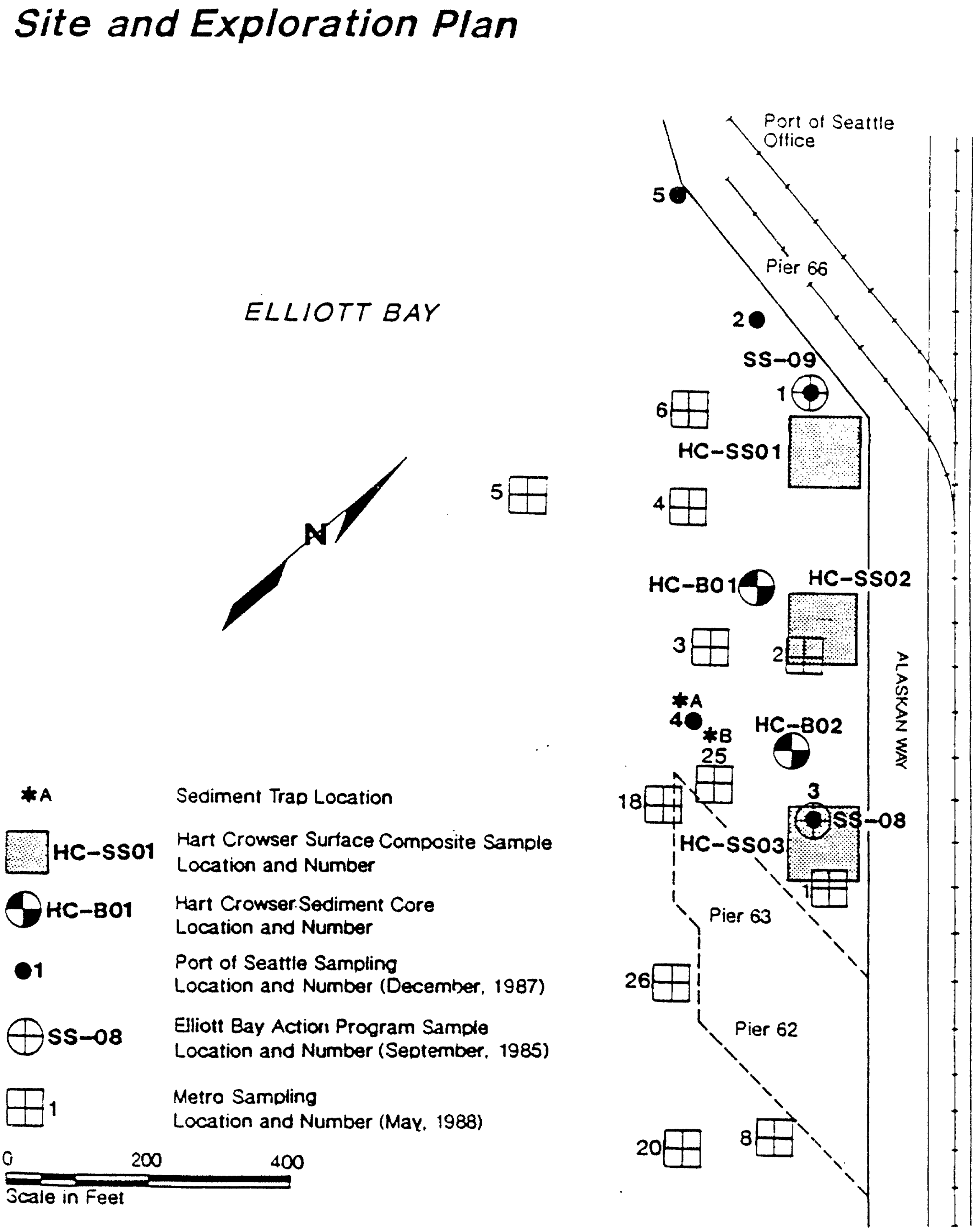


Figure 31. Hart Crowser (1990)

Surficial HPAH: TOC Concentrations Contour Map

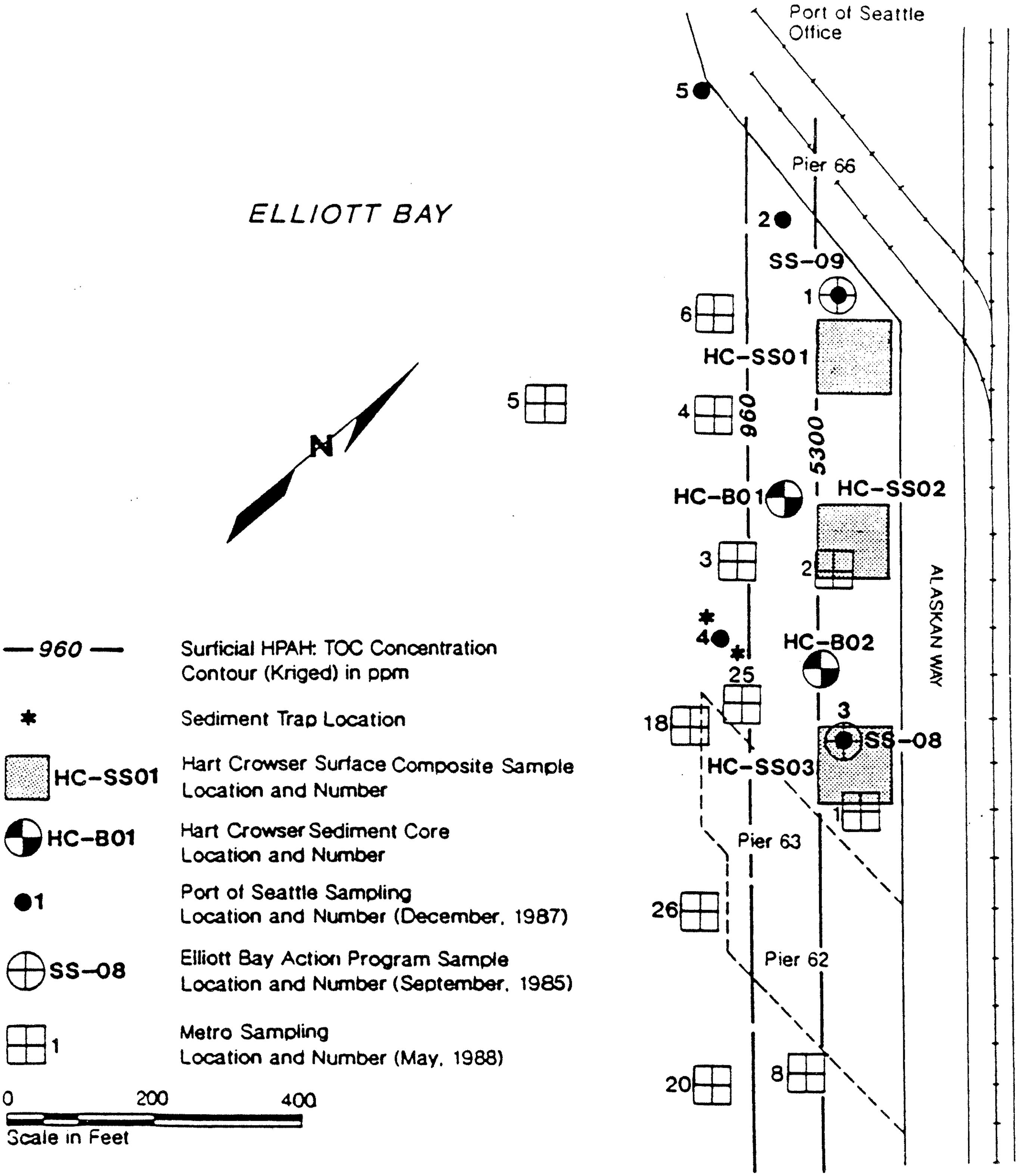


Figure 32. Hart Crowser (1990)

Surficial LPAH: TOC Concentrations Contour Map

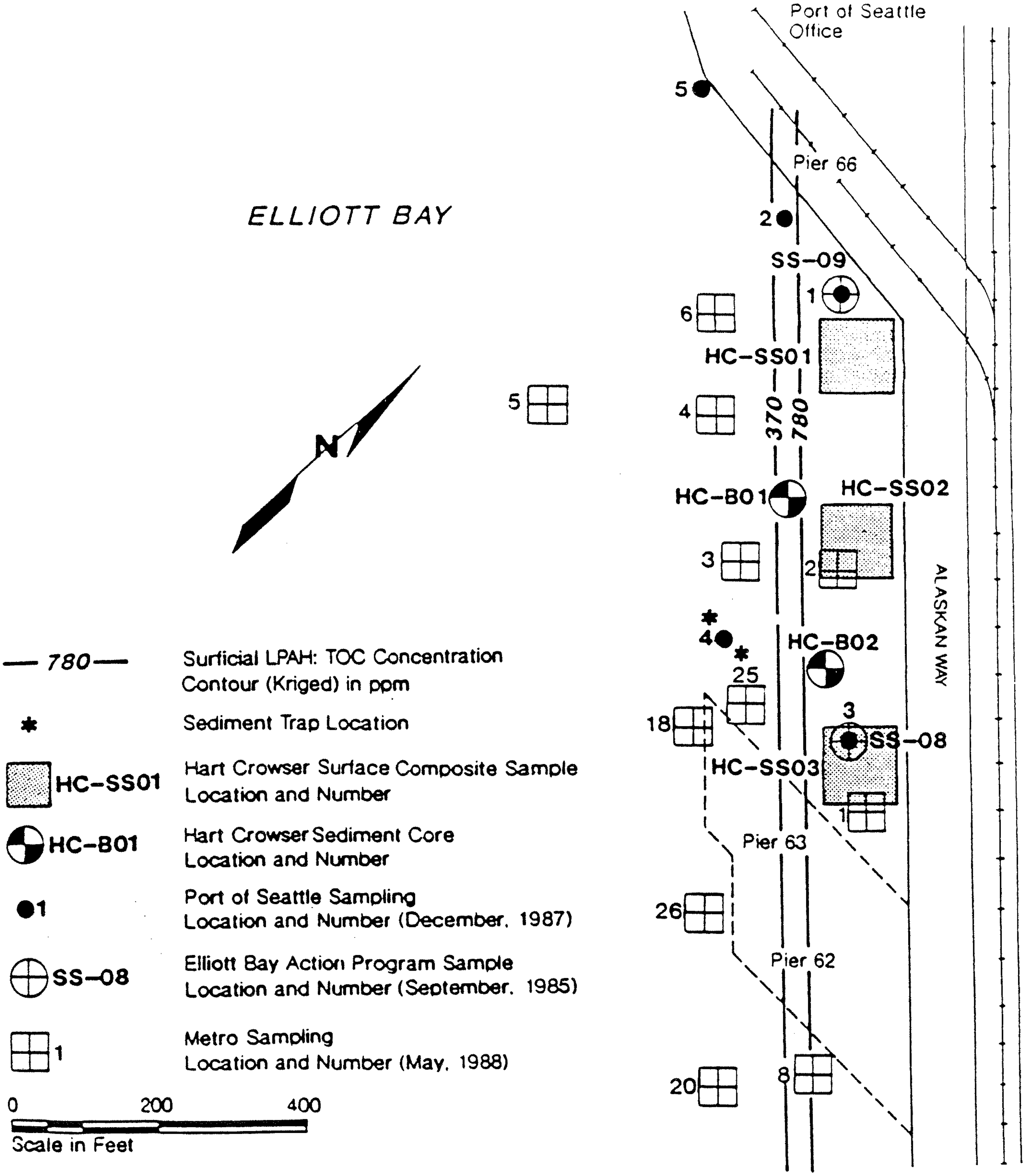


Figure 33. Hart Crowser (1990)

Surficial Lead Concentrations Contour Map

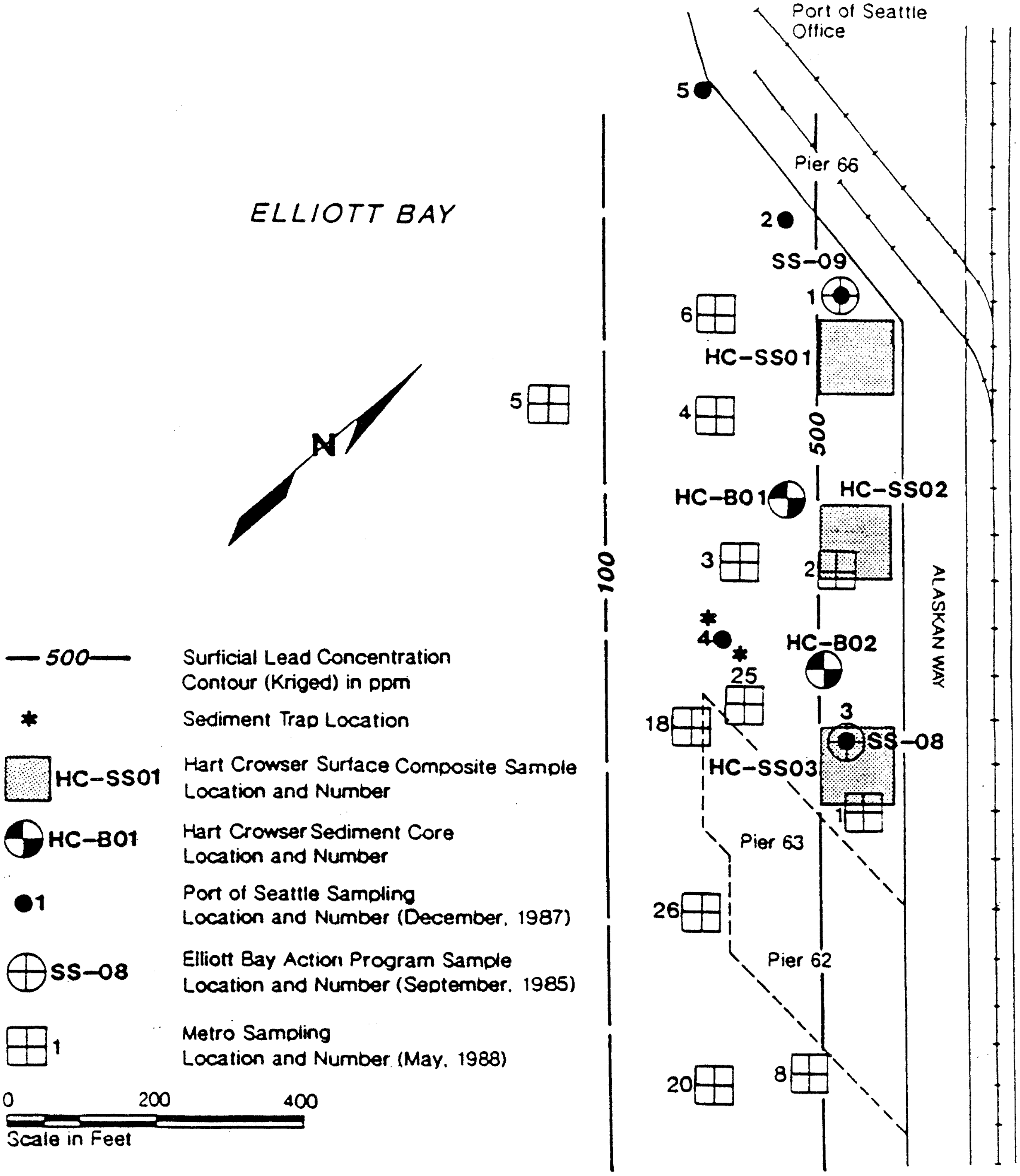
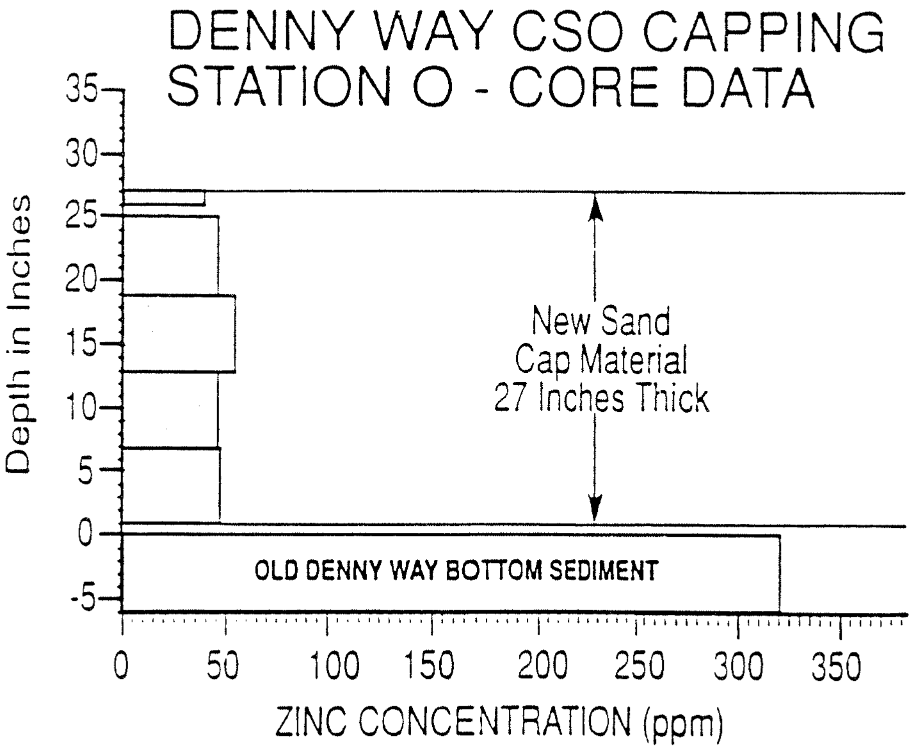


Figure 34. Hart Crowser (1990)



Zinc Sediment Concentrations at Station O

Figure 35. Sumeri & Romberg (undated)

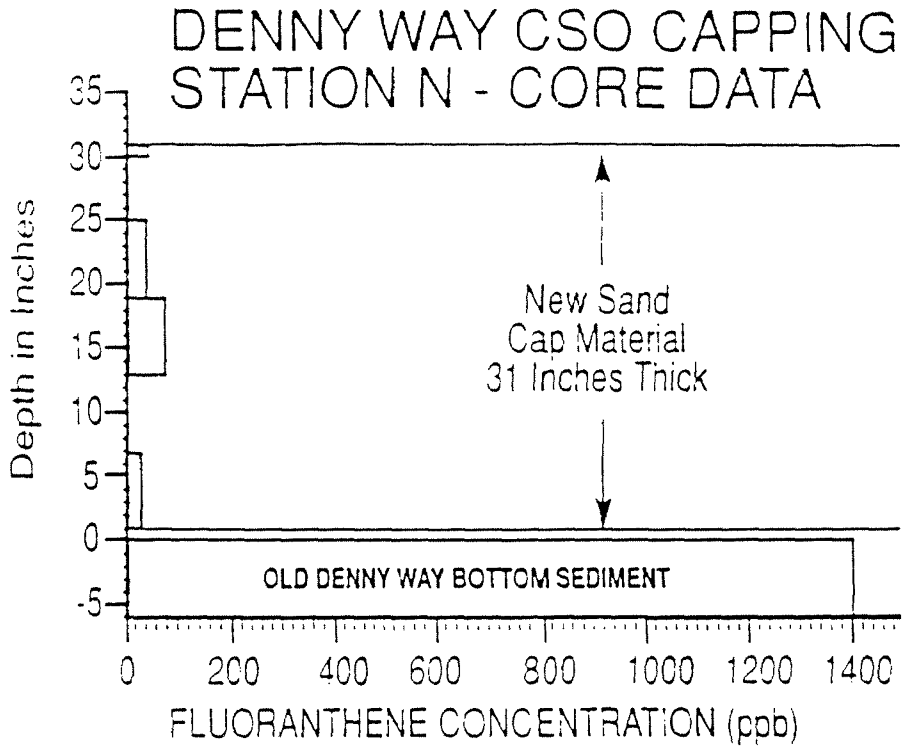
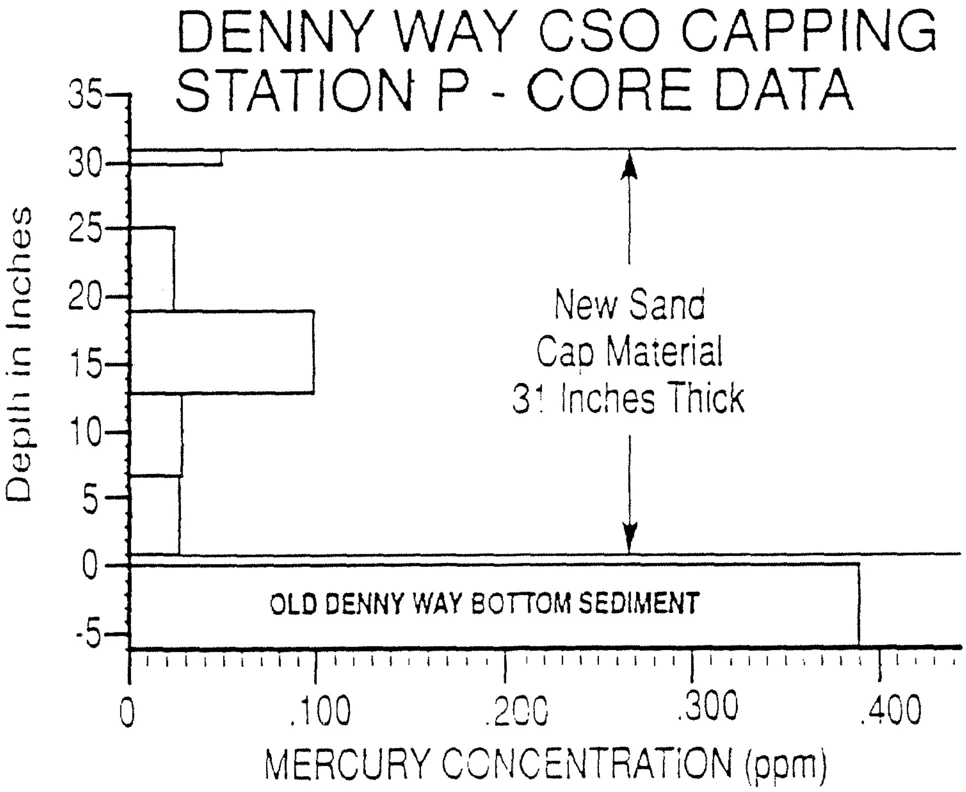


Figure 11. Fluoranthene Sediment Concentrations at Station N



Mercury Sediment Concentrations at Station P

Figure 36. Sumeri & Romberg (undated)

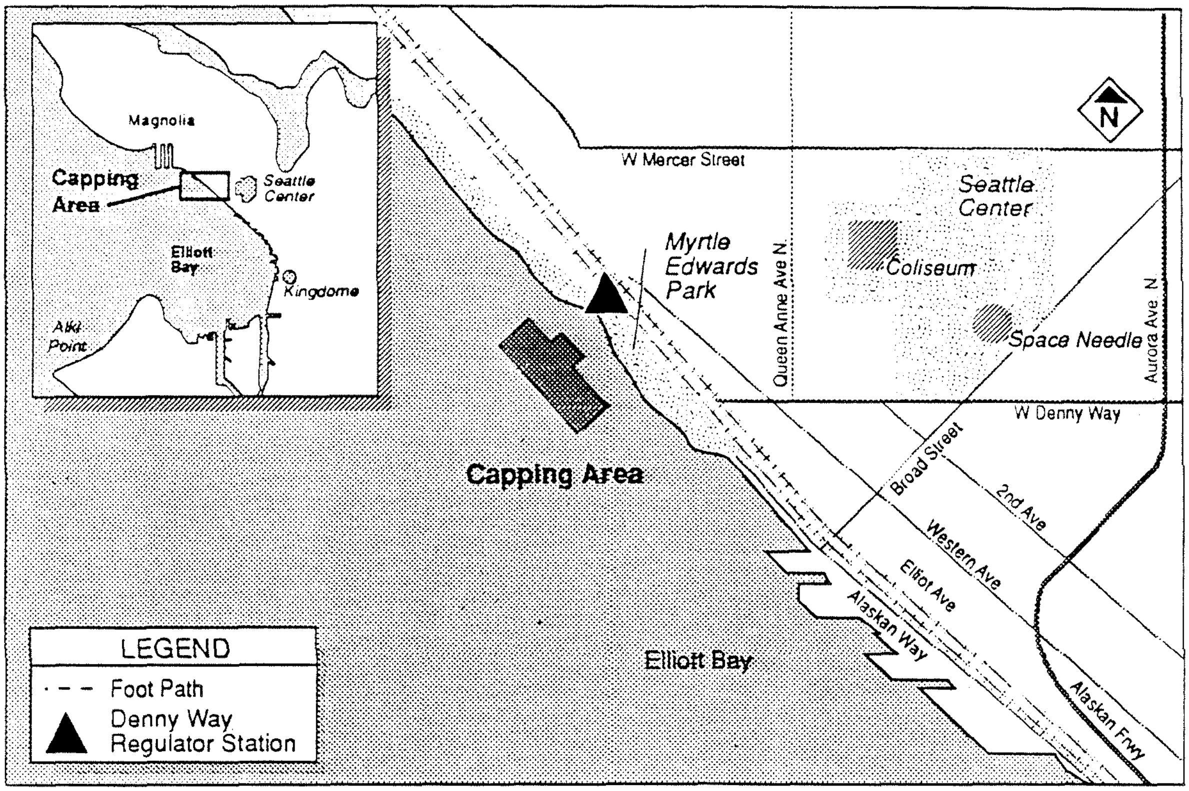


Figure 37. METRO unpublished

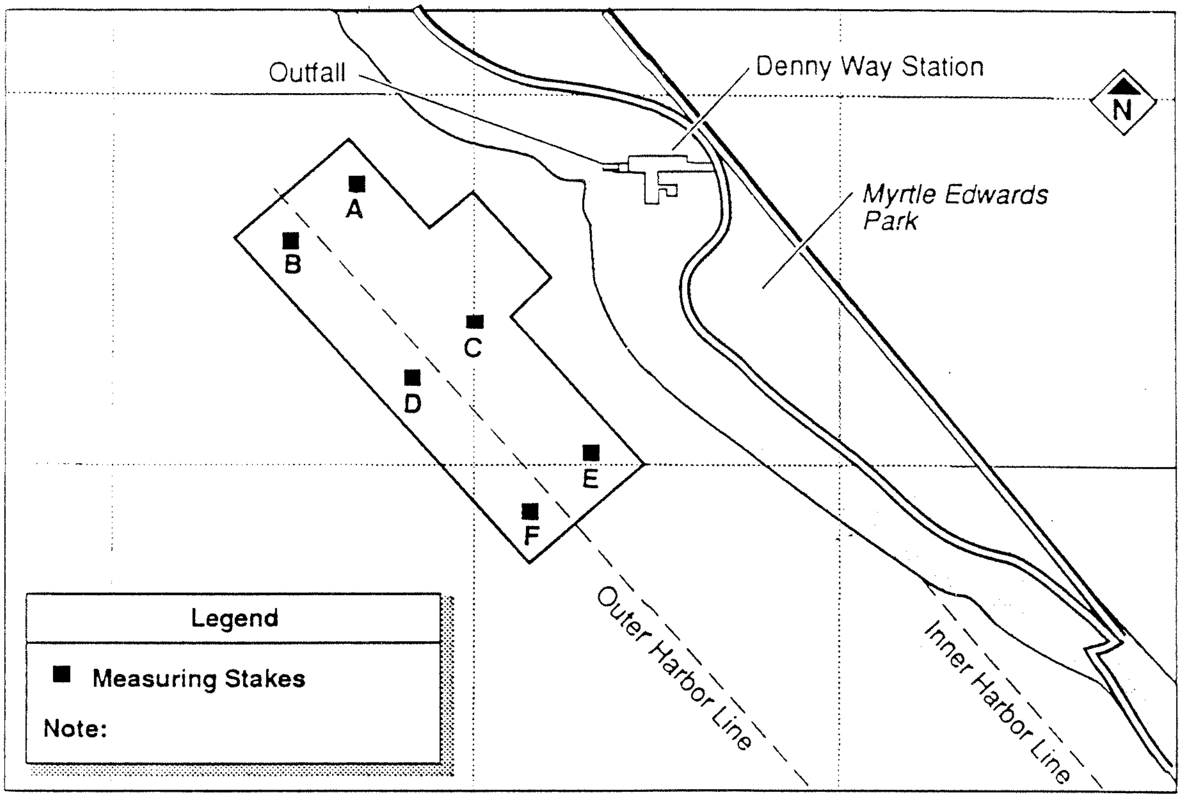


Figure 38. METRO unpublished

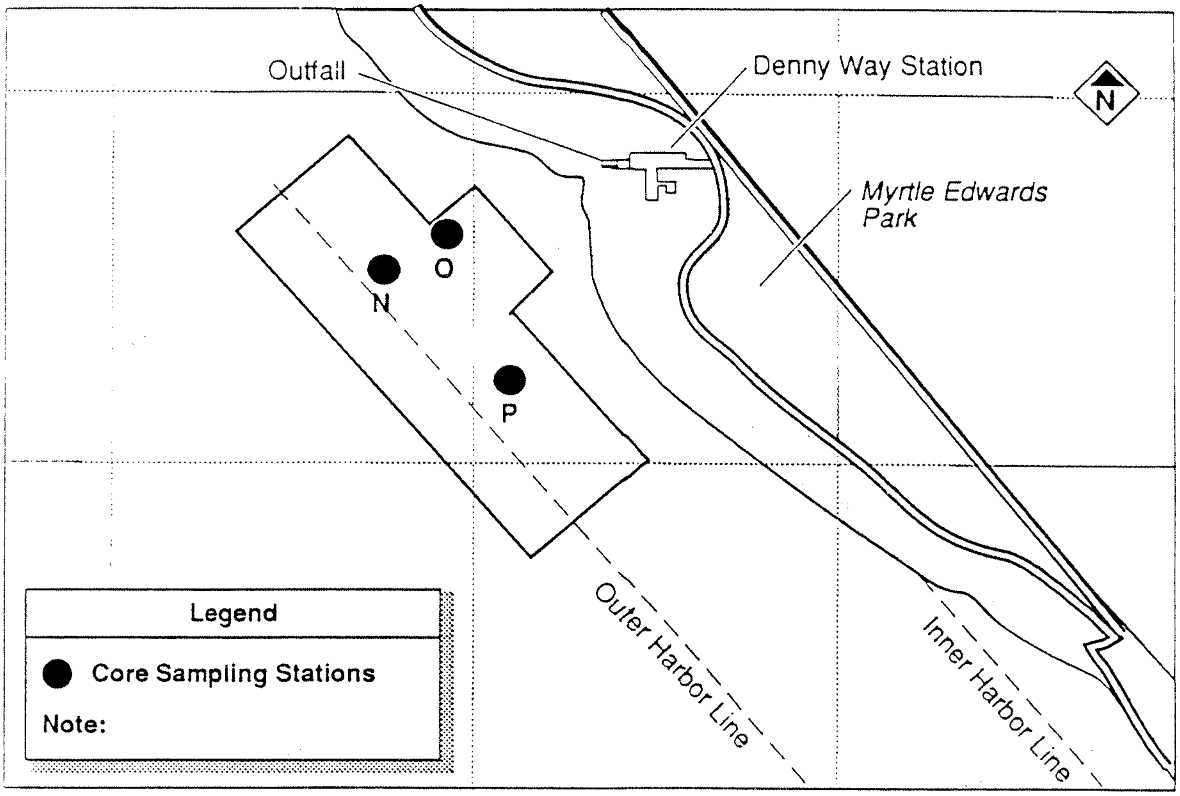


Figure 39. METRO unpublished

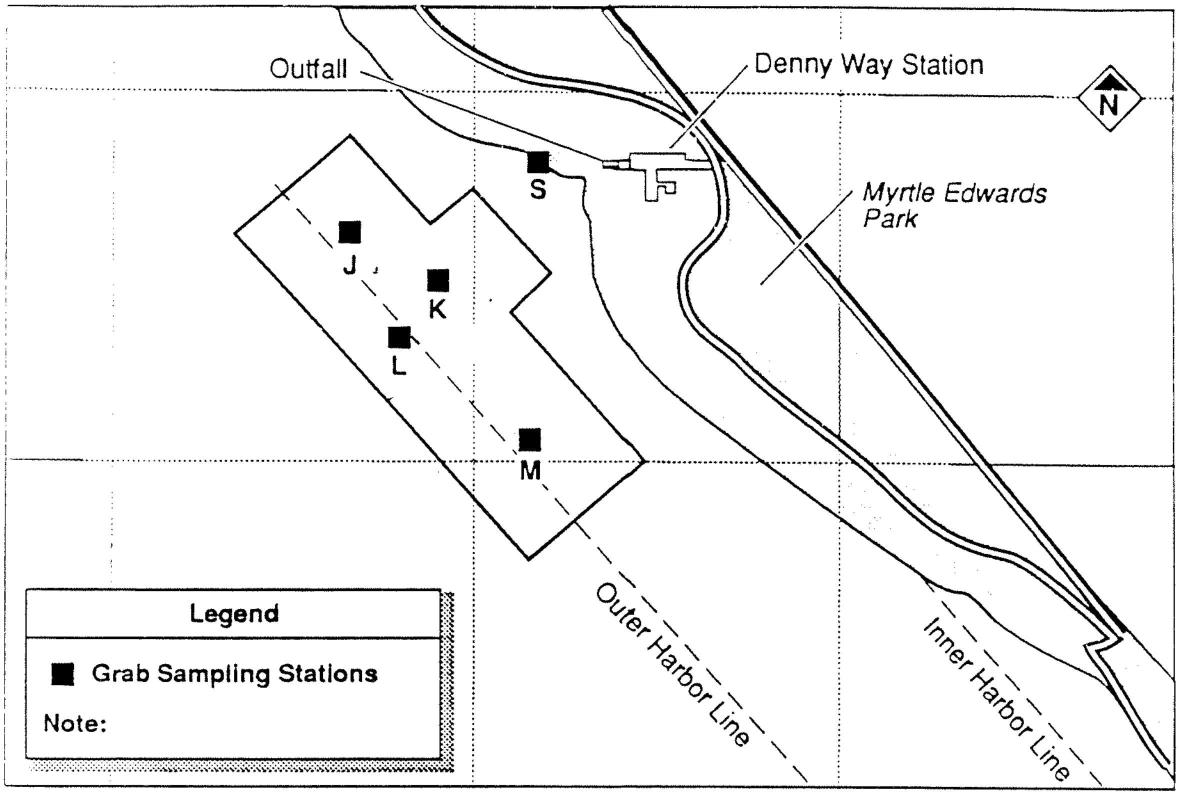


Figure 40. METRO unpublished

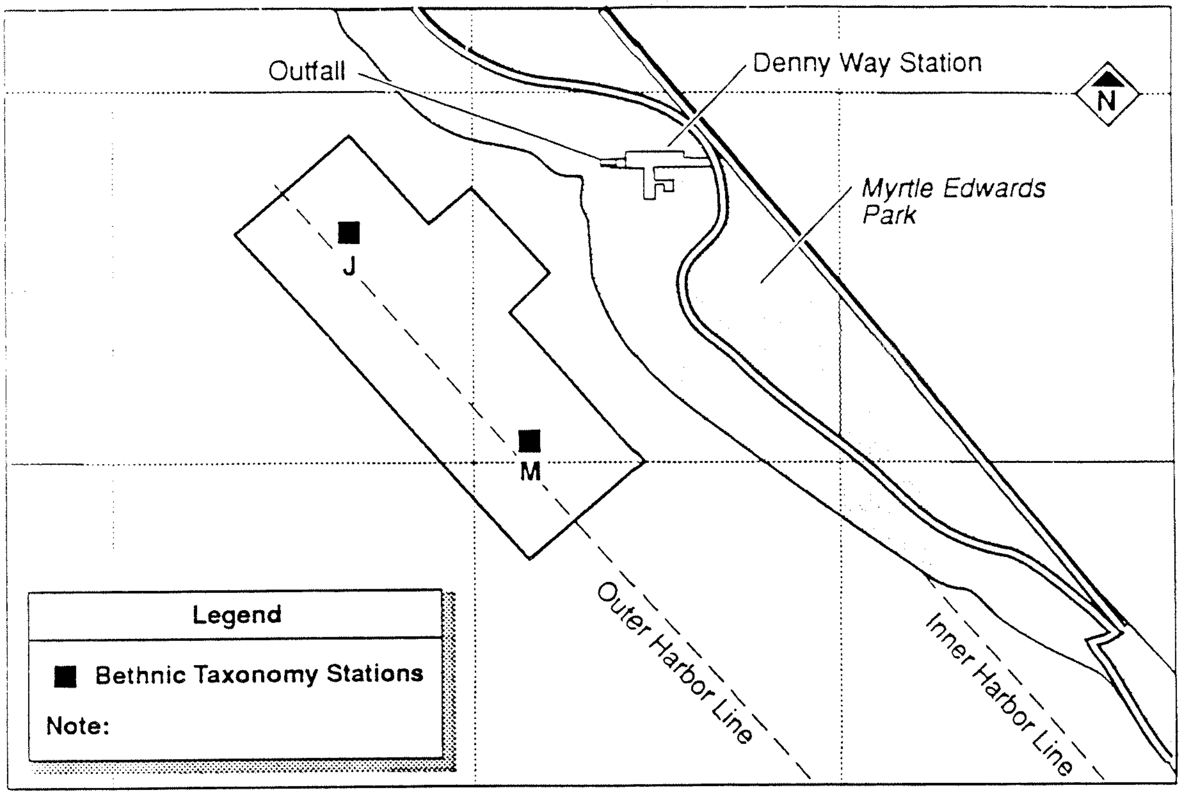


Figure 41. METRO unpublished

V. SEDIMENT TRAP STUDIES

Most Useful References: 3, 4, 18, 19, 32, 36, 57, 59

Other References: 7, 17, 22, 30, 61

Synopsis of Information Found: The only instance of sediment trap use along the Seattle waterfront was found in the Hart Crowser (1990) study. They deployed two traps 0.75m off the bottom 100 ft. north of Pier 63 during May 2 - July 10, 1990 (see Figure 31 in Bottom Sediment Surveys Section). Chemical analysis of the particulates in the trap showed mercury, LPAH and high molecular weight PAH (HPAH) exceeded Ecology draft sediment quality guidelines (Table 6).

NOAA had sediment traps in the deeper waters of the bay during 1979, 1980 and 1985 in studies already mentioned above. Baker (1982) and Baker, *et al.*, (1983) contain the results from moorings 2 and 4 (see Figure 1 in Section 1) that operated August-September 1979 and February-March 1980. Chemical analysis was limited to organic carbon.

During 1985, NOAA had traps at the station south of Pier 90; Paulson, *et al.*, (1991a) contains location and metals data (Figure 42; Tables 7 and 8). Paulson, *et al.*, (1989) and Feely, *et al.*, (1988) use these data to calculate vertical fluxes of metals. Curl, *et al.*, (1987) report concentrations of PAH, DDT compounds, and PCBs (see Figure 13 in Section 3 and Table 9).

Other sediment trap data for the main basin outside Elliott Bay are reported in Dexter, *et al.*, (1981), Curl (1982), Bates, *et al.*, (1984), Feely, *et al.*, (1986), and Paulson, *et al.* (1991c).

Conclusion: Limited sediment trap data was found for the study area, these being the two Hart Crowser (1990) deployments. These sediment trap data indicated the potential for recontamination along the waterfront from area-wide sources, but may also have been influenced by resuspension of local sediments (see Section VII).

Summary of Selected Sediment Trap and Surficial Sediment Chemical Data - Pier 64/65

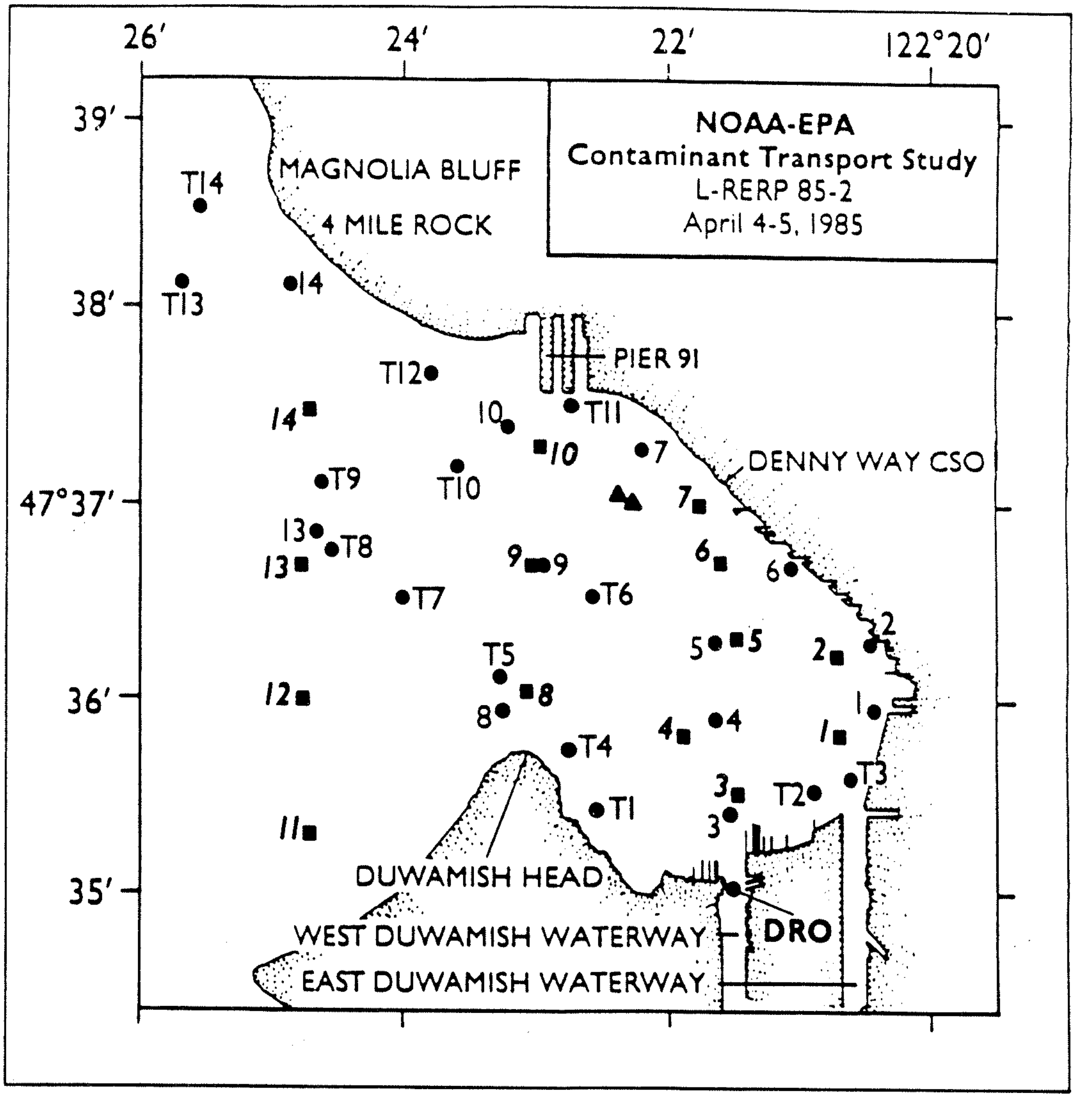
						Sediment Coring Data	
	Sediment Trap Data		Surface Sediment Composite Data			HC-B01	HC-B02
Chemical	Pier 63A	Pier 63B	HC-SS01	HC-SS02	HC-SS03	0 to 4 cm	0 to 4 cm
Bulk Parameters:							
Deposition Rate (gm DW/cm2-yr)	0.86	0.84					
210-Pb Activity (dpm/gm DW)	4.05	4.35				4.03	2.14
Total Solids (%)	26.8%	25.5%	55.1%	40.4%	60.4%	37.7%	34.4%
Total Organic Carbon (% DW)	3.9%	4.7%	1.5%	1.5%	1.5%	8.5%	14.9%
Metals (mg/kg DW):							
Aluminum	65,200	55,900					
Arsenic	16	15					
Calcium	18,200	16,900				9,880	3,860
Chromium	94	93					
Copper	118	117					
Iron	40,200	41,400					
Lead	156	186	486	704	420	569	1,180
Manganese	584	548					
Mercury	0.74	0.76	0.45	0.60	0.25		
Nickel	44	39					
Silicon	226,000	224,000					
Zinc	221	236	665	1,030	306	484	582
Low Weight PAHs (mg/kg DW):							
Naphthalene	0.13	0.33	1.6	3.3 J	1.8 J	5.4	8.4
Acenaphthalene	1.00	1.10	1.4	1.7 J	2.6 J	3.6 J	3.9
Acenaphthene	0.40	0.69	0.9	2.4 J	1.9 J	3.1 J	20.0
Fluorene	0.95	1.20	1.2	5.0 J	3.9 J	8.8	26.0
Phenanthrene	7.20	6.30	6.2	20.0 J	43.0	41.0	88.0
Anthracene	7.40	7.00	4.2	31.0 J	5.9	44.0	80.0
Total PP-LPAH	17.08	16.62	15.5	63.4 J	59.1	105.9	226.3
Total PP-LPAH (mg/kg TOC)	438	354	1,064	4,144 J	3,888	1,252	1,519
High Weight PAHs (mg/kg DW):							
Fluoranthene	13.00	15.00	11.0	33.0 J	57.0	87.0	62.0
Pyrene	12.00	13.00	28.0	48.0 J	54.0	81.0	140.0
Benzo(a)Anthracene	8.70	9.00	15.0	32.0 J	10.0	48.0	51.0
Chrysene	15.00	15.00	9.3	27.0 J	18.0	52.0	75.0
Benzo(b)Fluoranthene	11.00	11.00	0.6 U	11.0 J	8.4	4.6 U	57.0
Benzo(k)Fluoranthene	8.10	8.00	29.0	32.0 J	4.0 U	85.0	71.0
Benzo(a)Pyrene	10.00	10.00	8.1	17.0 J	7.2	42.0	64.0
Indeno(1,2,3-cd)Pyrene	4.80	4.80	4.3	7.7 J	3.2 J	13.0	29.0
Dibenzo(a,h)Anthracene	1.40	1.50	2.0	2.9 J	4.0 U	5.2	12.0
Benzo(g,h,i)Perylene	4.20	4.20	4.3	8.1 J	4.0 U	13.0	32.0
Total PP-HPAH	88.20	91.50	111.3	218.7 J	163.8	428.5	593.0
Total PP-HPAH (mg/kg TOC)	2,262	1,947	7,623	14,294 J	10,776	5,065	3,980
Polychlorinated Biphenyls:							
(mg/kg DW)	0.27		0.97	0.86	0.67	1.06	13.20
(mg/kg TOC)	7		66.	56	44	13	89

NOTES:

a. "U" denotes that the analyte was not detected; value presented is the sample detection limit.

b. "J" denotes that the analyte was positively identified, but the associate numerical value is estimated.

Table 6. Hart Crowser (1990)



Sampling locations in Elliott Bay for L-RERP 85-2. Surface samples by small boat stations (●), vertical profiles (■) and sediment trap mooring (▲).

Figure 42. Paulson *et al.* (1991a)

Location of moored equipment.

Mooring	Location	Depth	Duration
CB-3	47°16′24″N 122°27′12″W	25	3/25/81–5/4/81
CB-4	47°17′37″N 122°26′48″W	123	3/25/81–5/4/81
		123	
CB-5B	47°19′48″M 122°26′48″W	73	3/25/81–5/4/81
PS85-01	47°37′02″N 122°22′42″W	6	3/29/85–4/6/85
		50	3/29/85–4/6/85
PS85-02	47°37′06″N 122°22′42″W	95	3/29/85–4/6/85
		98	3/27/85–7/9/85
		101	3/22/85–7/9/85
PS85-04	47°17′44″N 122°27′31″W	6	3/26/85–4/15/85
			4/1/85–4/2/85
PS85-05	47°17′39″N 122°27′15″W	150	3/26/85–4/15/85
			4/1/85–4/12/85

Table 7. Paulson *et al.* (1991a)

Trace metals in sediment trap samples (in units of wt./wt. sample).

Mooring	Bay	Depth ppm	Vertical mass flux (g/m^{-2}day^{-1})	Cu ppm	Mn ppm	Cd ppm	Pb ppm	Fe wt%	Zn ppm	As	Cr
CB-4	Commencement	23	5.91	102	610		55	3.99	435	35	67
		123	81.93	73	910		39	4.14	115	24	67
85-1	Elliott	6	0.09 (0.16±0.07)	52	553	*	100	4.25	480†		
		52	0.11 (0.16±0.05)	76	1113	3.60	229	4.64	287†		
85-2	Elliott	95	7.3 (7.7±1.9)	61	1725	0.17	76	4.49	156		
85-4	Commencement	6	0.22 (0.22±0.07)	52	625	0.16	68	3.82	159		
85-5	Commencement	150	31.7 (29.3±8.7)	57	1436	0.21	48	4.59	123		

* Below detection limit

† Contamination from mooring 85-1 suspected

Table 8. Paulson *et al.* (1991a)

TRACE ORGANICS
(in total ng/g)
COLLECTED BY SEDIMENT TRAPS

MOORING#	85-1/17	85-1/20	85-2/18	85-4/15	85-5/16
DEPTH(m)	6m	50m	95m	6m	150m
START/STOP	32985, 62285	32985, 62285	32985, 62285	32685, 41585	32585, 41585
LATITUDE	47°37.0'N	47°37.0'N	47°37.0'N	47°17.6'N	47°17.6'N
LONGITUDE	122°22.7'W	122°22.7'W	122°22.7'W	122°27.5'W	122°27.3'W
LOCATION	ELLIOTT BAY	ELLIOTT BAY	ELLIOTT BAY	COMM. BAY	COMM BAY
Phe	590	820	440	<260	190
Ant	160	270	190	<260	53
MPh	320	670	360	<260	370
Fla	1000	930	720	<260	240
Pyr	900	850	630	<260	200
Ret	150	380	260	<260	400
BAA	340	330	260	<260	62
Chr	710	580	410	<260	90
BFl	520	580	560	<260	124
BEP	320	330	250	<260	84
BAP	210	230	280	<260	90
IPy	210	230	280	<260	90
BPe	210	230	280	<260	90
DDE	12	<5.2	<.18	<26	<.15
DDT	<21	<21	<.71	<104	<.61
DDD	<21	<21	<.71	<104	<.61
CL2	<5.2	<5.2	<.18	<26	<.15
CL3	<5.2	<5.2	<.18	<26	<.15
CL4	<8.3	<8.4	5.5	<42	0.7
CL5	12	<8.4	15	<42	2.2
CL6	33	<5.2	12	<26	2.3
CL7	<8.3	<8.4	5.9	<42	1.4
CL8	<8.3	<8.4	3.2	<42	<.24
CL9	<17	<17	.81	<84	<.48

Table 9. Curl et al. (1987)

VI. SEDIMENT ACCUMULATION RATES

Most Useful References: 3, 4, 17, 18, 36, 55, 75, 94, 95, 101, 103

Other References: 6, 17, 22, 30, 35, 43, 45

Synopsis of Information Found: Baker (1982), Baker, *et al.*, (1983), and Curl, *et al.*, (1987, 1988) used previously mentioned sediment traps to calculate SPM vertical fluxes (Table 10).

In the Pier 64/65 study, Hart Crowser reports average sediment accumulation rates of 0.85 g/cm^2-yr (0.63 cm/yr) in traps compared to 0.26 g/cm^2-yr (0.19 cm/yr) in cores (Table 11). The difference was explained by resuspension of bottom materials (see Section VII).

URS and Evans-Hamilton (1986) have tabulated sedimentation rates determined from cores collected at 150-288 m in and around Elliott Bay (Table 12). Rates ranged from 0.14 - 3.12 cm/yr with a mean of 1.38 cm/yr.

Tetra Tech (1988b,c) selected sedimentation rates of 0.2 and 0.7 cm/yr to evaluate recovery of contaminated sediments off the Denny Way CSO and Duwamish River Slip 4. Harper-Owes (1983) and Weston (1993) also estimated sedimentation in the Duwamish estuary. The most recent of these studies (Weston 1993) estimated accumulation rates for the south end of Harbor Island and Kellogg Island at 1.0 inches/yr (2.5 cm/yr). Weston (1993) also estimated that the north end of West and East Waterways were eroding at a rate of 2-3 inches/yr (5.1-7.6 cm/yr).

Conclusion: Sediment accumulation data for the study area are limited to the Hart Crowser study, although additional estimates of rates for the general Elliott Bay/Duwamish estuary are available. Sedimentation rate estimates for the waterfront range from 0.19 to 0.7 cm/yr, and range up to 3 cm/yr in the central basin.

Characteristics of the trapped material in Elliott Bay

			Size Distribution			
Trap/Depth	Flux ($g/m^2/day$)	Organic matter (%)	Mean ϕ	Modal ϕ	>4ϕ (%)	Aggregate in >4ϕ fraction (%)
EB4						
Summer/30 m	0.66	23.0	5.3*	>4	44.8	92.7
	0.75	17.7	6.3	7	18.1	85.4
Summer/132 m	37.9	12.8	6.6	7	5.2	97.1
	37.0	10.9	6.8	7	7.1	75.3
Winter/130 m	32.7	9.6	6.0	7	4.8	81.9
	30.0	8.9	6.3	7	5.2	85.1
EB2						
Summer/92 m	30.1	8.6	6.7	7	5.3	88.7
	33.1	12.3	7.0	8	4.3	87.9
Winter/30 m	6.7	11.3	5.9	7	13.4	79.0
	6.6	9.1	6.5	7	10.9	79.8
Winter/90 m	22.1	7.9	6.0	7	6.2	66.5
	22.3	6.9	5.9	7	8.6	71.0

* Median, not mean, for this trap

Table 10. Baker (1982)

Sediment Trap Deposition Rates

Trap No.	Percent Solids	Accumulated Dry Weight in Grams	Sediment Flux in gm DW/cm^2-yr
Pier 63A	26.8	61.	0.86
Pier 63B	25.5	60.	0.84
Elliott Bay Mooring PS8501 (Curl et al., 1988)			0.0057
Central Puget Sound Mooring PS7 (Baker et al., 1985)			0.062

Table 11. Hart Crowser (1990)

Sedimentation rates measured in central Puget Sound and Elliott Bay.

Station/Core Number	Location	Water Depth (m)	Sedimentation Rate (cm/yr)	Sampler Used	Method of Analysis	Reference
Core #5	47 36.5'N 122 25.7'W	194	1.40	Box Core	137Cs	Romberg et al., 1984
BPS-19	47 36.9'N 122 26.7'W	205	2.00	Kasten Core	Stable Pb	
BPS-20	47 36.6'N 122 25.2'W	199	2.04	Kasten Core	Stable Pb and 210Pb	
BPS-21	47 36.6'N 122 24.1'W	155	0.88	Kasten Core	Stable Pb	
K-4	47 35.7'N 122 25.3'W	201	2.0	Kasten Core	210Pb	Nevissi and McClain, 1984
K-6	47 35.7'N 122 24.8'W	150	1.3	Kasten Core	210Pb	
K-7	47 36.05'N 122 25.2'W	190	1.8	Kasten Core	210Pb	
6101	47 48.8'N 122 26.3'W	170	0.36	Multiple Core	210Pb	Carpenter et al., 1985
6102		171	0.56	Box core	210Pb	
5101	47 40.3'N 122 26.4'W	246	0.41	Multiple Core	210Pb	
5102		249	0.12	Box Core	210Pb	
5103		288	0.17	Box Core	210Pb	
5104		284	0.14	Box Core	210Pb	
C	47 32.5'N 122 26.4'W	212	2.4	?	210Pb	

Table 12. URS & Evans Hamilton (1986)

Sedimentation rates measured in central Puget Sound and Elliott Bay. (cont.)

Station/Core Number	Location	Water Depth (m)	Sedimentation Rate (cm/yr)	Sampler Used	Method of Analysis	Reference
6	47 31.6'N 122 25.4'W	201	2.48	Kasten Core	210Pb	Lavelle, Massoth, and Crecelius, 1985
6a	-	-	3.12	-	210Pb	
7	47 36.9'N 122 26.75'W	205	1.52	Kasten Core	210Pb	
8	47 39.75'N 122 27.9'W	229	1.20	Kasten Core	210Pb	
12	47 43.0'N 122 24.3'W	188	0.98	Kasten Core	210Pb	
12a	-	-	0.97	-	210Pb	
12b	-	-	1.03	-	210Pb	
13	47 42.3'N 122 26.4'W	199	1.92	Kasten Core	210Pb	
13a	-	-	1.88	-	210Pb	
13b	-	-	2.37	-	210Pb	

Average of all cores	1.38	Minimum value:	0.12
Standard deviation	0.84		
		Maximum value:	3.12
Average of all stations	1.54		
Standard deviation	0.72	Median value:	1.4

Table 12. Continued

VII. RESUSPENSION

Most Useful References: 3, 4, 18, 19, 21, 36, 55, 83, 101

Other References: 1, 2, 22, 103

Synopsis of Information Found: The topic of resuspension of bottom material in Elliott Bay is discussed for deep water areas by Sillcox, *et al.*, (1981), Baker (1982, 1983), Pavlou, *et al.*, (1982), Dexter (1984), URS Engineers and Evans-Hamilton (1986), Curl, *et al.*, (1987) and Army Corps Engineers (1988a,b). Hart Crowser (1990) evaluated resuspension at Pier 64/65. All but Hart Crowser conclude the potential for resuspension is low.

Sillcox, *et al.*, (1981) state that currents of 23.5 cm/sec at 2m above bottom will resuspend unconsolidated coarse silt, but that higher speeds would be required to move the consolidated sediments of Elliott Bay. Bottom currents at NOAA's moorings (Figure 1) exceeded this speed only infrequently. URS Engineers and Evans-Hamilton (1986) made in situ measurements of sediment stability in water as shallow as 31 feet just east of Duwamish Head and found current velocities greater than 30 cm/sec were needed to initiate sediment movement. The NOAA studies of 1985-1986 summarized by Curl, *et al.*, (1987) showed speeds above 6 cm/sec occurred less than eight percent of the time in the bottom waters south of Pier 91 and near bottom in the Duwamish West Waterway. Although Baker (1982, 1983) observed relatively high concentrations of SPM near bottom in Elliott Bay, he concluded this was primarily due to advection from the main basin - where currents are high - and not local resuspension.

Dexter, *et al.*, (1984) calculated sediments of size 5 phi (31 um, coarse silt) or finer could be resuspended approximately one day per year at the previously mentioned dredge disposal site in the south bay. PSSDA studies concluded dredged material at the inner Elliott Bay disposal site was not eroded by bottom currents (Army Corps of Engineers, 1988a,b).

For Pier 64/65 however, Hart Crowser (1990) concluded: "Considerable sediment resuspension appears to occur in the site vicinity. Based on a comparison of sediment trap and in-place sediment data, approximately two-thirds of the material deposited in the study area may be resuspended material. The original source of the resuspended material cannot be determined with the available data, but may include large areas of the central and southern Seattle waterfront."

The report concludes with a discussion of the need for remediation, potential for natural recovery following source controls, and scope of remediation needed. The greatest need for remediation was for PAH; mercury was said to have a natural source in the Green River: zinc, lead and PCBs had evidence of decline over time.

Conclusion: The results of Hart Crowser (1990) suggest resuspension may be important in the study area.

VIII. ONGOING MONITORING ACTIVITIES

Most Useful References: 48, 77, 79

Other References: 64, 65, 86

Synopsis of Information Found: There are several ongoing monitoring programs in Elliott Bay that will be collecting data over the next 10 years in Elliott Bay and at the mouth of the Duwamish River. Within and just north of the study area, there are two long-term monitoring efforts associated with sediment caps that have been placed over contaminated sediment near CSOs or sewer outfalls.

Within the study area, METRO and the City of Seattle placed a cap offshore of Piers 53-55 on state-owned sediments to the north and west of the former deepwater outfall at Madison St (METRO 1992). Pre- and post-cap monitoring were conducted before and after cap placement in 1992. Additional sediment quality information was collected in 1993 on the cap and at three stations just south of the cap. Similar monitoring is planned for 1996 and 2002, beyond the time period of the recontamination study. Although one of the primary purposes of the monitoring was to determine whether long-term recontamination of the cap would occur, a one-time release of creosote-contaminated sediments from the adjacent Ferry Terminal has recontaminated the cap above cleanup levels (Romberg 1993c) and may have obscured interpretation of the data with respect to long-term trends.

Post-cap monitoring is also occurring offshore of the Denny Way CSO, just north of Pier 71. Monitoring of sediment quality on the cap has occurred in 1990, 1991, and 1992, and is planned for 1994. Preliminary data indicate that some recontamination of the cap has occurred; however, it is not known whether the recontamination is due to area-wide deposition, resuspension of nearshore contaminated sediments not covered by the cap, or continued discharge of contaminants from the Denny Way CSO (Romberg 1993b).

Outside the study area, the Puget Sound Ambient Monitoring Program annually monitors sediment quality at two stations in Elliott Bay, one near Magnolia Bluff and one in the Central Basin (Striplin 1988). The NOAA Status and Trends Program also monitors sediment chemistry and english sole bioaccumulation at one station off the north end of Harbor Island, approximately every two years. These data are useful in identifying overall long-term trends for Elliott Bay, but are not expected to provide information directly applicable to sites along nearshore areas of the waterfront.

DNR has monitored the PSDDA disposal site in Central Elliott Bay in 1988, 1990, and 1992. Future monitoring is dependent on the volume of dredged material disposed of at the site, and will likely occur in either 1994 or 1995. Most stations are located within or at the perimeter of the disposal site; however, four background stations are located to the north, south, east, and west of the disposal site (PSDDA 1988). The eastern background station is located about 500 ft. west of the study area, at approximately Washington St., and the southern background station is located approximately 1,750 ft. north of the east end of Terminal 3, at the mouth of West Waterway. At the 1993 Annual Review Meeting, the Corps of Engineers reported that a general increase of contaminant concentrations has been observed in the background stations, unrelated to disposal of dredged sediments and indicating a baywide source. However, the concentrations at background stations are still well below Sediment Quality Standards (PSDDA 1993).

Future Monitoring (Unscheduled): Several one-time sampling events are likely to occur within the 1993-1995 timeframe at contaminated sediment sites along the waterfront and in Elliott Bay. Within the study area, there are three possibilities. Negotiations are ongoing for characterization of potentially contaminated sediments at the Unocal Seattle Marketing Terminal (Pier 71). In addition, the Elliott Bay/Duwamish Restoration Program is considering characterization of high-scoring waterfront sites concurrent with this study. Finally, DOT will be requested to characterize sediments surrounding the Colman Dock as a result of a recent release of contaminants in that area.

Other sites in Elliott Bay at which sediment characterization may occur in the next few years include Lockheed Shipyard, Todd Shipyard, ARCO, and Texaco on Harbor Island; various Port of Seattle facilities, including possible additional characterization at Terminal 3; and Wyckoff West Seattle. The Elliott Bay/Duwamish Restoration Program also plans to conduct site characterization at four high-ranking sites selected by the Panel in the Duwamish River (Diagonal, Duwamish Pump Station, West Michigan, and Norfolk outfalls).

In addition, several facilities are expected to conduct sediment sampling in the next few years as part of baseline monitoring for an NPDES permit. These facilities include Duwamish and Todd Shipyards (expected in late 1993) and various METRO and City outfalls, including West Point, Alki, and Renton STP, and large CSOs in Elliott Bay and Duwamish River. The final schedule for the outfall sampling has not been finalized, but is expected to take place sometime in 1995.

Conclusion: Although several monitoring programs are ongoing in Elliott Bay, none are located directly in the study area, with the exception of the Pier 53-55 monitoring. The next round of monitoring is not scheduled to occur until 1996. In addition, evaluation of data from monitoring programs along the waterfront has been complicated by the effects of localized sources. The most important supporting information will likely be collected by future sediment sampling during NPDES baseline monitoring and characterization of contaminated sites along the waterfront. Several of these studies are likely to be conducted in the time-frame of the recontamination study.

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ELLIOTT BAY WATERFRONT RECONTAMINATION STUDY

Sampling and Analysis Plan

Prepared by

Toxics Investigations Section
Environmental Investigations and Laboratory Services Program
Washington State Department of Ecology
Olympia, Washington

Water Body #WA-09-0010

November 2, 1993

INTRODUCTION

Problem Description

The Elliott Bay/Duwamish River Restoration Panel is currently evaluating potential cleanup sites in Elliott Bay and the Duwamish River that will require remedial actions. Remediation alternatives under consideration include: dredging and disposal, capping with clean sediments, and enhanced natural recovery.

Recent studies have suggested that recontamination of bottom sediments along the central Seattle Waterfront is a concern and could affect the long-term success of cleanup projects. Potential sources of recontamination include: ongoing discharges (combined sewer overflows, storm drains, etc.), resuspension and redistribution of contaminated bottom sediments, and longshore transport of contaminants from other areas of Elliott Bay and the Duwamish River. The potential for recontamination needs to be determined prior to conducting sediment remediation projects.

This document describes sampling and analysis activities to be undertaken for the Elliott Bay Waterfront Recontamination Study. Recommendations from attendees at the Field Investigation Planning Meeting held on August 12 have been incorporated into the sampling design where appropriate.

The study area, shown in Figure 1, is generally defined as the nearshore (<75') waterfront area extending from Terminal 46 on the south to Pier 59 on the north.

Survey Objectives

The overall goal of the Elliott Bay Waterfront Recontamination Study is to determine if it is feasible for the Elliott Bay/Duwamish Restoration Panel to undertake sediment remediation projects within the waterfront area by 1997. More specifically, the major objectives of the field investigation portion of the study are as follows:

- Characterize chemical concentrations (metals and organics) associated with settling particulate matter (SPM) at various points along the central Seattle Waterfront;
- Determine sediment accumulation rates in the study area, including an estimation of net sedimentation (deep burial) and resuspension (gross sedimentation - net sedimentation);
- Estimate current velocity (speed and direction) in various portions of the nearshore waterfront area; and
- Identify sediment transport pathways and areas of deposition and erosion.

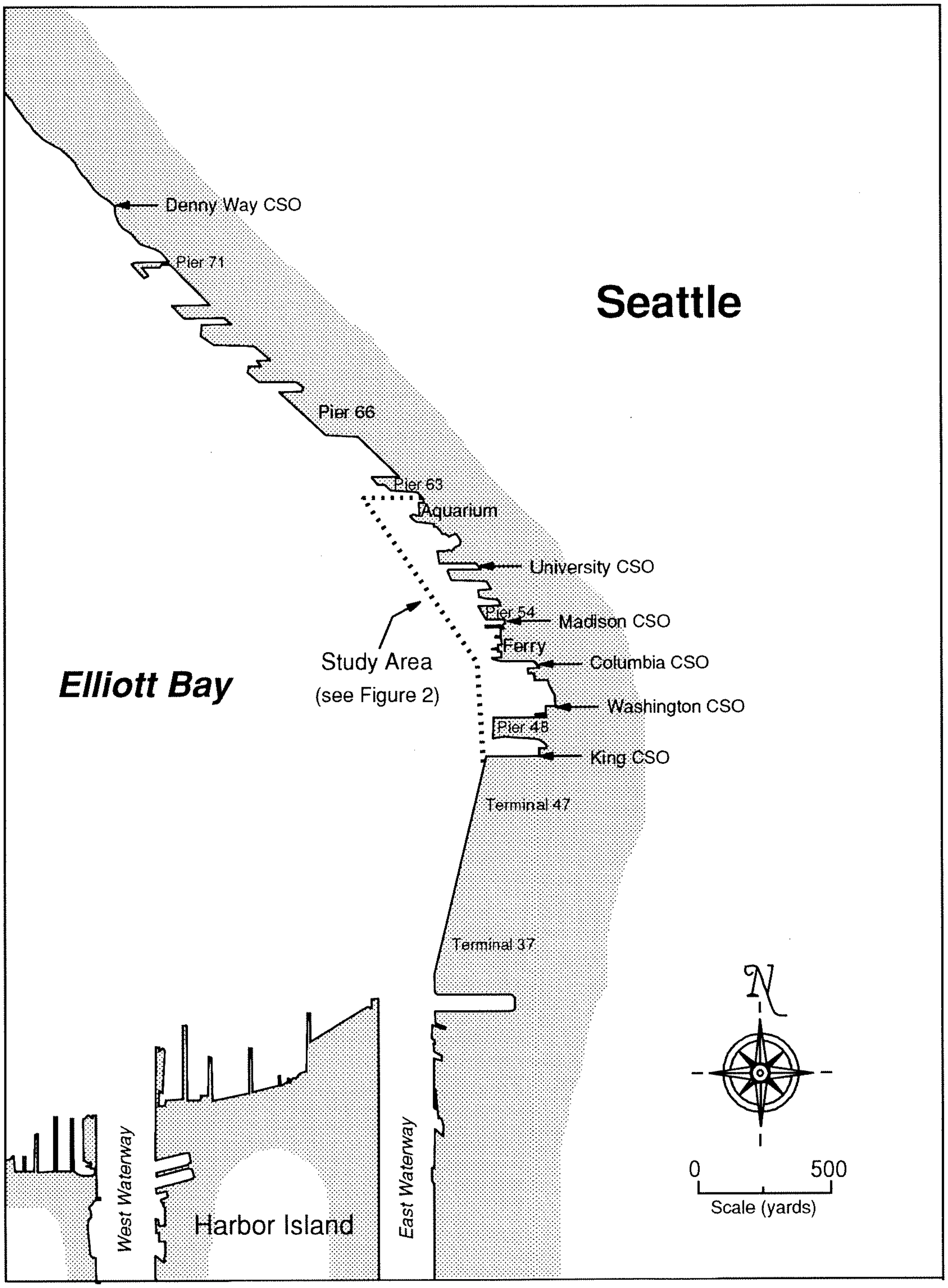

Figure 1: Location of Study Area for the Elliott Bay Waterfront Recontamination Study.

The results from the field investigation portion of the study will be used in conjunction with modeling efforts to answer the overall objective of the Waterfront Recontamination Study.

METHODS

Site Selection

Proposed sampling locations, shown in Figure 2, were selected to characterize spatial variability between different regimes in the study area (*i.e.*, near CSO, under piers, within slips, and expose pier faces). Detailed descriptions of each station and the purpose for its location are provided in Table 1.

Station positions will be recorded with the use of a Magellan Nav 5000D® GPS receiver, in conjunction with depth readings. Distances from fixed onshore structures will also be recorded.

Sampling Procedures

To characterize present conditions in the nearshore area of the Central Seattle Waterfront settling particulate matter (SPM), bottom sediments, sediment cores, current velocity measurements and vertical profiles of light transmittance will be collected between October 1993 and October 1994. Table 2 presents a summary of the proposed sampling for the Elliott Bay Waterfront Recontamination Study. Each component of the field investigation is briefly described below. In addition, field work will be conducted in accordance with procedures outlined in the *Elliott Bay Waterfront Recontamination Study Health and Safety Plan.*

Grain Size Mapping

To define depositional and erosional environments within the Waterfront Recontamination Study area, surface sediments (top 2cm) were collected along fifteen transects (north to south) and analyzed for "apparent" particle size (PSEP, 1986). Where feasible spacing between stations, at a minimum, was 40 yards moving offshore to a maximum depth of 60 feet and 100 yards between transects moving north to south. However, due to physical limitations encountered in the field this grid had to be modified. Approximate locations of the grain size transects sampled are shown in Figure 3.

To evaluate comparability of grain size data generated using the Puget Sound Estuary Protocols (PSEP) method (apparent grain size) and data generated for the Puget Sound Dredge Disposal Analysis (PSDDA) blind field duplicates (a single sample homogenized and split into two aliquots) were prepared at approximately 10% of the stations sampled. Grain size results generated for PSDDA differ from PSEP in that they are reported as "true"

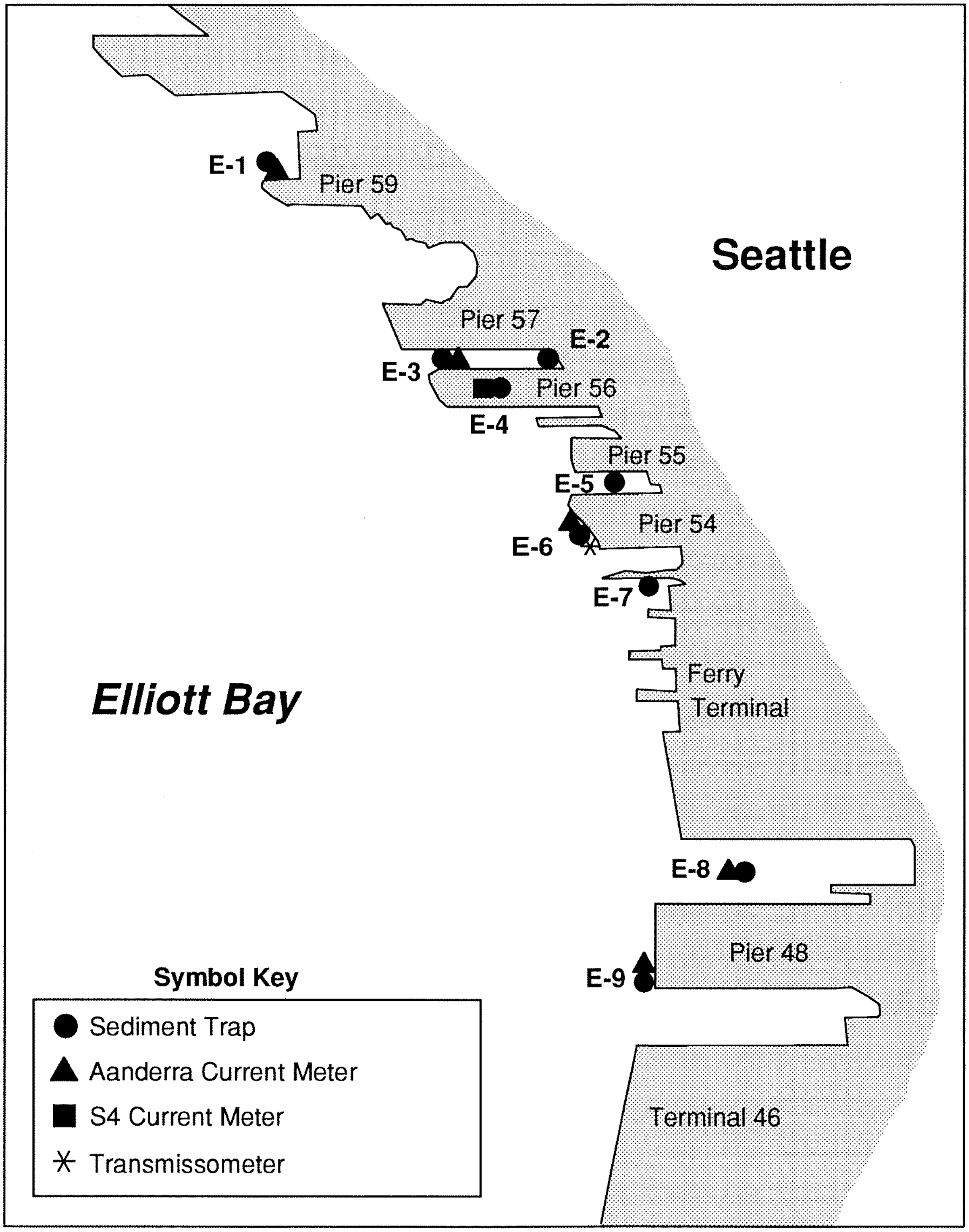

Figure 2: Station Locations for the Elliott Bay Waterfront Recontamination Study.

Table 1: Station locations for the Elliott Bay Waterfront Recontamination Study.

Station	Location	Est. Depth (ft @ MLLW)	Sample Type	Purpose
E-1	Northwest Corner of Pier 59	60	ST*,ACM	Northern boundary of study area- exposed conditions
E-2	Between Pier 56 and 57 at head near Univ. CSO	30	ST	Near CSO discharge (head of slip- gradient)
E-3	Between Pier 56 and 57 at mouth of slip (center)	50	ST,ACM	Between piers (mouth of slip- gradient)
E-4	Under Pier 56	25	ST,S4	Under pier conditions
E-5	Between Piers 54 and 55 (center of slip)	25	ST	Between piers (short slip)
E-6	West end of Pier 54	50	ST*,ACM*,T	Center of study area- exposed conditions
E-7	Adjacent to Fire Boat Pier (Station #5)	25	ST	Ferry Terminal effects
E-8	North of Pier 48 (center of slip)	40	ST,ACM	Between piers (long-wide slip)
E-9	Southwest corner of Pier 48	60	ST,ACM	Southern boundary of study area- exposed conditions

ST= Sediment Trap

ACM= Aanderra Current Meter

S4= Current Meter

T= Vertical array of Transmissometers (Surface, mid-depth, and bottom)

*= Deployed at surface and bottom of Water Column

Table 2: Summary of sampling for the Elliott Bay Waterfront Recontamination Study.

Analysis	Sampler	Sampling Frequency	Duration of Deployment
I. WATER			
Current Velocity	Aanderra RCM-4	Quarterly	One Year
" " "	S4	"	Six Months
Light Transmittance	Transmissometers	Monthly	One Year
II. SETTLING PARTICULATE MATTER			
Percent Solids	Sediment Traps	Quarterly	One Year
Grain Size	"	"	"
Total Organic Carbon	"	"	"
Total Metals			
Aluminum	"	"	"
Arsenic	"	"	"
Cadmium	"	"	"
Chromium	"	"	"
Copper	"	"	"
Iron	"	"	"
Lead	"	"	"
Manganese	"	"	"
Mercury	"	"	"
Silver	"	"	"
Zinc	"	"	"
Organics			
Semivolatiles	"	"	"
PCBs	"	"	"
Pb-210	"	"	"
III. BOTTOM SEDIMENT CORES			
Percent Solids	Kasten or alternate	Once	N/A
Grain Size	"	"	"
Total Organic Carbon	"	"	"
Metals			
Aluminum	"	"	"
Copper	"	"	"
Iron	"	"	"
Lead	"	"	"
Manganese	"	"	"
Mercury	"	"	"
Zinc	"	"	"
Organics			
PCBs	"	"	"
Pb-210	"	"	"
Cs-137	"	"	"
IV. BOTTOM SEDIMENT			
Grain Size Mapping	Van Veen/Ponar	Once	N/A

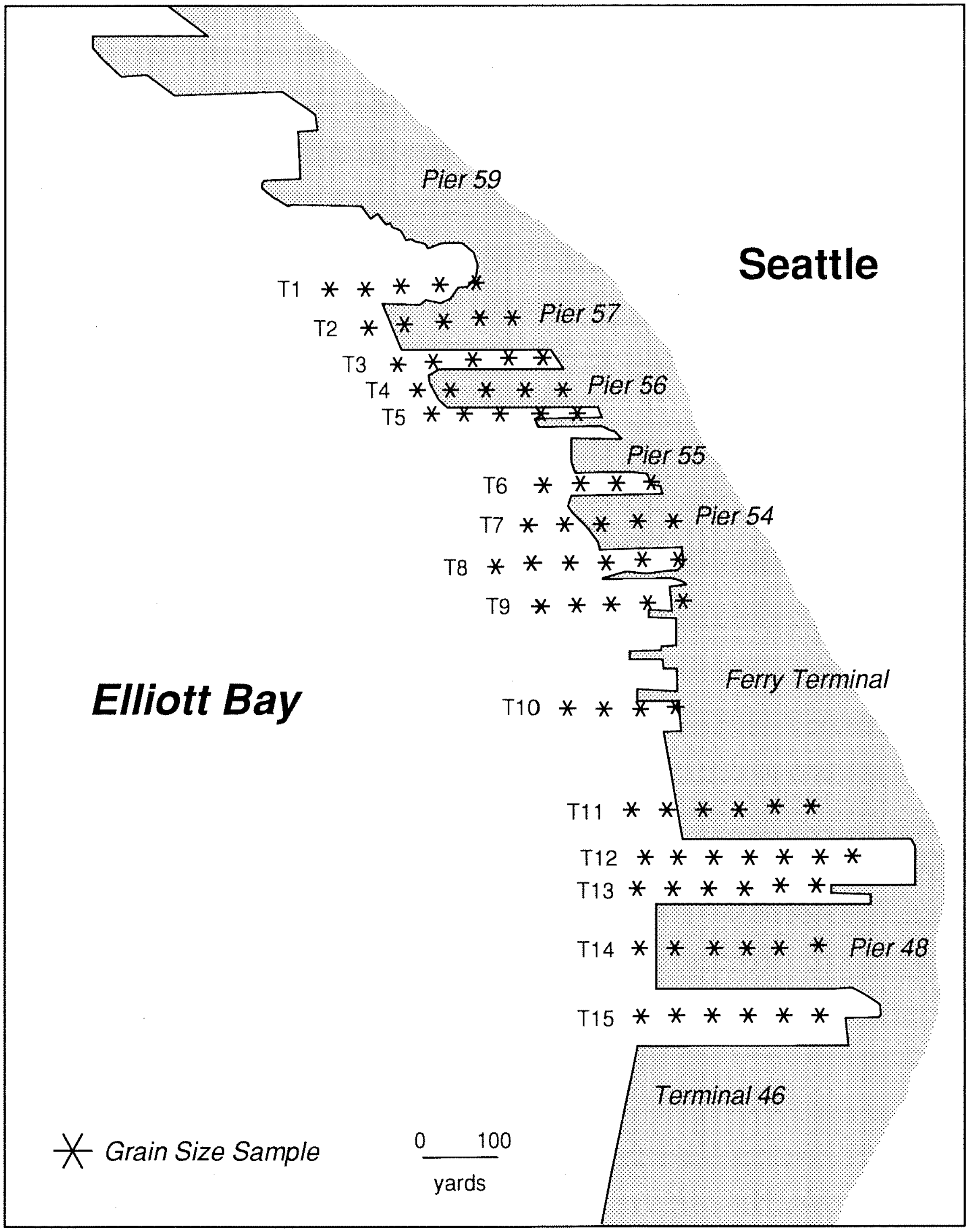

Figure 3: Locations of Transects for Grain Size Mapping, Elliott Bay Waterfront Recontamination Study.

particle size (hydrogen peroxide addition). In addition, to assess environmental variability field replicates (a separate sample from a similar location) were also prepared at approximately 10% of the locations.

The grain size data obtained will be used to contour percent clay levels in bottom sediments. These grain size plots will ultimately be used to aid in selecting locations for bottom sediment cores and be used to define erosional and depositional environments in the study area.

Water

Current velocity measurements will be made at 6 locations. Aanderra® Model RCM-4 current meters will be used at 5 of the 6 stations (E-1, E-3, E-6, E-8, and E-9) to measure near bottom current velocities. The meters will be deployed 3 feet off the bottom for a period of one year. In addition, at station E-6 one meter will also be deployed in the upper 5 feet of the water column to measure surface velocities. To evaluate short term velocity increases, that might be expected from vessel traffic, each meter would be set to a recording interval of 15 minutes.

At the remaining station (E-4) a S-4 current meter will be deployed under Pier 56 for 6 months, beginning in quarter 2 and ending in quarter 3 (January-July, 1994).

To aid in evaluating the height of sediment resuspension, at station E-6, three beam transmissometers will be placed in a vertical array. Transmissometers will be deployed at heights of 2 feet, 10 feet, and 20 feet above the bottom.

SPM

SPM will be collected at nine locations with the use of moored sediment traps positioned 3 feet above the bottom (see Figure 2). In addition, to evaluate surface (low salinity) and bottom (high salinity) conditions, at two locations (E-1 and E6) sediment traps will also be deployed in the upper 5 feet of the water column.

A diagram of the construction details of the traps is shown in Figure 4. These traps have been used by Ecology in the Waterways of Commencement Bay over the past four years to monitor contaminant concentrations associated with SPM and estimate bottom sediment resuspension rates (Norton and Barnard, 1992a,b; Norton, 1993).

Briefly, the traps are straight-sided glass cylinders with a collection area of 78.5cm^2 and a height to width ratio of 5. Each mooring holds two cylinders for a total collection area of 157cm^2 per mooring. To collect enough material for quarterly analysis of all parameters and reduce the possibility of missing data points, two independent moorings would be installed at each station.

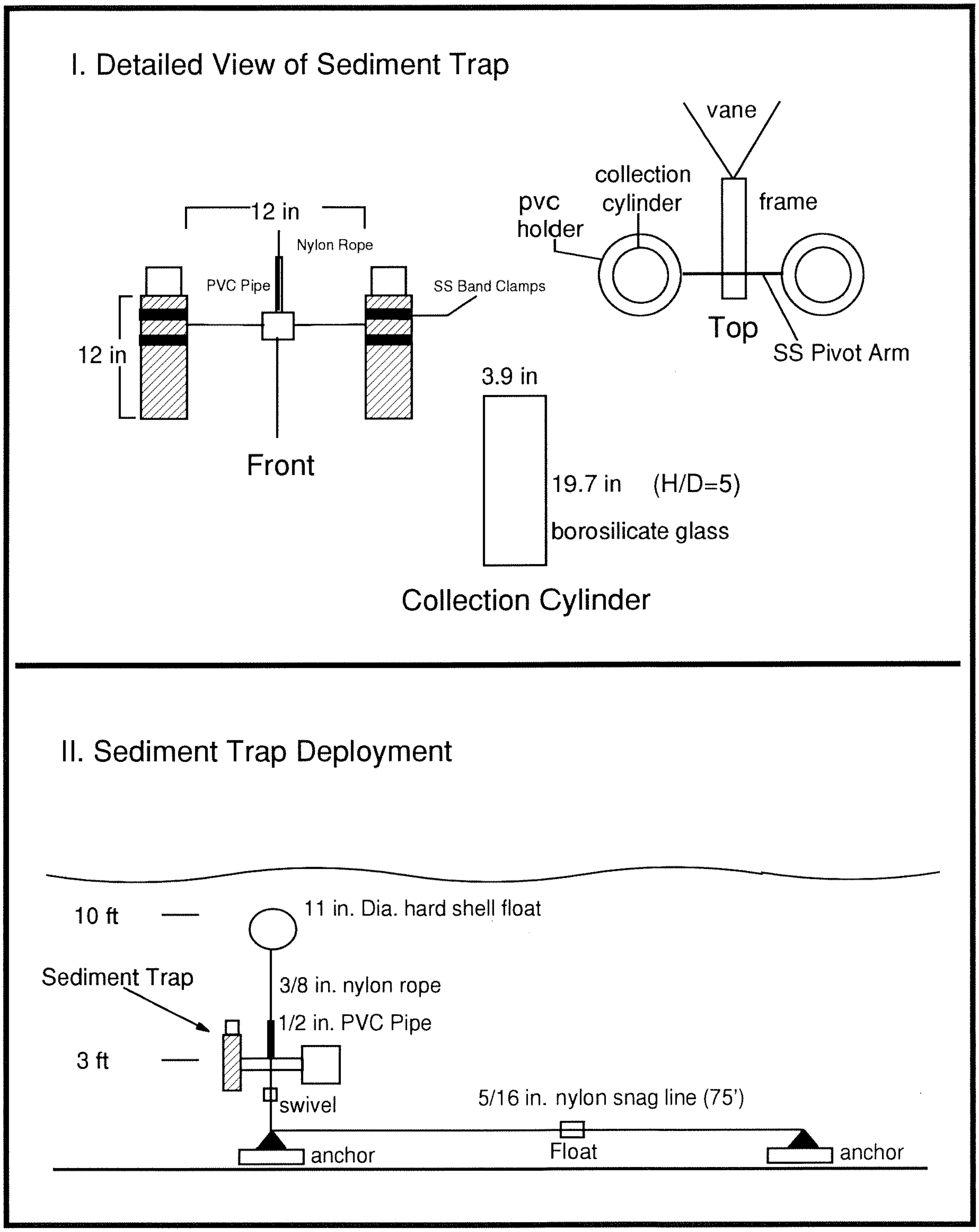

Figure 4: Diagram of Sediment Traps and bottom mooring to be used for the Elliott Bay Waterfront Recontamination Study.

Prior to deployment, the collection cylinders will be cleaned with sequential washes of hot tap water/Liquinox® detergent, 10% nitric acid, distilled deionized water, and pesticide grade acetone, then wrapped in aluminum foil until used in the field. At deployment the traps will be filled with two liters of high salinity distilled water (4% NaCl), which contains sodium azide (2%) as a preservative to reduce microbial degradation of the samples.

Upon retrieval of the traps, overlying water in the collection cylinders will be removed with a peristaltic pump. The salinity of water overlying the collected SPM will be tested to determine if the traps had been disturbed. SPM will then be transferred to 1/2 gallon sample containers and taken to the laboratory for processing, where the particulate fraction will be isolated with the use of a centrifuge. Based on preliminary calculations it is anticipated that approximately 100g of dry particulates will be available for analysis each quarter.

Sediment Cores

To supplement existing data, four sediment cores would be collected for Pb-210 and Cs-137 dating and selected chemical analysis. The location of the sediment cores will be determined after reviewing the results of grain size mapping and dredging records for the area. Each core, should at a minimum, be 100cm in length and sectioned into at least ten intervals for dating. Chemical analysis will be limited to five intervals and focus on selected metals and polychlorinated biphenyls (PCBs), (see Table 2). Analysis of metals and PCBs in the sediment cores could have several advantages including: providing data on bottom sediment concentrations of these contaminants and furnishing additional time markers to verify the Pb-210 dating results. In addition, aluminum, manganese, and iron concentrations can be used as indicators to evaluate the natural inorganic content among sediment samples.

Final selection of sampling intervals for both dating and chemical analyses would be determined after examining the core horizons. The coring device selected should be capable of collecting an adequate volume of material for all analysis, and to the extent possible, minimize shortening of the core.

Sediment coring will be completed no later then the third quarter of sampling to allow adequate time for analysis and data reporting.

Sample Handling

All sediment samples will be placed in appropriate containers, properly labeled and held on ice in insulated coolers. Ice will be held in watertight bags to prevent potential contamination of the samples. Samples will be removed at least every second day and transported directly to the analytical laboratory. Prior to transport, individual jars will be wrapped to prevent breakage.

Sample tracking procedures will follow those outlined in the Manchester Laboratory Users Manual (Ecology, 1991). Briefly, Chain-of-Custody forms will be completed at the end of each day's sampling. The chief scientist will ensure that these forms are properly completed and signed at the time of sample transfer. One copy of the form will be placed into a waterproof bag and attached to the inside of each sample cooler. The chief scientist will keep the second copy. The coolers will be sealed and kept in a secured location when not in the possession of the chief scientist or assigned crew.

At the time the samples are received in the laboratory, the laboratory sample custodian will inspect the shipment to ensure that sample integrity has been maintained. Broken or inappropriate sample containers and inconsistencies in chain-of-custody forms will be documented. The project manager will be notified of such problems immediately.

Sample Analysis and Quality Assurance

All physical/chemical analyses of samples for the Elliott Bay Recontamination Study will be conducted using procedures specified in the Puget Sound Protocols (PSEP, 1986) as amended and updated, except for Total Organic Carbon, which will be analyzed according to the 1993 PSSDA modifications to the PSEP method. In addition, the type and frequency of laboratory quality assurance (QA) samples will at a minimum follow those specified in the Manchester QA Manual (Ecology, 1988). Table 3 presents a summary of proposed analytical methods, minimum detection limits, and data quality objectives for the Waterfront Recontamination Study.

All laboratories conducting analyses for this study will supply information needed to support a QA1 review of the data as specified in *PSDDA Guidance Manual- Data Quality Evaluation for Proposed Dredged Material Disposal Projects* (PTI, 1989). All data generated will undergo a quality assurance review to evaluate the precision and accuracy of the data set.

In addition, to standard laboratory QA samples, to assess analytical accuracy certified reference materials will be analyzed in duplicate at a frequency of one per sample batch for metals, polynuclear aromatic hydrocarbons (PAH), and polychlorinated biphenyls (PCBs). To evaluate overall precision one set of blind field duplicates (a single sample homogenized and split into multiple aliquots) will be prepared at a frequency of approximately 10%. Environmental variability will be evaluated by analysis of field replicates (a separate sample from a similar location) also at a frequency of 10%. Table 4 summarizes QA samples and their frequency of analysis for this project.

Table 3: Summary of proposed analytical methods, minimum detection limits, and data quality objectives for the Elliott Bay Waterfront Recontamination Study.

I. Analytical Methods

Analysis	Method	Reference
Total Solids	Dry @ 104°C	PSEP, 1986
Grain Size	Seive and Pipet Apparent (w/o H2O2 addition) True (w/ H2O2 addition)	"
Total Organic Carbon	Combustion/CO2 Measurement as modified by PSSDA	PSDDA, 1993
Total Metals		
Aluminum	ICP	EPA, 1986
Arsenic	GFAA	"
Cadmium	GFAA	"
Chromium	ICP	"
Copper	ICP	"
Iron	ICP	"
Lead	GFAA	"
Manganese	ICP	"
Mercury	CVAA	"
Silver	ICP	"
Zinc	ICP	"
Organics		
Semivolatiles	GC/MS #8270	EPA, 1986
PCBs	GC/ECD #8080	"
Pb-210	Polonium-210 activity	Koide et.al., 1973
Cs-137	Gamma Spectroscopy	-

II. Data Quality Objectives

Analysis	Detection Limits (mg/kg)	Precision (RPD)	Accuracy (%)	Completeness (%)
Total Solids	0.1%	20	10	90
Grain Size	N/A	20	10	90
Total Organic Carbon	0.1%	20	10	90
Metals				
Aluminum	0.1	20	10	90
Arsenic	0.1	20	10	90
Cadmium	0.1	20	10	90
Chromium	0.1	20	10	90
Copper	0.1	20	10	90
Iron	0.1	20	10	90
Lead	0.1	20	10	90
Manganese	0.1	20	10	90
Mercury	0.05	20	10	90
Silver	0.1	20	10	90
Zinc	0.1	20	10	90
Organics				
Semivolatiles	0.2	50	20	90
PCBs	0.2	50	20	90
Pb-210	0.1 dpm/g	15	10	90
Cs-137	0.1 dpm/g	15	10	90

RPD= Relative Percent Difference from Duplicate Analysis (Range as percent of mean)

Table 4: Summary of quality assurance samples and frequency of analysis for the Elliott Bay Waterfront Recontamination Study.

Analyte	Internal Standards	Surrogate Spikes	Method Blank	Matrix Spike*	Reference Materials*	Field Duplicate*	Field Replicate
Percent Solids	-	-	-	-	-	2 Batch	1 Batch
Grain Size	-	-	-	-	-	2 Batch	1 Batch
Total Organic Carbon	-	-	1 Batch	2 Batch	-	2 Batch	1 Batch
Metals							
Aluminum	-	-	1 Batch	-	2 Batch	2 Batch	1 Batch
Arsenic	-	-	1 Batch	-	2 Batch	2 Batch	1 Batch
Cadmium	-	-	1 Batch	-	2 Batch	2 Batch	1 Batch
Chromium	-	-	1 Batch	-	2 Batch	2 Batch	1 Batch
Copper	-	-	1 Batch	-	2 Batch	2 Batch	1 Batch
Iron	-	-	1 Batch	-	2 Batch	2 Batch	1 Batch
Lead	-	-	1 Batch	-	2 Batch	2 Batch	1 Batch
Manganese	-	-	1 Batch	-	2 Batch	2 Batch	1 Batch
Mercury	-	-	1 Batch	-	2 Batch	2 Batch	1 Batch
Silver	-	-	1 Batch	-	2 Batch	2 Batch	1 Batch
Zinc	-	-	1 Batch	-	2 Batch	2 Batch	1 Batch
Organics							
Semivolatiles	1 sample	1 sample	1 Batch	2 Batch	(2 Batch)	2 Batch	1 Batch
PCBs	1 sample	1 sample	1 Batch	2 Batch	2 Batch	2 Batch	1 Batch
Pb-210	-	-	-	-	-	2 Batch	2 Batch
Cs-137	-	-	-	-	-	2 Batch	2 Batch

*= Samples are duplicates

( )= PAH only

Certified Reference Materials

Metals- NIST #1646 (Estuarine Sediment)
PAH- NRCC #HS-6 (Harbour Marine)
PCBs- NRCC #HS-2 (Harbour Marine)

Sediment Transport Study

A large-scale sediment transport study of the Elliott Bay/Duwamish area will also be conducted to determine sediment transport pathways and potential linkages between contaminated sites in the region, and areas of erosion, equilibrium, and sediment deposition. The Sediment Transport Study will be conducted by GeoSea Consulting and funded in cooperation with EPA, DNR, NOAA, and the Port of Seattle.

The Sediment Transport Study would cover an area extending from approximately Slip 3 on the Duwamish River to a line in outer Elliott Bay extending from Alki Point to West Point. To provide adequate resolution, taking into consideration the variety of anthropogenic disturbances of sediments in Elliott Bay, and particularly along the Seattle Waterfront, three sample densities will be used.

Samples will be spaced at 10-second (310m) intervals on a grid in outer Elliott Bay. Outer Elliott Bay is defined as the area between a line running north from Alki Point to West Point then east to a line extending from Duwamish Head north to Smith Cove. In inner Elliott Bay (Duwamish Head to Smith Cove and east to the western edge of the Waterfront Recontamination Study area), an 8-second (250m) grid would be used. A smaller sample spacing (approximately 150m) will be used in the Duwamish Waterway and additional samples would be placed along the shoreline at the ends of piers, and nearshore between piers along the waterfront.

A total of approximately 500 samples will be collected in October 1993 using a van Veen or Ponar grab sampler, including 122 samples in outer Elliott Bay, 206 samples in inner Elliott Bay, 89 samples along the shoreline, and 81 samples in the Duwamish Waterways. Grain size analysis will be conducted by GeoSea Consulting using a Malvern 2600L laser particle sizer, supplemented by dry sieving where necessary. The data generated will be interpreted to identify sediment transport pathways and depositional trends using a statistical model developed by Patrick McLaren and described in detail in GeoSea Consulting (1993).

To provide a measure of field variability and model robustness, field replicates will be collected at selected stations in areas of high heterogeneity. The replicate grain size curves will be analyzed for percent difference. Two different data sets will be generated using replicate curves that are significantly different and modeling performed on each set, to determine the level of heterogeneity that results in a difference in model interpretation. An initial presentation of results will take place in early February, and will include expert review to guide final interpretation and write-up of the results.

Meteorological Data

Meteorological data and oceanographic data over the course of the study will be obtained from the existing tidal station operated by NOAA at the DOT Ferry Terminal. The tidal station records wind speed and direction, air and water temperature and tide height. The variability, or "noise," associated with the tide height data can be correlated to sea state and wave height. These data are transmitted by satellite to NOAA computers and can be downloaded periodically to a spreadsheet.

Other Variables

As required by the model selected, other variables may be measured later in the study, including dispersion, total suspended solids, and particle fall velocity. These data will be collected as part of Task 3 once a modeling contractor and a model have been selected.

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ELLIOTT BAY WATERFRONT RECONTAMINATION STUDY

Modifications to the Sampling and Analysis Plan

May 1995

Several modifications to the *"Elliott Bay Waterfront Recontamination Study: Sampling and Analysis Plan"* dated November 2 1993 were made during the course of the field investigation. These changes are documented below;

Sampling Procedures

Grain Size Mapping- Spacing between sampling stations was originally planned to be 40 yards apart moving offshore to a depth of 60' and 100 yards between transects moving north to south. However, due to physical constraints encountered in the field (piers and pilings) this grid had to be modified. Actual spacing between stations was approximately 40 yards moving offshore and 50 yards between transects moving north to south. Final locations of the grain size stations are shown in the main body of Volume I, in Figure 4.

Current Velocity Measurements- Current velocity measurements were originally planned for six locations using Aanderra RCM4 meters. After reviewing current velocity information collected during the first quarter of monitoring it was apparent that a significant portion of the current speeds in the study area were below the RCM4's recording threshold of 2.5 cm/sec. To better characterize current velocities <2.5 cm/sec, starting on January 28 and ending October 14 two Interocean® S4 current meters were rotated monthly between a total of 11 locations (EB-1A, EB-2, EB-4, EB-6S, EB-6B, EB-8, EB-9, EB-10, EB-11, EB-12, EB-13, EB-14). For comparability with the RCM4 data, the S4 meters were set to record one minute averages every 15 minutes.

In addition, the meter at station EB-1 was moved offshore to station EB-1A during the third and fourth quarter of monitoring to better reflect conditions outside the pier line. In addition, at station EB-6 one meter was placed in the upper 7 feet of the water column to measure surface current velocities. This surface meter was placed at a lower depth (7' vs 3') to avoid swing conflicts with the sediment traps deployed from the same mooring.

Finally a ancillary data was collected at the end of the field investigation to estimate the effects of vessel prop wash on bottom currents. This was accomplished by deploying S4 current meters for two days between October 25-27 at two locations (EB-8 and EB-16). These meters were set to record 30 second averages of current velocity continuously.

The final locations of all current meter deployments are shown in Volume I, Figure 2.

Transmissometers- An attempt was made to evaluate the height of sediment resuspension at station EB-6 with the use of three 25 cm beam transmissometers in a vertical array at three depths. Transmissometers were placed at heights of 2 feet, 10 feet, and 20 feet above the bottom. Originally these instruments were to be serviced at a monthly frequency. Due to fouling of the optics this frequency was changed to bi-weekly. This change significantly increase the amount of staff field time. As a result transmissometer monitoring was terminated approximately 4 months early (June 1994).

Settling Particulate Matter- No changes to the planned deployments or sampling frequency of the sediment trap network was undertaken during the course of monitoring.

Sediment Coring- Final selection of a coring equipment was deferred to a later date in the original sampling and analysis plan. A 4" gravity barrel corer was ultimately used to collect deep cores.

Sample Analysis

Settling Particulate Matter- Due to insufficient volume of matter collected by the sediment traps the following physical and chemical analyses were dropped during the quarters indicated:

Quarter 1- TOC (EB-6S); Grain size (all stations except EB-5); ^{210}Pb (EB-1S, EB-1B, EB-2, and EB-6S); Semivolatiles (EB-1B, EB-2, and EB-6S); PCBs (EB-1B, EB-2, and EB-6S).

Quarter 2- Grain Size (EB-6-S); PCBs (EB-6S and EB-7); ^{210}Pb (EB-6S)

Quarter 3- No changes

Quarter 4- ^{210}Pb (all stations due to cost considerations)

A detailed discussion of the sampling and analysis conducted for the project is also present in the main body of the report under the methods section.

Appendix B - Field Information

Station Location Information (Table B1)

Deployment Schedule for Sediment Traps (Table B2)

Sample Tracking Sheets

Core Logs

Sediment Trap Design and Mooring Configuration (Figure B1)

Table B1: Station descriptions for the Elliott Bay Waterfront Recontamination Study.

Station	Location	Latitude			Longitude			Depth	Sample
		Deg	Min	Sec	Deg	Min	Sec	(ft @ MLLW)	Type
Core Stations									
EB-1	Northwest of pier 59	47	36	29	122	20	38	41	ST*,ACM
EB-2	Between pier 56 and 57 at head near Univ. CSO	47	36	21	122	20	27	25	ST,S4
EB-3	Between Pier 56 and 57 at mouth of slip (center)	47	36	21	122	20	32	50	ST,ACM
EB-4	Under pier 56	47	36	20	122	20	28	25	ST,S4
EB-5	Between piers 54 and 55 (center of slip)	47	36	17	122	20	23	29	ST
EB-6	West end of pier 54	47	36	15	122	20	25	23	T*,ACM*,S4,
EB-7	Adjacent to former wing wall at Colman Ferry Termin	47	36	13	122	20	22	27	ST
EB-8	North of pier 48 (center of slip)	47	36	03	122	20	19	38	ST,ACM,S4
EB-9	South west end of pier 48	47	35	59	122	20	24	58	ST,ACM,S4
Current Velocity Only									
EB-1A	West end of pier 59	47	36	28	122	20	40	57	ACM,S4
EB-10	West of pier 58 (waterfront park)	47	36	26	122	20	37	72	S4
EB-11	Under pier 57	47	36	22	122	20	33	45	S4
EB-12	Northeast end of pier 52 (Coleman Ferry Terminal)	47	36	11	122	20	22	35	S4
EB-13	Under southwest end of pier 52	47	36	05	122	20	21	26	S4
EB-14	Northwest end of pier 48	47	36	02	122	20	25	58	S4
EB-16	West end of pier 56	47	36	19	122	20	33	70	S4

ST= Sediment Trap

ACM= Aanderra RCM4 Current Meter

S4= Interocean S4 Current Meter

T=Transmissometer- vertical array

*= Surface and bottom deployments

Table B1 (cont.): Station descriptions for the Elliott Bay Waterfront Recontamination Study.

Station	Location	Purpose
<u>Core Stations</u>		
EB-1	Northwest of pier 59 (surface and bottom)	Northern boundary of study area- Inside pier face
EB-2	Between pier 56 and 57 at head near Univ. CSO	Near CSO discharge (head of slip- gradient)
EB-3	Between Pier 56 and 57 at mouth of slip (center)	Between piers (mouth of slip- gradient)
EB-4	Under pier 56	Under pier conditions-narrow piling spacing
EB-5	Between piers 54 and 55 (center of slip)	Between piers (short-narrow slip)
EB-6	West end of pier 54 (surface and bottom)	Center of study area-exposed conditions
EB-7	Adjacent to former wing wall at Colman Ferry Terminal	Ferry Terminal effects
EB-8	North of pier 48 (center of slip)	Between piers (long-wide slip)
EB-9	South west end of pier 48	Southern boundary of study area-exposed conditions
<u>Current Velocity Only</u>		
EB-1A	West end of pier 59	Northern boundary of study area- exposed conditions
EB-10	West of pier 58 (waterfront park)	Northern area outside pier face-exposed conditions
EB-11	Under pier 57	Under pier conditions-wide piling spacing
EB-12	Northeast end of pier 52 (Coleman Ferry Terminal)	Ferry Terminal effects
EB-13	Under southwest end of pier 52	Ferry Terminal effects
EB-14	Northwest end of pier 48	Southern area off pier face-exposed conditions
EB-16	West end of pier 56	Propwash effects- high frequency monitoring

Table B2: Deployment and retreival dates for Elliott Bay Sediment Traps (October 93 - October 94)

Quarter		1			2			3			4	
Station	Deployed	Retrieved	Days	Deployed	Retrieved	Days	Deployed	Retrieved	Days	Deployed	Retrieved	Days
EB1S-1A	10/20/93	1/10/94	82	1/10/94	4/11/94	91	04/11/94	07/12/94	92	7/12/94	10/10/94	90
-S1B*	10/20/93	1/10/94	82	1/10/94	4/11/94	91	04/11/94	07/12/94	92	7/12/94	10/10/94	90
-S2A*	10/20/93	1/10/94	82	1/10/94	4/11/94	91	04/11/94	07/12/94	92	7/12/94	10/10/94	90
-S2B*	10/20/93	1/10/94	82	1/10/94	4/11/94	91	04/11/94	07/12/94	92	7/12/94	10/10/94	90
EB1B-1	10/20/93	1/10/94	82	1/10/94	4/13/94	93	04/14/94	07/12/94	89	7/12/94	10/10/94	90
-B1B+	10/20/93	1/10/94	82	1/10/94	4/13/94	93	04/14/94	07/12/94	89	7/12/94	10/10/94	90
-B2A+	10/20/93	1/10/94	82	1/10/94	4/14/94	94	04/14/94	07/12/94	89	7/12/94	NR	-
-B2B+	10/20/93	1/10/94	82	1/10/94	4/14/94	94	04/14/94	07/12/94	89	7/12/94	NR	-
EB2-1A	10/13/93	NR	-	1/13/94	4/12/94	89	04/12/94	07/14/94	93	7/14/94	10/13/94	91
-1B	10/13/93	NR	-	1/13/94	4/12/94	89	04/12/94	07/14/94	93	7/14/94	10/13/94	91
-2A	10/13/93	1/13/94	92	1/13/94	4/12/94	89	04/12/94	07/14/94	93	7/14/94	10/13/94	91
-2B	10/13/93	NS	-	1/13/94	4/12/94	89	04/12/94	07/14/94	93	7/14/94	10/13/94	91
EB3-1A	10/13/93	1/12/94	91	1/12/94	NS	-	04/13/94	07/14/94	92	7/14/94	10/10/94	88
-1B	10/13/93	1/12/94	91	1/12/94	4/13/94	91	04/13/94	07/14/94	92	7/14/94	10/10/94	88
-2A	10/13/93	1/12/94	91	1/12/94	4/13/94	91	04/13/94	07/14/94	92	7/14/94	10/10/94	88
-2B	10/13/93	1/12/94	91	1/12/94	4/13/94	91	04/13/94	07/14/94	92	7/14/94	10/10/94	88
EB4-1A	10/13/93	1/13/94	92	1/13/94	4/15/94	92	04/15/94	07/13/94	89	7/13/94	10/13/94	92
-1B	10/13/93	1/13/94	92	1/13/94	NS	-	04/15/94	07/13/94	89	7/13/94	10/13/94	92
-2A	10/13/93	1/13/94	92	1/13/94	4/15/94	92	04/15/94	07/13/94	89	7/13/94	10/13/94	92
-2B	10/13/93	1/13/94	92	1/13/94	4/15/94	92	04/15/94	07/13/94	89	7/13/94	10/13/94	92
EB5-1A	10/12/93	1/11/94	91	3/02/94	4/12/94	41	04/12/94	07/11/94	90	7/11/94	10/12/94	93
-1B	10/12/93	1/11/94	91	3/02/94	4/12/94	41	04/12/94	07/11/94	90	7/11/94	10/12/94	93
-2A	10/12/93	1/11/94	91	1/11/94	4/12/94	91	04/12/94	07/11/94	90	7/11/94	10/12/94	93
-2B	10/12/93	1/11/94	91	1/11/94	4/12/94	91	04/12/94	07/11/94	90	7/11/94	10/12/94	93
EB6S-1A	10/20/93	1/11/94	83	1/11/94	NS	-	04/11/94	07/14/94	94	7/14/94	10/12/94	90
-S1B*	10/20/93	NS	-	1/11/94	4/11/94	90	04/11/94	07/14/94	94	7/14/94	10/12/94	90
-S2A*	10/20/93	NS	-	1/11/94	NS	-	04/11/94	07/14/94	94	7/14/94	10/12/94	90
-S2B*	10/20/93	NS	-	1/11/94	4/11/94	90	04/11/94	07/14/94	94	7/14/94	10/12/94	90
EB6B-1	10/20/93	1/12/94	84	1/12/94	4/13/94	91	04/13/94	07/11/94	89	7/11/94	10/11/94	92
-B1B+	10/20/93	1/12/94	84	1/12/94	4/13/94	91	04/13/94	07/11/94	89	7/11/94	10/11/94	92
-B2A+	10/20/93	1/12/94	84	1/12/94	4/13/94	91	04/13/94	07/11/94	89	7/11/94	10/11/94	92
-B2B+	10/20/93	1/12/94	84	1/12/94	4/13/94	91	04/13/94	07/11/94	89	7/11/94	10/11/94	92
EB7-1A	10/20/93	1/12/94	84	1/12/94	4/12/94	90	04/12/94	07/12/94	91	7/12/94	10/11/94	91
-1B	10/20/93	1/12/94	84	1/12/94	4/12/94	90	04/12/94	07/12/94	91	7/12/94	10/11/94	91
-2A	10/20/93	1/12/94	84	1/12/94	NS	-	04/12/94	07/12/94	91	7/12/94	NS	-
-2B	10/20/93	1/12/94	84	1/12/94	NS	-	04/12/94	07/12/94	91	7/12/94	10/11/94	91
EB8-1A	10/12/93	1/11/94	91	1/11/94	4/14/94	93	04/14/94	07/13/94	90	7/13/94	10/11/94	90
-1B	10/12/93	1/11/94	91	1/11/94	4/14/94	93	04/14/94	07/13/94	90	7/13/94	10/11/94	90
-2A	10/12/93	1/11/94	91	1/11/94	4/14/94	93	04/14/94	07/13/94	90	7/13/94	10/11/94	90
-2B	10/12/93	1/11/94	91	1/11/94	4/14/94	93	04/14/94	07/13/94	90	7/13/94	10/11/94	90
EB9-1A	10/12/93	1/10/94	90	1/10/94	4/15/94	95	04/15/94	07/13/94	89	7/13/94	10/12/94	91
-1B	10/12/93	1/10/94	90	1/10/94	4/15/94	95	04/15/94	07/13/94	89	7/13/94	10/12/94	91
-2A	10/12/93	1/10/94	90	1/10/94	4/15/94	95	04/15/94	07/13/94	89	7/13/94	10/12/94	91
-2B	10/12/93	NS	-	1/10/94	4/15/94	95	04/15/94	07/13/94	89	7/13/94	10/12/94	91

*= Surface Mooring

+= Bottom Mooring

NR= Not Recovered

NS= No Sample

SAMPLE TRACKING SHEETS

Program Code ☐☐☐

SAMPLE DATA & ANALYSIS REQUIRED

Page ___ of ___

Project Code D3000

Project/Name Elliott Bay

☐ **Enforcement/Custody** ☐ **Class II**

☐ **Possible Toxic/Hazardous Notes** ___

SAMPLING					FIELD STATION IDENTIFICATION	LAB SAMPLE NUMBER		Matrix Code	Source Code	No. of Containers	General Chemistry																Biology				Organic Chem.									METALS	
DATE Yr	Mo	Da	TIME Hr	Mn		Wk	Seq				Turbidity	pH	Conductivity	Total Hardness	Chloride	TS, TSS, TNVS, TNVSS	TSS	% Solids	Nutrients (4)	Ammonia	Nitrate-Nitrite	Total Phosphorous	Ortho-Phosphate	BOD/5 Day	COD Chem Oxy Demand	[illegible]	Fecal Coliform Bacteria	Total Coliform Bacteria	Enterococcus	Fish Bioassay	Base/Neutrals/Acids	Volatile Organics	Pesticides/PCB's	PCB's Only	Purgeable Halocarbons	Herbicides	Hydrocarbon Analysis	Phenolics (AAP)	Oil & Grease	P.P. Metals	EP Tox Metals
	27				TI-4-3	39	8573	10	40	1																✓															
					TI-4-1	39	8571																			✓															
					TI-4-2	39	8572																			✓															
					TT--5A	39	8575																			✓															
					TI-5B	39	8576																			✓															
					TI-4-5	39	8577																			✓															
					TI-4-4	39	8574																			✓															

METALS Specific List
- Total
- ☐ Recoverable
- ☐ Totals
- ☐ Dissolved

Project Officer Dale Norton

Sampler(s) Dale Norton

Recorder Dale Norton

Date __/__/92

Chain Of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
	[illegible]	92	[illegible]	24					

Laboratory Copy White

Project Office Copy Yellow

Field or Office Copy Pink

040 115 Rev. 7/87

Particulate samples submitted for analysis January 1994 for Elliott Bay.

Station ID	Sample #	Trap #1	Station ID	Sample #	Trap #2	Station ID	Sample #	Composite Traps 1 + 2
EB1-S (Surface)			EB1-S					
1A	38230	%S	2A	38250	%S	EB1-C	38270	TOC,Metals,Semiv.,PCBs
1B	38231	%S	2B	38252	%S	EB-1SC	38279	TOC,Metals,Semiv.,PCBs
EB1-B (Bottom)			EB1-B					
1A	38232	%S	2A	38253	%S	EB1-BC	38271	TOC,Metals
1B	38233	%S	2B	38254	%S			
EB2-			EB2-					
1A	- -		2A	38255	%S,TOC,Metals	EB2-C	- -	
1B	- -		2B	- -				
EB3-			EB3-					
1A	38234	%S	2A	38256	%S	EB3-C	- -	
1B	38235	%S	2B	38257	%S			
1C	38236	TOC,Metals,Semiv,PCBs,Pb-210	2C	38258	TOC,Metals,Semiv,PCBs,Pb-210			
EB4-			EB4-					
1A	38237	%S	2A	38259	%S	EB4-C	38272	TOC,Metals,(Semiv.,PCBs),Pb-210
1B	38238	%S	2B	38260	%S	EB4-CD(du	38273	TOC,Metals,Semiv.,PCBs,Pb-210
EB5-			EB5-					
1A	38239	%S	2A	38261	%S	EB5-C	38274	TOC,Metals,Semiv.,PCBs,Pb-210,GS
1B	38240	%S	2B	38262	%S			
EB6-S (Surface)			EB6-S					
1A	38241	%S,Metals	2A	- -		EB6-SC	- -	
1B	- -		2B	- -				
EB6-B (Bottom)			EB6-B					
1A	38242	%S	2A	38263	%S	EB6-BC	38275	TOC,Metals,Semiv.,PCBs,Pb-210
1B	38243	%S	2B	38264	%S			
EB7-			EB7-					
1A	38244	%S	2A	38265	%S	EB7-C	38276	TOC,Metals,Semiv.,PCBs,Pb-210
1B	38245	%S	2B	38266	%S			
EB8-			EB8-					
1A	38246	%S,TOC	2A	38267	%S	EB8-C	38277	Metals,Semiv.,PCBs,Pb-210
1B	38247	%S	2B	38268	%S			
EB9-			EB9-					
1A	38248	%S	2A	38269	%S	EB9-C	38278	TOC,Metals,Semiv.,PCBs,Pb-210
1B	38249	%S	2B	- -				

( )-Fraction lost in extraction
GS-Grain Size Seive and pipet portion only
No sample
Metals (11)=Al,As,Cd,Cr,Cu,Fe,Pb,Mn,Hg,Ag,Zn)

Reference Materials
HS-6 (PAH) NRCC in duplicate
HS-2 (PCBs) NRCC in duplicate
#1646 (Metals) NIST in duplicate
EPA LCS (Metals) in duplicate

Notes:
EB1-C= Composite of surface and bottom samples
EB1-1SC= Samples 2A and 2B used in composite
EB1-BC= Samples 2A and 2B used in composite
EB5-2A= Not used in overall composite

ject Name: Elliott Bay Recontamination
D3C00

Results to: Dale Norton Mail Stop: 7710

LABORATORY ANALYSES REQUIRED

Page 1 of 5

☐ Preliminary Investigation
☒ Monitoring

☐ For HW Designation
☐ For NPDES

Results needed by 3/7/94

Top 10 Peaks

ampling Da	Time Hr	Time Mn	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers
			EB-1S1A	38230	40	42	1
			EB-1S1B	8231			1
			EB-1S2A	8250			1
			-1S2B	8252			1
			EB-1C	8270			3
			EB-1SC	8279			3
			EB-1B1A	8232			1
			-1B1B	8233			1
			-1B2A	8253			1
			-1B2B	8254			1
			EB-1BC	8271			2
			EB-22A	8255			3

General Chemistry

Field Station Identification	Alkalinity	Conductivity	Hardness	pH	Turbidity	☐ Chloride ☐ Sulfate	Cyanide ☐ Total ☐ Weak	Total Solids	Total Nonvolatile Solids	Total Suspended Solids	Total Nonvol Suspend	Total Dissolved Solids	☒ %Solids ☐ %Vol. Solids	TOC	BOD (5 day)	Oil & Grease	Ammonia	Nitrate-Nitrite	Total Phosphorous	Orthophosphorous	Nitrate	Nitrite	☐ TPN ☐ TKN	Grain Size ①
EB-1S1A													✓											
EB-1S1B													✓											
EB-1S2A													✓											
-1S2B													✓											
EB-1C														✓										
EB-1SC														✓										
EB-1B1A													✓											
-1B1B													✓											
-1B2A													✓											
-1B2B													✓											
EB-1BC														✓										
EB-22A													✓	✓										

Micro / Biology

Field Station Identification	Fecal Coliforms ☐ MF ☐ MPN	Total Coliforms	E-Coli	%Klebsiella	Ceriodaphnia ☐ acute ☐ chron	D magna ☐ acute ☐ chron	D pulex ☐ acute ☐ chron	Fathead minnow	Microtox	Salmonid	Salmonid Haz Waste
EB-1S1A											
EB-1S1B											
EB-1S2A											
-1S2B											
EB-1C											
EB-1SC											
EB-1B1A											
-1B1B											
-1B2A											
-1B2B											
EB-1BC											
EB-22A											

Metals ☒ Total ☐ Total Rec

Field Station Identification	ICP Scan	PP Metals	TCLP Metals	Cd Cr Cu Ni Pb Zn	Mercury (Hg)	Metals(11) ②	Pb-210
EB-1S1A							
EB-1S1B							
EB-1S2A							
-1S2B							
EB-1C						✓	
EB-1SC						✓	
EB-1B1A							
-1B1B							
-1B2A							
-1B2B							
EB-1BC						✓	
EB-22A						✓	

Organic Chemistry

Field Station Identification	BNA ☒ CLP TIC's ☐ No TIC's	BNA w/ extensive TIC's	PAH's	VOA ☐ CLP TIC's ☐ No TIC's	VOA w/ extensive TIC's	BTEX	Organo Chlorine Pests/PCB's	PCB's only	Organophosphorous Pests	Chlorophenoxy Herbs	WTPH-HCID	WTPH-G	WTPH-D	WTPH-418.1 Modified	AED screen
EB-1S1A															
EB-1S1B															
EB-1S2A															
-1S2B															
EB-1C	✓							✓							
EB-1SC	✓							✓							
EB-1B1A															
-1B1B															
-1B2A															
-1B2B															
EB-1BC															
EB-22A															

fficer Dale Norton
ber 407-6765
, Dale
, Dave

Norton
/94

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		94	01	21	16	00			
	Pam Covey	94	01	24	09	00			

Comments: ① Grain Size = Abbreviate using only seive + pipet portion BNA - TOP 10 TIC'S
② Metals (11) = Al, As, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Ag and Zn
Analysis to be conducted per Sampling & Analysis Plan Specs.
Rf. Materials = HS-6 (PAH); HS-2 (PCB'S), 1646 (metals) and EPA LCS (metals) all materials analyzed in duplicate

Page

Project Name: Elliott Bay Recontamination

LABORATORY ANALYSES REQUIRED

PIC: D3C00

Send Results to: Dale Norton **Mail Stop:** 7710

☐ Preliminary Investigation
☒ Monitoring

☐ For HW Designation
☐ For NPDES

Results needed by 3/7/94

Sampling Date Mo	Da	Time Hr	Mn	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers
0	21			EB-31A	38234	40	42	1
				-31B	38235			1
				-31C	8236			4
				-32A	8256			1
				-32B	8257			1
				-32C	8258			4
				EB-41A	8237			1
				-41B	8238			1
				-42A	8259			1
				-42B	8260			1
				-4C	8272			4
				-4CD	8273			4

Year: 94

General Chemistry

Field Station Identification	Alkalinity	Conductivity	Hardness	pH	Turbidity	☐ Chloride ☐ Sulfate	Cyanide ☐ Total ☐ Weak	Total Solids	Total Nonvolatile Solids	Total Suspended Solids	Total Nonvol Suspend	Total Dissolved Solids	☒ %Solids ☐ %Vol. Solids	TOC	BOD (5 day)	Oil & Grease	Ammonia	Nitrate-Nitrite	Total Phosphorous	Orthophosphorous	Nitrate	Nitrite	☐ TPN ☐ TKN	Grain Size
EB-31A													✓											
-31B													✓											
-31C														✓										
-32A													✓											
-32B													✓											
-32C														✓										
EB-41A													✓											
-41B													✓											
-42A													✓											
-42B													✓											
-4C														✓										
-4CD														✓										

Micro / **Biology**

Field Station Identification	Fecal Coliforms ☐ MF ☐ MPN	Total Coliforms	E-Coli	%Klebsiella	Ceriodaphnia ☐ acute ☐ chron	D magna ☐ acute ☐ chron	D pulex ☐ acute ☐ chron	Fathead minnow	Microtox	Salmonid	Salmonid Haz Waste
EB-31A											
-31B											
-31C											
-32A											
-32B											
-32C											
EB-41A											
-41B											
-42A											
-42B											
-4C											
-4CD											

Metals (☒ Total ☐ Total Rec) / **Organic Chemistry**

Field Station Identification	ICP Scan	PP Metals	TCLP Metals	Cd Cr Cu Ni Pb Zn	Mercury (Hg)	Metals (11)	Pb-210	BNA ☒ CLP TIC's ☐ No TIC's	BNA w/ extensive TIC's	PAH's	VOA ☐ CLP TIC's ☐ No TIC's	VOA w/ extensive TIC's	BTEX	Organo Chlorine Pests/PCB's	PCB's only	Organophosphorous Pests	Chlorophenoxy Herbs	WTPH-HCID	WTPH-G	WTPH-D	WTPH-418.1 Modified	AED screen
EB-31A																						
-31B																						
-31C						✓	✓	✓							✓							
-32A																						
-32B																						
-32C						✓	✓	✓							✓							
EB-41A																						
-41B																						
-42A																						
-42B																						
-4C						✓	✓	✓							✓							
-4CD						✓	✓	✓							✓							

Project Officer: Dale Norton
Scan number: 407-6765
Samplers: Dale Norton
Dave Serdar

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		94	01	21					
	[illegible] Cilley	94	01	24	09	00			

Comments: See page 1 BNA - Top 10 TICs

Recorder: Norton
Date: 1/21/94

ECY 040-115 Rev. 12/93

LABORATORY ANALYSES REQUIRED

Page 3 of 5

ct Name: Ellrott Bay Recontamination
23 C00
esults to: Dale Norton Mail Stop: 7710

☐ Preliminary Investigation
☒ Monitoring
☐ For HW Designation
☐ For NPDES

Results needed by 3/7/94

General Chemistry: Alkalinity, Conductivity, Hardness, pH, Turbidity, ☐ Chloride ☐ Sulfate, Cyanide ☐ Total ☐ Weak, Total Solids, Total Nonvolatile Solids, Total Suspended Solids, Total Nonvol Suspend, ~~Total Dissolved Solids~~ ☒ %Solids ☐ %Vol. Solids, TOC, BOD (5 day), Oil & Grease, Ammonia, Nitrate-Nitrite, Total Phosphorous, Orthophosphorous, Nitrate, Nitrite, ☐ TPN ☐ TKN, Grain Size

Micro: Fecal Coliforms ☐ MF ☐ MPN, Total Coliforms, E-Coli, %Klebsiella

Biology: Ceriodaphnia ☐ acute ☐ chron, D magna ☐ acute ☐ chron, D pulex ☐ acute ☐ chron, Fathead minnow, Microtox, Salmonid, Salmonid Haz Waste

Metals: ☒ Total ☐ Total Rec; ICP Scan, PP Metals, TCLP Metals, Cd Cr Cu Ni Pb Zn, Mercury (Hg), Metals (1), Pb-210

Organic Chemistry: BNA ☒ CLP TIC's ☐ No TIC's, BNA w/ extensive TIC's, PAH's, VOA ☐ CLP TIC's ☐ No TIC's, VOA w/ extensive TIC's, BTEX, Organo Chlorine Pests/PCB's, [✓ PCB's only], Organophosphorous Pests, Chlorophenoxy Herbs, WTPH-HCID, WTPH-G, WTPH-D, WTPH-418.1 Modified, AED screen

ampling te	Time Hr Mn	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers	%Solids	TOC	Grain Size	Metals (1)	Pb-210	BNA	PCB's only
		EB-51A	38239	40	42	1	✓						
		-51B	38240			1	✓						
		-52A	38261			1	✓						
		-52B	38262			1	✓						
		-5C	38274			5		✓	✓	✓	✓	✓	✓
		EB-6S1A	38241			1	✓			✓			
		EB-6B1A	8242			1	✓						
		-6B1B	8243			1	✓						
		-6B2A	8263			1	✓						
		-6B2B	8264			1	✓						
		-6BC	8275			4		✓		✓	✓	✓	✓
		EB-71A	8244			1		✓					

ct Officer: Dale Norton
number: 407-6765
plers: Dale Norton
Dave Serdar

rder: Norton
te 1/21/94

115 Rev. 12/93

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		94	01	21					
	Pam Covey	94	01	24	09	00			

Comments: See page 1

ect Name: Elliott Bay Recontamination

D3C00

sults to: Norton   Mail Stop: 7710

LABORATORY ANALYSES REQUIRED

Page 4 of 5

☐ Preliminary Investigation
☒ Monitoring
☐ For HW Designation
☐ For NPDES

Results needed by 3/7/94

ping

Time	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers	General Chemistry																								Micro				Biology							Metals ☒ Total ☐ Total Rec							Organic Chemistry														
Hr Mn						Alkalinity	Conductivity	Hardness	pH	Turbidity	☐ Chloride ☐ Sulfate	Cyanide ☐ Total ☐ Weak	Total Solids	Total Nonvolatile Solids	Total Suspended Solids	Total Nonvol Suspend	Total Dissolved Solids	☒ %Solids ☐ %Vol. Solids	TOC	BOD (5 day)	Oil & Grease	Ammonia	Nitrate-Nitrite	Total Phosphorous	Orthophosphorous	Nitrate	Nitrite	☐ TPN ☐ TKN	Grain Size	Fecal Coliforms ☐ MF ☐ MPN	Total Coliforms	E-Coli	%Klebsiella	Ceriodaphnia ☐ acute ☐ chron	D magna ☐ acute ☐ chron	D pulex ☐ acute ☐ chron	Fathead minnow	Microtox	Salmonid	Salmonid Haz Waste	ICP Scan	PP Metals	TCLP Metals	Cd Cr Cu Ni Pb Zn	Mercury (Hg)	Metals (11)	Pb-210	BNA ☒ CLP TIC's ☐ No TIC's	BNA w/ extensive TIC's	PAH's	VOA ☐ CLP TIC's ☐ No TIC's	VOA w/ extensive TIC's	BTEX	Organo Chlorine Pests/PCB's	PCB's only	Organophosphorous Pests	Chlorophenoxy Herbs	WTPH-HCID	WTPH-G	WTPH-D	WTPH-418.1 Modified	AED screen
	EB-71B	38245	40	42	1													✓																																												
	-72A	8265			1													✓																																												
	-72B	8266			1													✓																																												
	-7C	8276			4														✓																											✓	✓	✓							✓							
	EB-81A	8246			2													✓	✓																																											
	-81B	8247			1													✓																																												
	-82A	8267			1													✓																																												
	-82B	8268			1													✓																																												
	-8C	8277			3																																									✓	✓	✓							✓							
	EB-91A	8248			1													✓																																												
	-91B	8249			1													✓																																												
	-92A	8269			1													✓																																												

ect Officer: Dale Norton
n number: 407-6765
mplers: Dale Norton
Dave Sidor

der: Norton
1/21/94

Rev. 12/93

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		94	01	21					
	Jami Curry	94	01	24	08	00			

Comments: See page 1.

Page 5 of 5

LABORATORY ANALYSES REQUIRED

Name: Elliott Bay Recontamination

3C00

sults to: D. Norton Mail Stop: 7710

☐ Preliminary Investigation
☒ Monitoring

☐ For HW Designation
☐ For NPDES

Results needed by 3/7/94

pling Time Da	Hr	Mn	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers
1			EB-9C	38278	40	42	4

General Chemistry

Field Station Identification	Alkalinity	Conductivity	Hardness	pH	Turbidity	☐ Chloride ☐ Sulfate	Cyanide ☐ Total ☐ Weak	Total Solids	Total Nonvolatile Solids	Total Suspended Solids	Total Nonvol Suspend	Total Dissolved Solids	[✓ %Solids] ☐ %Vol. Solids	TOC	BOD (5 day)	Oil & Grease	Ammonia	Nitrate-Nitrite	Total Phosphorous	Orthophosphorous	Nitrate	Nitrite	☐ TPN ☐ TKN
EB-9C														✓									

Micro / Biology

Field Station Identification	Fecal Coliforms ☐ MF ☐ MPN	Total Coliforms	E-Coli	%Klebsiella	Ceriodaphnia ☐ acute ☐ chron	D magna ☐ acute ☐ chron	D pulex ☐ acute ☐ chron	Fathead minnow	Microtox	Salmonid	Salmonid Haz Waste
EB-9C											

Metals: ☒ Total ☐ Total Rec

Field Station Identification	ICP Scan	PP Metals	TCLP Metals	Cd Cr Cu Ni Pb Zn	Mercury (Hg)	Mn-15(11)	Pb-210
EB-9C						✓	✓

Organic Chemistry

Field Station Identification	BNA ☒ CLP TIC's ☐ No TIC's	BNA w/ extensive TIC's	PAH's	VOA ☐ CLP TIC's ☐ No TIC's	VOA w/ extensive TIC's	BTEX	Organo Chlorine Pests/PCB's	[✓ PCB's only]	Organophosphorous Pests	Chlorophenoxy Herbs	WTPH-HCID	WTPH-G	WTPH-D	WTPH-418.1 Modified	AED screen
EB-9C	✓							✓							

ct Officer: Dale Norton
number: 407-6765
plers: Dale Norton
Dave Serdar

er: Norton
1/21/94

ev. 12/93

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		94	01	21					
	Perry Carey	94	01	24	07	00			

Comments: See page 1

Sam, submitted for analysis April 1994 (2nd quarter) for Elliott Waterfront Recontamination Study.

Station ID	Sample#	Trap #1	Station ID	Sample#	Trap #2	Station ID	Sample#	Composite Traps 1 + 2
EB1-S (Surface)			EB1-S					
1A	168400	%S	2A	168402	%S	EB-1SOC	168404	TOC,Metals,Semiv.,PCBs.Pb-210,GS
1B	168401	%S	2B	168403	%S			
EB1-B (Bottom)			EB1-B					
1A	168405	%S	2A	168407	%S	EB1-BOC	168409	TOC,Metals,Semiv.,PCBs.Pb-210,GS
1B	168406	%S	2B	168408	%S			
EB2-			EB2-					
1A	168410	%S	2A	168412	%S	EB2-OC	168414	TOC,Metals,Semiv.,Pb-210,GS
1B	168411	%S	2B	168413	%S	EB2-OCD	168415	TOC,Metals,Semiv.,Pb-210,GS
EB3-			EB3-					
1A	- -		2A	168417	%S	EB3-OC	168419	TOC,Metals,Semiv.,PCBs.Pb-210,GS
1B	168416	%S	2B	168418	%S			
EB4-			EB4-					
1A	168420	%S	2A	168421	%S	EB4-OC	168423	TOC,Metals,Semiv.,PCBs.Pb-210,GS
1B	- -		2B	168422	%S			
EB5-			EB5-					
1A	168424	%S	2A	168426	%S	EB5-OC	168428	TOC,Metals,Semiv.,PCBs.Pb-210,GS
1B	168425	%S	2B	168427	%S			
EB6-S (Surface)			EB6-S					
1A	- -		2A	- -		EB6-SOC	168431	TOC,Metals,Semiv.
1B	168429	%S	2B	168430	%S			
EB6-B (Bottom)			EB6-B					
1A	168432	%S	2A	168434	%S	EB6-BOC	168436	TOC,Metals,Semiv.,PCBs.Pb-210,GS
1B	168433	%S	2B	168435	%S			
EB7-			EB7-					
1A	168437	%S	2A	- -		EB7-OC	- -	
1B	168438	%S	2B	- -				
1C	168439	TOC,Metals,Semiv.,Pb-210,GS						
EB8-			EB8-					
1A	168440	%S(dup)-168441	2A	168443	%S	EB8-OC	168445	TOC,Metals,Semiv.,PCBs.Pb-210,GS
1B	168442	%S	2B	168444	%S			
EB9-			EB9-					
1A	168446	%S	2A	168448	%S	EB9-OC	168450	TOC,Metals,Semiv.,PCBs.Pb-210,GS
1B	168447	%S	2B	168449	%S			

GS-Grain Size Seive and pipet portion only

Metals (11)=Al,As,Cd,Cr,Cu,Fe,Pb,Mn,Hg,Ag,Zn)

Reference Materials

HS-6 (PAH) NRCC in duplicate

HS-2 (PCBs) NRCC in duplicate

#1646 (Metals) NIST in duplicate

EPA LCS (Metals) in duplicate

Minimum Sample Volumes (wet grams)	
%S	5-10
Grain Size	10-20
TOC	5-10
Metals	10-15
Semivolatiles	20-25
PCBs	20-25
Pb-210	10-15
Total=	80-120

Project Name: Elliott Bay WF Recontamination

LABORATORY ANALYSES REQUIRED

Page 1 of

PIC: D3C00

Send Results to: Dale Norton **Mail Stop:** 47710

☐ Preliminary Investigation
☒ Monitoring
☐ For HW Designation
☐ For NPDES

Results needed by 45 days (6/6/94)

General Chemistry: Alkalinity, Conductivity, Hardness, pH, Turbidity, ☐ Chloride ☐ Sulfate, Cyanide ☐ Total ☐ Weak, Total Solids, Total Nonvolatile Solids, Total Suspended Solids, Total Nonvol Suspend, Total Dissolved Solids, [✓ ☒ %Solids] ☐ %Vol. Solids, [✓ TOC], BOD (5 day), Oil & Grease, Ammonia, Nitrate-Nitrite, Total Phosphorous, Orthophosphorous, Nitrate, Nitrite, ☐ TPN ☐ TKN, Grain Size

Micro: Fecal Coliforms ☐ MF ☐ MPN, Total Coliforms, E-Coli, %Klebsiella

Biology: Ceriodaphnia ☐ acute ☐ chron, D magna ☐ acute ☐ chron, D pulex ☐ acute ☐ chron, Fathead minnow, Microtox, Salmonid, Salmonid Haz Waste

Metals: [✓ ☒ Total] ☐ Total Rec, ICP Scan, PP Metals, TCLP Metals, Cd Cr Cu Ni Pb Zn, Mercury (Hg), Metals (11), Pb-210

Organic Chemistry: BNA ☒ [✓ CLP TIC's] ☐ No TIC's, BNA w/ extensive TIC's, PAH's, VOA ☐ CLP TIC's ☐ No TIC's, VOA w/ extensive TIC's, BTEX, Organo Chlorine Pests/PCB's, [✓ PCB's only], Organophosphorous Pests, Chlorophenoxy Herbs, WTPH-HCID, WTPH-G, WTPH-D, WTPH-418.1 Modified, AED screen

Date Mo	Date Da	Time Hr	Time Mn	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers	%Solids	TOC	Grain Size	Metals (11)	Pb-210	BNA	PCB's only
04	20			EB1S-1A	168400	40	40	1	✓						
				-1B	8401			1	✓						
				-2A	8402			1	✓						
				-2B	8403			1	✓						
				EB1SOC	8404			6		✓	✓	✓	✓	✓	✓
				EB1B-1A	8405			1	✓						
				-1B	8406			1	✓						
				-2A	8407			1	✓						
				-2B	8408			1	✓						
				EB1BOC	8409			6		✓	✓	✓	✓	✓	✓
				EB2-1A	8410			1	✓						
				-1B	8411			1	✓						

Year: 94

Project Officer: Dale Norton

Scan number: 407-6765

Samplers: Dale Norton
Dave Serdar

Recorder: Dale Norton

Date: 4/20/94

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		94	04	20	15	00			
	Pam Covey	94	04	21	09	00			

Comments: See Attached Sheet for list of metals + QA info.
Grain Size - Abbreviate if necessary to Sieve + Pipet only

ECY 040-115 Rev. 12/93

Page 2 of 5

LABORATORY ANALYSES REQUIRED

t Name: Elliott Bay WF Recontamination

3000

sults to: Dale Norton **Mail Stop:** 47710

☐ Preliminary Investigation
☒ Monitoring

☐ For HW Designation
☐ For NPDES

Results needed by 45 days (6/6/94)

npling

ear: ☐

Da	Hr	Mn	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers	Alkalinity	Conductivity	Hardness	pH	Turbidity	☐ Chloride ☐ Sulfate	Cyanide ☐ Total ☐ Weak	Total Solids	Total Nonvolatile Solids	Total Suspended Solids	Total Nonvol Suspend	Total Dissolved Solids	☒ %Solids ☐ %Vol. Solids	TOC	BOD (5 day)	Oil & Grease	Ammonia	Nitrate-Nitrite	Total Phosphorous	Orthophosphorous	Nitrate	Nitrite	☐ TPN ☐ TKN	Grain Size	Fecal Coliforms ☐ MF ☐ MPN	Total Coliforms	E-Coli	%Klebsiella
20			EB2-2A	168412	40	40	1													✓															
			-2B	8413			1													✓															
			EB20C	8414			5														✓										✓				
			EB20CD	8415			5														✓										✓				
			EB3-1B	8416			1													✓															
			-2A	8417			1													✓															
			-2B	8418			1													✓															
			EB30C	8419			6														✓										✓				
			EB4-1A	8420			1													✓															
			-2A	8421			1													✓															
			-2B	8422			1													✓															
			EB40C	8423			6														✓										✓				

Field Station Identification	Ceriodaphnia ☐ acute ☐ chron	D magna ☐ acute ☐ chron	D pulex ☐ acute ☐ chron	Fathead minnow	Microtox	Salmonid	Salmonid Haz Waste	ICP Scan	PP Metals	TCLP Metals	Cd Cr Cu Ni Pb Zn	Mercury (Hg)	Metals (11)	Pb-210	BNA ☒ [✓ CLP TIC's] ☐ No TIC's	BNA w/ extensive TIC's	PAH's	VOA ☐ CLP TIC's ☐ No TIC's	VOA w/ extensive TIC's	BTEX	Organo Chlorine Pests/PCB's	[✓ PCB's only]	Organophosphorous Pests	Chlorophenoxy Herbs	WTPH-HCID	WTPH-G	WTPH-D	WTPH-418.1 Modified	AED screen
EB2-2A																													
-2B																													
EB20C													✓	✓	✓														
EB20CD													✓	✓	✓														
EB3-1B																													
-2A																													
-2B																													
EB30C													✓	✓	✓							✓							
EB4-1A																													
-2A																													
-2B																													
EB40C													✓	✓	✓							✓							

Metals: ☒ Total ☐ Total Rec

roject Officer: Dale Norton

an number: 407-6765

mplers: Dale Norton
Dave Serdar

der: Dale Norton
4/20/94

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		94	04	20	15	00			
	Pam Covey	94	04	21	09	00			

Comments: See attached sheet for list of metals + QA Info
Grain Size Abreviate to Sieve + pipet only if neccessary

Rev. 12/93

ect Name: Elliott Bay WF Recontamination

D3C00

end Results to: Dale Norton   Mail Stop: 47710

ABORATORY ANALYSES REQUIRED

Page 3 of 5

☐ Preliminary Investigation
☒ Monitoring

☐ For HW Designation
☐ For NPDES

Results needed by 45 days (6/6/94)

General Chemistry: Alkalinity; Conductivity; Hardness; pH; Turbidity; ☐ Chloride ☐ Sulfate; Cyanide ☐ Total ☐ Weak; Total Solids; Total Nonvolatile Solids; Total Suspended Solids; Total Nonvol Suspend; Total Dissolved Solids; [✓ ☒ %Solids] ☐ %Vol. Solids; [✓ TOC]; BOD (5 day); Oil & Grease; Ammonia; Nitrate-Nitrite; Total Phosphorous; Orthophosphorous; Nitrate; Nitrite; ☐ TPN ☐ TKN; Grain Size

Micro: Fecal Coliforms ☐ MF ☐ MPN; Total Coliforms; E-Coli; %Klebsiella

Biology: Ceriodaphnia ☐ acute ☐ chron; D magna ☐ acute ☐ chron; D pulex ☐ acute ☐ chron; Fathead minnow; Microtox; Salmonid; Salmonid Haz Waste

Metals: [✓ ☒ Total] ☐ Total Rec; ICP Scan; PP Metals; TCLP Metals; Cd Cr Cu Ni Pb Zn; Mercury (Hg); Metals (11); Pb-210

Organic Chemistry: [✓ BNA ☒ CLP TIC's] ☐ No TIC's; BNA w/ extensive TIC's; PAH's; VOA ☐ CLP TIC's ☐ No TICs; VOA w/ extensive TIC's; BTEX; Organo Chlorine Pests/PCB's; [✓ PCB's only]; Organophosphorous Pests; Chlorophenoxy Herbs; WTPH-HCID; WTPH-G; WTPH-D; WTPH-418.1 Modified; AED screen

Sampling Date Year: 4

Mo	Da	Hr	Mn	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers	%Solids	TOC	Grain Size	Metals (11)	Pb-210	BNA	PCB's only
4	20			EB5-1A	168424	40	40	1	✓						
				-1B	8425			1	✓						
				-2A	8426			1	✓						
				-2B	8427			1	✓						
				EB50C	8428			6		✓	✓	✓	✓	✓	✓
				EB6S-~~1~~1B	8429			1	✓						
				-2B	8430			1	✓						
				EB65OC	8431			3		✓		✓		✓	
				EB6B-1A	8432			1	✓						
				-1B	8433			1	✓						
				-2A	8434			1	✓						
				-2B	8435			1	✓						

ct Officer: Dale Norton
number: 407-6765
plers: Dale Norton
Dave Serdor

order: Dale Norton
4/20/94

115 Rev. 12/93

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		94	04	20	15	00			
	Jim Corey	94	04	21	09	00			

Comments: See attached sheet for list of metals & QA info.
Abreviate grain size to sieve & pipet only, if necessary

Project Name: Elliott Bay WF Recontamination

PIC: D3C00

Send Results to: Dale Norton **Mail Stop:** 47710

LABORATORY ANALYSES REQUIRED

Page 4 of 5

☐ Preliminary Investigation
☒ Monitoring

☐ For HW Designation
☐ For NPDES

Results needed by 45 days (6/6/94)

Year: 94

Sampling Date Mo	Da	Time Hr	Mn	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers
	20			EB6BOC	168436	40	40	6
				EB7-1A	8437			1
				-1B	8438			1
				-1C	8439			5
				EB8-1A	8440			1
				-1AD	8441			1
				-1B	8442			1
				-2A	8443			1
				-2B	8444			1
				EB8OC	8445			6
				EB9-1A	8446			1
				-1B	8447			1

General Chemistry

Field Station Identification	Alkalinity	Conductivity	Hardness	pH	Turbidity	☐ Chloride ☐ Sulfate	Cyanide ☐ Total ☐ Weak	Total Solids	Total Nonvolatile Solids	Total Suspended Solids	Total Nonvol Suspend	Total Dissolved Solids	☒ %Solids ☐ %Vol. Solids	TOC	BOD (5 day)	Oil & Grease	Ammonia	Nitrate-Nitrite	Total Phosphorous	Orthophosphorous	Nitrate	Nitrite	☐ TPN ☐ TKN	Grain Size
EB6BOC														✓										✓
EB7-1A													✓											
-1B													✓											
-1C														✓										✓
EB8-1A													✓											
-1AD													✓											
-1B													✓											
-2A													✓											
-2B													✓											
EB8OC														✓										✓
EB9-1A													✓											
-1B													✓											

Micro / Biology

Field Station Identification	Fecal Coliforms ☐ MF ☐ MPN	Total Coliforms	E-Coli	%Klebsiella	Ceriodaphnia ☐ acute ☐ chron	D magna ☐ acute ☐ chron	D pulex ☐ acute ☐ chron	Fathead minnow	Microtox	Salmonid	Salmonid Haz Waste
EB6BOC											
EB7-1A											
-1B											
-1C											
EB8-1A											
-1AD											
-1B											
-2A											
-2B											
EB8OC											
EB9-1A											
-1B											

Metals (☒ Total ☐ Total Rec)

Field Station Identification	ICP Scan	PP Metals	TCLP Metals	Cd Cr Cu Ni Pb Zn	Mercury (Hg)	Metals (11)	Pb-210
EB6BOC						✓	✓
EB7-1A							
-1B							
-1C						✓	✓
EB8-1A							
-1AD							
-1B							
-2A							
-2B							
EB8OC						✓	✓
EB9-1A							
-1B							

Organic Chemistry

Field Station Identification	BNA ☒ CLP TIC's ☐ No TIC's	BNA w/ extensive TIC's	PAH's	VOA ☐ CLP TIC's ☐ No TIC's	VOA w/ extensive TIC's	BTEX	Organo Chlorine Pests/PCB's	PCB's only	Organophosphorous Pests	Chlorophenoxy Herbs	WTPH-HCID	WTPH-G	WTPH-D	WTPH-418.1 Modified	AED screen
EB6BOC	✓							✓							
EB7-1A															
-1B															
-1C	✓														
EB8-1A															
-1AD															
-1B															
-2A															
-2B															
EB8OC	✓							✓							
EB9-1A															
-1B															

ject Officer: Dale Norton
n number: 407-6765
nplers: Dale Norton
Dave Serdar

order: Dale Norton
te: 4/20/94

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		94	04	20					
	Pam Covey	94	04	21	08	00			

Comments: See Attach sheet for list of metals & QA info.
Abbreviate Grain Size to Seive + pipet only if necessary

115 Rev. 12/93

LABORATORY ANALYSES REQUIRED

Page 5 of 5

roject Name: Elliott Bay WF Recontamination
IC: D3C00
end Results to: Dale Norton   Mail Stop: 47710

☐ Preliminary Investigation
☒ Monitoring

☐ For HW Designation
☐ For NPDES

Results needed by 45 days (6/6/94)

Sampling Date	Time Hr	Time Mn	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers
			EB9-2A	168448	40	40	1
			-2B	8449			1
			EB90C	8450			6

General Chemistry

Field Station Identification	Alkalinity	Conductivity	Hardness	pH	Turbidity	☐ Chloride ☐ Sulfate	Cyanide ☐ Total ☐ Weak	Total Solids	Total Nonvolatile Solids	Total Suspended Solids	Total Nonvol Suspend	Total Dissolved Solids	☒ %Solids ☐ %Vol. Solids	TOC	BOD (5 day)	Oil & Grease	Ammonia	Nitrate-Nitrite	Total Phosphorous	Orthophosphorous	Nitrate	Nitrite	☐ TPN ☐ TKN	Grain Size
EB9-2A													✓											
-2B													✓											
EB90C														✓										✓

Micro

Field Station Identification	Fecal Coliforms ☐ MF ☐ MPN	Total Coliforms	E-Coli	%Klebsiella
EB9-2A				
-2B				
EB90C				

Biology

Field Station Identification	Ceriodaphnia ☐ acute ☐ chron	D magna ☐ acute ☐ chron	D pulex ☐ acute ☐ chron	Fathead minnow	Microtox	Salmonid	Salmonid Haz Waste
EB9-2A							
-2B							
EB90C							

Metals ☒ Total ☐ Total Rec

Field Station Identification	ICP Scan	PP Metals	TCLP Metals	Cd Cr Cu Ni Pb Zn	Mercury (Hg)	Metals (11)	Pb-210
EB9-2A							
-2B							
EB90C						✓	✓

Organic Chemistry

Field Station Identification	BNA ☒ CLP TIC's ☐ No TIC's	BNA w/ extensive TIC's	PAH's	VOA ☐ CLP TIC's ☐ No TIC's	VOA w/ extensive TIC's	BTEX	Organo Chlorine Pests/PCB's	PCB's only	Organophosphorous Pests	Chlorophenoxy Herbs	WTPH-HCID	WTPH-G	WTPH-D	WTPH-418.1 Modified	AED screen
EB9-2A															
-2B															
EB90C	✓							✓							

Officer: Dale Norton
number: 407-6765
lers: Dale Norton
Dave Serdar

Dale Norton
4/20/94

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		94	04	20	15	00			
	Pam Covey	94	04	21	07	00			

Comments: See attached sheet for list of metals + QA info
Abbreviate Grain Size to seive + pipet only if necessary

LABORATORY ANALYSES REQUIRED

Page 1 of 6

oject I ne: Elliott Bay Recontamination
D3C00
Results to: Dale Norton   Mail Stop: 7710

☐ Preliminary Investigation
☒ Monitoring
☐ For HW Designation
☐ For NPDES

Results needed by 8/12/94

General Chemistry: Alkalinity, Conductivity, Hardness, pH, Turbidity, ☐ Chloride ☐ Sulfate, Cyanide ☐ Total ☐ Weak, Total Solids, Total Nonvolatile Solids, Total Suspended Solids, Total Nonvol Suspend, Total Dissolved Solids, ☑ %Solids ☐ %Vol. Solids, TOC, BOD (5 day), Oil & Grease, Ammonia, Nitrate-Nitrite, Total Phosphorous, Orthophosphorous, Nitrate, Nitrite, ☐ TPN ☐ TKN, Pb-210, Cs-137 } Radio-dating

Micro: Fecal Coliforms ☐ MF ☐ MPN, Total Coliforms, E-Coli, %Klebsiella

Biology: Ceriodaphnia ☐ acute ☐ chron, D magna ☐ acute ☐ chron, D pulex ☐ acute ☐ chron, Fathead minnow, Microtox, Salmonid, Salmonid Haz Waste

Metals: ☒ Total ☐ Total Rec; ICP Scan, PP Metals, TCLP Metals, Cd Cr Cu Ni Pb Zn, Mercury (Hg)

Organic Chemistry: BNA ☐ CLP TIC's ☐ No TIC's, BNA w/ extensive TIC's, PAH's, VOA ☐ CLP TIC's ☐ No TIC's, VOA w/ extensive TIC's, BTEX, Organo Chlorine Pests/PCB's, PCB's only, Organophosphorous Pests, Chlorophenoxy Herbs, WTPH-HCID, WTPH-G, WTPH-D, WTPH-418.1 Modified, AED screen

ampling Da	Time Hr	Time Mn	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers	TOC	Pb-210	Cs-137
4			C1-1	268500	42	40	1	✓	✓	✓
			C1-3	8501			1	✓	✓	✓
			C1-5	8502			1	✓	✓	✓
			C1-7	8503			1	✓	✓	✓
			C1-9	8504			1	✓	✓	✓
			C1-11	8505			1	✓	✓	✓
			C1-13	8506			1	✓	✓	✓
			C1-15	8507			1	✓	✓	✓
			C1-17	8508			1	✓	✓	✓
			C1-19	8509			1	✓	✓	✓
			C1-21	8510			1	✓	✓	✓
			C1-22	8511			1	✓	✓	✓

Officer: Dale Norton
mber: 407-6765
Dale Norton
Bob Barnard
Laura Weiss

Dale Norton
/28/94

12/93

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		94	06	28	15	00			
	[illegible]	94	06	29	13	20			

Comments: Pb-210 and Cs-137 per previous contract w/ Battelle Sequim

LABORATORY ANALYSES REQUIRED

Page 2 of

roject I ne: Elliott Bay Recontamination
  : D3C00
Send Results to: Dale Norton   Mail Stop: 7710

☐ Preliminary Investigation
☒ Monitoring
☐ For HW Designation
☐ For NPDES

Results needed by 8/12/94

General Chemistry: Alkalinity, Conductivity, Hardness, pH, Turbidity, ☐ Chloride ☐ Sulfate, Cyanide ☐ Total ☐ Weak, Total Solids, Total Nonvolatile Solids, Total Suspended Solids, Total Nonvol Suspend, Total Dissolved Solids, ☒ %Solids ☐ %Vol. Solids, TOC, BOD (5 day), Oil & Grease, Ammonia, Nitrate-Nitrite, Total Phosphorous, Orthophosphorous, Nitrate, Nitrite, ☐ TPN ☐ TKN, Grain Size, Pb-210, Cs-137 } dating

Micro: Fecal Coliforms ☐ MF ☐ MPN, Total Coliforms, E-Coli, %Klebsiella

Biology: Ceriodaphnia ☐ acute ☐ chron, D magna ☐ acute ☐ chron, D pulex ☐ acute ☐ chron, Fathead minnow, Microtox, Salmonid, Salmonid Haz Waste

Metals: ☒ Total, ☐ Total Rec, ICP Scan, PP Metals, TCLP Metals, Cd Cr Cu Ni Pb Zn, Mercury (Hg), Metals(7)

Organic Chemistry: BNA ☐ CLP TIC's ☐ No TIC's, BNA w/ extensive TIC's, PAH's, VOA ☐ CLP TIC's ☐ No TIC's, VOA w/ extensive TIC's, BTEX, Organo Chlorine Pests/PCB's, PCB's only, Organophosphorous Pests, Chlorophenoxy Herbs, WTPH-HCID, WTPH-G, WTPH-D, WTPH-418.1 Modified, AED screen

Sampling Date Da	Time Hr	Time Mn	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers	%Solids	TOC	Grain Size	Pb-210	Cs-137	Metals(7)	PCB's only
24			C1-A	268512	42	40	4		✓	✓			✓	✓
			C1-B	8513			2						✓	✓
			C1-C	8514			2						✓	✓
			C1-D	8515			2						✓	✓
			C1-E	8516			2						✓	✓
			C1-F	8517			2						✓	✓
			C2-1	8518			1	✓			✓	✓		
			C2-3	8519			1	✓			✓	✓		
			C2-5	8520			1	✓			✓	✓		
			C2-7	8521			1	✓			✓	✓		
			C2-9	8522			1	✓			✓	✓		
			C2-11	8523			1	✓			✓	✓		

ct Officer: Dale Norton
number: 407-6765
lers: Dale Norton
B. Barnard
L. Weiss

corder: Dale Norton
ate: 6/28/94

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		94	06	28	15	00			
	Tom Carey	94	06	29	13	20			

Comments: Metals(7) = Al, Cu, Fe, Pb, Mg, Hg, Zn - per previous sample set. See Sampling & Analysis plan
Dating = See Battelle Contract
Grain Size = PSEP method Abbreviate to seive + pipet if insufficient Volume

ECY 040-115 Rev. 12/90

LABORATORY ANALYSES REQUIRED

Page 3 of 6

Project Name: Elliott Bay Recontamination
D3C00
Results to: Dale Norton   Mail Stop: 7710

☐ Preliminary Investigation
☒ Monitoring

☐ For HW Designation
☐ For NPDES

Results needed by 8/12/94

Sampling Date Year: ☐ Da	Time Hr	Time Mn	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers
			C2-13	268524	42	40	1
			C2-15	8525			1
			C2-17	8526			1
			C2-19	8527			1
			C2-21	8528			1
			C2-23	8529			1
			C2-25	8530			1
			C2-A	8531			4
			C2-B	8532			2
			C2-C	8533			2
			C2-D	8534			2
			C2-E	8535			2

General Chemistry

Field Station Identification	Alkalinity	Conductivity	Hardness	pH	Turbidity	☐ Chloride ☐ Sulfate	Cyanide ☐ Total ☐ Weak	Total Solids	Total Nonvolatile Solids	Total Suspended Solids	Total Nonvol Suspend	Total Dissolved Solids	☒ %Solids ☐ %Vol. Solids	TOC	BOD (5 day)	Oil & Grease	Ammonia	Nitrate-Nitrite	Total Phosphorous	Orthophosphorous	Nitrate	Nitrite	☐ TPN ☐ TKN	Pb-210	Cs-137	Grain Size
C2-13													✓											✓	✓	
C2-15													✓											✓	✓	
C2-17													✓											✓		
C2-19													✓											✓		
C2-21													✓											✓		
C2-23													✓											✓		
C2-25													✓											✓		
C2-A														✓												✓
C2-B																										
C2-C																										
C2-D																										
C2-E																										

Micro / Biology

Field Station Identification	Fecal Coliforms ☐MF ☐MPN	Total Coliforms	E-Coli	%Klebsiella	Ceriodaphnia ☐ acute ☐ chron	D magna ☐ acute ☐ chron	D pulex ☐ acute ☐ chron	Fathead minnow	Microtox	Salmonid	Salmonid Haz Waste
C2-13											
C2-15											
C2-17											
C2-19											
C2-21											
C2-23											
C2-25											
C2-A											
C2-B											
C2-C											
C2-D											
C2-E											

Metals ☒ Total ☐ Total Rec

Field Station Identification	ICP Scan	PP Metals	TCLP Metals	Cd Cr Cu Ni Pb Zn	Mercury (Hg)	Metals (7)
C2-13						
C2-15						
C2-17						
C2-19						
C2-21						
C2-23						
C2-25						
C2-A						✓
C2-B						✓
C2-C						✓
C2-D						✓
C2-E						✓

Organic Chemistry

Field Station Identification	BNA ☐ CLP TIC's ☐ No TIC's	BNA w/ extensive TIC's	PAH's	VOA ☐ CLP TIC's ☐ No TICs	VOA w/ extensive TIC's	BTEX	Organo Chlorine Pests/PCB's	PCB's only	Organophosphorous Pests	Chlorophenoxy Herbs	WTPH-HCID	WTPH-G	WTPH-D	WTPH-418.1 Modified	AED screen
C2-13															
C2-15															
C2-17															
C2-19															
C2-21															
C2-23															
C2-25															
C2-A								✓							
C2-B								✓							
C2-C								✓							
C2-D								✓							
C2-E								✓							

Project Officer: Dale Norton
Scan number: 407-6765
Samplers: Dale Norton
B. Barnard
L. Weiss

Recorder: Dale Norton
Date: 6/28/94

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		94	06	28	15	00			
	Pam Covey	94	06	29	13	20			

Comments: See notes on Sheet #2

040-115 Rev. 12/93

LABORATORY ANALYSES REQUIRED

ect I ne: Elliott Bay Recontamination
03C00
Results to: Dale Norton Mail Stop: 7710

☐ Preliminary Investigation
☒ Monitoring
☐ For HW Designation
☐ For NPDES

Results needed by 8/12/94

Sampling Date	Time Hr	Time Mn	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers	Alkalinity	Conductivity	Hardness	pH	Turbidity	☐ Chloride ☐ Sulfate	Cyanide ☐ Total ☐ Weak	Total Solids	Total Nonvolatile Solids	Total Suspended Solids	Total Nonvol Suspend	Total Dissolved Solids	☒ %Solids ☐ %Vol. Solids	TOC	BOD (5 day)	Oil & Grease	Ammonia	Nitrate-Nitrite	Total Phosphorous	Orthophosphorous	Nitrate	Nitrite	☐ TPN ☐ TKN	Pb-210	Cs-137	Grain Size
			C2-F	268536	42	40	2																										
			C3-1	8537			1													✓											✓	✓	
			C3-3	8538			1													✓											✓	✓	
			C3-5	8539			1													✓											✓	✓	
			C3-7	8540			1													✓											✓	✓	
			C3-9	8541			1													✓											✓	✓	
			C3-11	8542			1													✓											✓	✓	
			C3-13	8543			1													✓											✓	✓	
			C3-15	8544			1													✓											✓	✓	
			C3-17	8545			1													✓											✓		
			C3-19	8546			1													✓											✓		
			C3-21	8547			1													✓											✓		

Field Station Identification	Micro: Fecal Coliforms ☐ MF ☐ MPN	Total Coliforms	E-Coli	%Klebsiella	Biology: Ceriodaphnia ☐ acute ☐ chron	D magna ☐ acute ☐ chron	D pulex ☐ acute ☐ chron	Fathead minnow	Microtox	Salmonid	Salmonid Haz Waste	Metals (☒ Total ☐ Total Rec): ICP Scan	PP Metals	TCLP Metals	Cd Cr Cu Ni Pb Zn	Mercury (Hg)	Metals (7)	Organic Chemistry: BNA ☐ CLP TIC's ☐ No TIC's	BNA w/ extensive TIC's	PAH's	VOA ☐ CLP TIC's ☐ No TIC's	VOA w/ extensive TIC's	BTEX	Organo Chlorine Pests/PCB's	PCB's only	Organophosphorous Pests	Chlorophenoxy Herbs	WTPH-HCID	WTPH-G	WTPH-D	WTPH-418.1 Modified	AED screen
C2-F																	✓								✓							
C3-1																																
C3-3																																
C3-5																																
C3-7																																
C3-9																																
C3-11																																
C3-13																																
C3-15																																
C3-17																																
C3-19																																
C3-21																																

Project Officer: Dale Norton
Scan number: 207-6765
Samplers: Dale Norton
B. Barnard
L. Weiss

Recorder: Dale Norton
Date: 6/28/94

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		94	06	24	15	00			
	Pam Covey	94	06	29	13	20			

Comments: See notes on Page 2

LABORATORY ANALYSES REQUIRED

oject I ne: Elliott Bay Precontamination
03C00
sults to: Dale Norton Mail Stop: 7710

☐ Preliminary Investigation
☒ Monitoring
☐ For HW Designation
☐ For NPDES

Results needed by 8/12/94

npling

Time Hr	Time Mn	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers	☒ %Solids	TOC	Pb-210 CS-137 dating	Grain Size	Metals (7)	PCB's only
		C3-23	268548	42	40	1	✓		✓			
		C3-25	8549			1	✓		✓			
		C3-A	8550			4		✓		✓	✓	✓
		C3-B	8551			2					✓	✓
		C3-C	8552			2					✓	✓
		C3-D	8553			2					✓	✓
		C3-E	8554			2					✓	✓
		C3-F	8555			2					✓	✓
		C3-G	8556			2					✓	✓
		C3-H	8557			2					✓	✓
		C3-AD	8558			2		✓		✓		
		C3-CD	8559			2					✓	✓

General Chemistry: Alkalinity, Conductivity, Hardness, pH, Turbidity, ☐ Chloride ☐ Sulfate, Cyanide ☐ Total ☐ Weak, Total Solids, Total Nonvolatile Solids, Total Suspended Solids, Total Nonvol Suspend, Total Dissolved Solids, ☒ %Solids ☐ %Vol. Solids, TOC, BOD (5 day), Oil & Grease, Ammonia, Nitrate-Nitrite, Total Phosphorous, Orthophosphorous, Nitrate, Nitrite, ☐ TPN ☐ TKN, Pb-210 CS-137 dating, Grain Size

Micro: Fecal Coliforms ☐ MF ☐ MPN, Total Coliforms, E-Coli, %Klebsiella

Biology: Ceriodaphnia ☐ acute ☐ chron, D magna ☐ acute ☐ chron, D pulex ☐ acute ☐ chron, Fathead minnow, Microtox, Salmonid, Salmonid Haz Waste

Metals: ☒ Total ☐ Total Rec; ICP Scan, PP Metals, TCLP Metals, Cd Cr Cu Ni Pb Zn, Mercury (Hg), Metals (7)

Organic Chemistry: BNA ☐ CLP TIC's ☐ No TIC's, BNA w/ extensive TIC's, PAH's, VOA ☐ CLP TIC's ☐ No TICs, VOA w/ extensive TIC's, BTEX, Organo Chlorine Pests/PCB's, PCB's only, Organophosphorous Pests, Chlorophenoxy Herbs, WTPH-HCID, WTPH-G, WTPH-D, WTPH-418.1 Modified, AED screen

oject Officer: Dale Norton
can number: 407-6765
amplers: Dale Norton
B. Bernard
L. Weiss

order: Dale Norton
6/28/94

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		94	06	28	15	00			
	Don Cowey	94	06	29	13	20			

Comments: See Page #2 for Note

Rev. 12/93

ne: Elliott Bay Recontamination

3C00

Results to: Dale Norton **Mail Stop:** 7710

LABORATORY ANALYSES REQUIRED

Page 6 of 6

☐ Preliminary Investigation
☒ Monitoring

☐ For HW Designation
☐ For NPDES

Results needed by 8/12/94

mpling

Year: 4

Mo	Da	Time Hr	Time Mn	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers	General Chemistry: ☒ %Solids	Cs-137 / Pb-210 dating
	24			C3-9D	2685604	42	40	1	✓	✓
	↓			C3-5D	↓8561			(1)	✓	✓

General Chemistry: Alkalinity; Conductivity; Hardness; pH; Turbidity; ☐ Chloride ☐ Sulfate; Cyanide ☐ Total ☐ Weak; Total Solids; Total Nonvolatile Solids; Total Suspended Solids; Total Nonvol Suspend; Total Dissolved Solids; ☒ %Solids ☐ %Vol. Solids; TOC; BOD (5 day); Oil & Grease; Ammonia; Nitrate-Nitrite; Total Phosphorous; Orthophosphorous; Nitrate; Nitrite; ☐ TPN ☐ TKN; Cs-137 / Pb-210 dating

Micro: Fecal Coliforms☐ MF ☐ MPN; Total Coliforms; E-Coli; %Klebsiella

Biology: Ceriodaphnia ☐ acute ☐ chron; D magna ☐ acute ☐ chron; D pulex ☐ acute ☐ chron; Fathead minnow; Microtox; Salmonid; Salmonid Haz Waste

Metals: ☐ Total ☐ Total Rec; ICP Scan; PP Metals; TCLP Metals; Cd Cr Cu Ni Pb Zn; Mercury (Hg)

Organic Chemistry: BNA ☐ CLP TIC's ☐ No TIC's; BNA w/ extensive TIC's; PAH's; VOA ☐ CLP TIC's ☐ No TIC's; VOA w/ extensive TIC's; BTEX; Organo Chlorine Pests/PCB's; PCB's only; Organophosphorous Pests; Chlorophenoxy Herbs; WTPH-HCID; WTPH-G; WTPH-D; WTPH-418.1 Modified; AED screen

Project Officer: Dale Norton
can number: 407-6765
mplers: Dale Norton
B. Barnard
L. Weiss

der: Dale Norton
6/28/94

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		94	06	28	15	00			
	Pam Covey	94	06	29	13	20			

Comments: See notes on page #2

5 Rev. 12/93

Sampl ubmitted for analysis July 1994 (3rd quarter) for Elliott Bay Waterfront Recontamination Study.

Station I	Sample#	Trap #1	Station ID	Sample#	Trap #2	Station ID	Sample#	Composite Traps 1 + 2
EB1-S (Surface)			EB1-S					
1A	298500	%S	2A	298502	%S	EB-1SOC	298504	TOC,Metals,Semiv.,PCBs.Pb-210,GS
1B	298501	%S	2B	298503	%S			
EB1-B (Bottom)			EB1-B					
1A	298505	%S	2A	298507	%S	EB1-BOC	298509	TOC,Metals,Semiv.,PCBs.Pb-210,GS
1B	298506	%S	2B	298508	%S			
EB2-			EB2-					
1A	298510	%S	2A	298512	%S	EB2-OC	298514	TOC,Metals,Semiv.,PCBs.Pb-210,GS
1B	298511	%S	2B	298513	%S			
EB3-			EB3-					
1A	298515	%S	2A	298517	%S	EB3-OC	298519	TOC,Metals,Semiv.,PCBs.Pb-210,GS
1B	298516	%S	2B	298518	%S			
EB4-			EB4-					
1A	298520	%S	2A	298522	%S	EB4-OC	298524	TOC,Metals,Semiv.,PCBs.Pb-210,GS
1B	298521	%S	2B	298523	%S	EB4-OCD	298525	TOC,Metals,Semiv.,PCBs.Pb-210,GS
EB5-			EB5-					
1A	298526	%S	2A	298528	%S	EB5-OC	298530	TOC,Metals,Semiv.,PCBs.Pb-210,GS
1B	298527	%S	2B	298529	%S			
EB6-S (Surface)			EB6-S					
1A	298531	%S	2A	298533	%S	EB6-SOC	298535	TOC,Metals,Semiv.,PCBs.Pb-210,GS
1B	298532	%S	2B	298534	%S			
EB6-B (Bottom)			EB6-B					
1A	298536	%S	2A	298538	%S	EB6-BOC	298540	TOC,Metals,Semiv.,PCBs.Pb-210,GS
1B	298537	%S	2B	298539	%S			
EB7-			EB7-					
1A	298541	%S	2A	298544	%S	EB7-OC	-	-
1B	298542	%S	2B	298545	%S			
1C	298543	TOC,Metals,Semiv.,PCBs.Pb-210,GS	2C	298546	TOC,Metals,Semiv.,PCBs.Pb-210,GS			
EB8-			EB8-					
1A	298547	%S(dup)-298548	2A	298550	%S	EB8-OC	298552	TOC,Metals,Semiv.,PCBs.Pb-210,GS
1B	298549	%S	2B	298551	%S			
EB9-			EB9-					
1A	298553	%S	2A	298555	%S	EB9-OC	298557	TOC,Metals,Semiv.,PCBs.Pb-210,GS
1B	298554	%S	2B	298556	%S			

GS-Grain Size Seive and pipet portion only

Metals (11)=Al,As,Cd,Cr,Cu,Fe,Pb,Mn,Hg,Ag,Zn)

Reference Materials

HS-6 (PAH) NRCC in duplicate

HS-2 (PCBs) NRCC in duplicate

#1646 (Metals) NIST in duplicate

Minimum Sample Volumes (wet grams)	
%S	5-10
Grain Size	10-20
TOC	5-10
Metals	10-15
Semivolatiles	20-25
PCBs	20-25
Pb-210	10-15
Total=	80-120

roject N[illegible]e: Elliott Bay Recontamination

LABORATORY ANALYSES REQUIRED

Page 1 of 5

IC: D3C00

end Results to: Dale Norton Mail Stop: 7710

☐ Preliminary Investigation
☒ Monitoring

☐ For HW Designation
☐ For NPDES

Results needed by 9/7/94 (45 days)

Sampling: Year: 94

Metals: ☒ Total ☐ Total Rec

Organic Chemistry: BNA ☒ CLP TIC's ☐ No TIC's

Da	Hr	Mn	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers	%Solids	TOC	Grain Size	Pb-210	Metals(11)	BNA	Organo Chlorine Pests/PCB's
20			EB1S-1A	298500	40	40	1	✓						
			-1B	8501			1	✓						
			-2A	8502			1	✓						
			-2B	8503			1	✓						
			EB1S-0C	8504			6		✓	✓	✓	✓	✓	✓
			EB1B-1A	8505			1	✓						
			-1B	8506			1	✓						
			-2A	8507			1	✓						
			-2B	8508			1	✓						
			EB1B-0C	8509			6		✓	✓	✓	✓	✓	✓
			EB2-1A	8510			1	✓						
			-1B	8511			1	✓						

ct Officer: Dale Norton
number: 407-6765
lers: Dale Norton
Dave Serdar
Rob Barnard

der: Dale Norton
7/20/94

Rev. 12/93

Chain of Custody Record

Relinquished By:	Received By:	Yr Mo Da Hr Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		940720 1500			
	Pam Covey	940721 1130			

Comments: Metals(11) = Al, As, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Ag and Zn
Reference materials = HS-2, HS-6 and NIST 1646 in duplicate
Battelle Sequim doing Pb-210

LABORATORY ANALYSES REQUIRED

Project Name: Elliott Bay Recontamination
PIC: D3C00
Send Results to: Dale Norton Mail Stop: 7710

☐ Preliminary Investigation
☒ Monitoring
☐ For HW Designation
☐ For NPDES

Results needed by 9/7/94

General Chemistry: Alkalinity; Conductivity; Hardness; pH; Turbidity; ☐ Chloride ☐ Sulfate; Cyanide ☐ Total ☐ Weak; Total Solids; Total Nonvolatile Solids; Total Suspended Solids; Total Nonvol Suspend; Total Dissolved Solids; ☒ %Solids ☐ %Vol. Solids; TOC; BOD (5 day); Oil & Grease; Ammonia; Nitrate-Nitrite; Total Phosphorous; Orthophosphorous; Nitrate; Nitrite; ☐ TPN ☐ TKN; Grain Size; Pb-210

Micro: Fecal Coliforms ☐ MF ☐ MPN; Total Coliforms; E-Coli; %Klebsiella

Biology: Ceriodaphnia ☐ acute ☐ chron; D magna ☐ acute ☐ chron; D pulex ☐ acute ☐ chron; Fathead minnow; Microtox; Salmonid; Salmonid Haz Waste

Metals: ☒ Total ☐ Total Rec; ICP Scan; PP Metals; TCLP Metals; Cd Cr Cu Ni Pb Zn; Mercury (Hg); [illegible]

Organic Chemistry: BNA ☒ CLP TIC's ☐ No TIC's; BNA w/ extensive TIC's; PAH's; VOA ☐ CLP TIC's ☐ No TIC's; VOA w/ extensive TIC's; BTEX; Organo Chlorine Pests/PCB's; PCB's only; Organophosphorous Pests; Chlorophenoxy Herbs; WTPH-HCID; WTPH-G; WTPH-D; WTPH-418.1 Modified; AED screen

Sampling Date Da	Time Hr	Time Mn	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers	%Solids	TOC	Grain Size	Pb-210	Metals [illegible]	BNA CLP TIC's	PCB's only
0			EB2-2A	298512	40	40	1	✓						
			-2B	8513			1	✓						
			EB2-0C	8514			6		✓	✓	✓	✓	✓	✓
			EB3-1A	8515			1	✓						
			-1B	8516			1	✓						
			-2A	8517			1	✓						
			-2B	8518			1	✓						
			EB3-0C	8519			6		✓	✓	✓	✓	✓	✓
			EB4-1A	8520			1	✓						
			-1B	8521			1	✓						
			-2A	8522			1	✓						
			-2B	8523			1	✓						

ct Officer: Dale Norton
n number: 407-6765
mplers: Dale Norton
Dave Serdor
Bob Barnard

Dale Norton
Bolay

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		94	07	20	15	00			
	Pam Covey	94	07	21	11	30			

Comments: See page 1

Rev. 12/91

oject N ne: Elliott Bay Recontamination **LABORATORY ANALYSES REQUIRED** Page 3 of 5

D3C00

Results to: Dale Norton Mail Stop: 7710

☐ Preliminary Investigation
☒ Monitoring

☐ For HW Designation
☐ For NPDES

Results needed by 9/7/94

							General Chemistry				Metals	Organic Chemistry	
Date Da	Time Hr	Mn	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers	☐ %Solids ☐ %Vol. Solids	TOC	Grain Size	Pb-210	Metals (11)	BNA ☑ CLP TIC's ☐ No TIC's	PCB's only
			EB4-0C	298524	40	40	6		✓	✓	✓	✓	✓	✓
			-0CD	8525			6		✓	✓	✓	✓	✓	✓
			EB5-1A	8526			1	✓						
			-1B	8527			1	✓						
			-2A	8528			1	✓						
			-2B	8529			1	✓						
			EB5-0C	8530			6		✓	✓	✓	✓	✓	✓
			EB6S-1A	8531			1	✓						
			-1B	8532			1	✓						
			-2A	8533			1	✓						
			-2B	8534			1	✓						
			EB6S-0C	8535			6		✓	✓	✓	✓	✓	✓

General Chemistry: Alkalinity, Conductivity, Hardness, pH, Turbidity, ☐ Chloride ☐ Sulfate, Cyanide ☐ Total ☐ Weak, Total Solids, Total Nonvolatile Solids, Total Suspended Solids, Total Nonvol Suspend, Total Dissolved Solids, ☐ %Solids ☐ %Vol. Solids, TOC, BOD (5 day), Oil & Grease, Ammonia, Nitrate-Nitrite, Total Phosphorous, Orthophosphorous, Nitrate, Nitrite, ☐ TPN ☐ TKN, Grain Size, Pb-210

Micro: Fecal Coliforms ☐ MF ☐ MPN, Total Coliforms, E-Coli, %Klebsiella

Biology: Ceriodaphnia ☐ acute ☐ chron, D magna ☐ acute ☐ chron, D pulex ☐ acute ☐ chron, Fathead minnow, Microtox, Salmonid, Salmonid Haz Waste

Metals: ☒ Total ☐ Total Rec, ICP Scan, PP Metals, TCLP Metals, Cd Cr Cu Ni Pb Zn, Mercury (Hg), Metals (11)

Organic Chemistry: BNA ☑ CLP TIC's ☐ No TIC's, BNA w/ extensive TIC's, PAH's, VOA ☐ CLP TIC's ☐ No TICs, VOA w/ extensive TIC's, BTEX, Organo Chlorine Pests/PCB's, PCB's only, Organophosphorous Pests, Chlorophenoxy Herbs, WTPH-HCID, WTPH-G, WTPH-D, WTPH-418.1 Modified, AED screen

fficer: Dale Norton
mber: 407-6765
Dale Norton
Dave Serdar
Bob Barnard

Dale Norton
7/20/94

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		94	07	20	15	00			
	Pam Covey	94	07	21	11	30			

Comments: See page 1

12 93

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LABORATORY ANALYSES REQUIRED

roject N e: Elliott Bay Recontamination

D3C00

end Results to: Dale Norton   Mail Stop: 7710

☐ Preliminary Investigation
☒ Monitoring

☐ For HW Designation
☐ For NPDES

Results needed by 9/7/94

Sampling Da	Hr	Mn	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers
20			EB6B-1A	298536	40	40	1
			-1B	8537			1
			-2A	8538			1
			-2B	8539			1
			EB6B-0C	8540			6
			EB7-1A	8541			1
			-1B	8542			1
			-1C	8543			6
			-2A	8544			1
			-2B	8545			1
			-2C	8546			6
			EB8-1A	8547			1

General Chemistry

Lab Sample Number	Alkalinity	Conductivity	Hardness	pH	Turbidity	☐ Chloride ☐ Sulfate	Cyanide ☐ Total ☐ Weak	Total Solids	Total Nonvolatile Solids	Total Suspended Solids	Total Nonvol Suspend	Total Dissolved Solids	☒ %Solids ☐ %Vol. Solids	TOC	BOD (5 day)	Oil & Grease	Ammonia	Nitrate-Nitrite	Total Phosphorous	Orthophosphorous	Nitrate	Nitrite	☐ TPN ☐ TKN	Grain Size	Pb-210
298536													✓												
8537													✓												
8538													✓												
8539													✓												
8540														✓										✓	✓
8541													✓												
8542													✓												
8543														✓										✓	✓
8544													✓												
8545													✓												
8546														✓										✓	✓
8547													✓												

Micro / Biology

Lab Sample Number	Fecal Coliforms ☐ MF ☐ MPN	Total Coliforms	E-Coli	%Klebsiella	Ceriodaphnia ☐ acute ☐ chron	D magna ☐ acute ☐ chron	D pulex ☐ acute ☐ chron	Fathead minnow	Microtox	Salmonid	Salmonid Haz Waste
298536											
8537											
8538											
8539											
8540											
8541											
8542											
8543											
8544											
8545											
8546											
8547											

Metals (☒ Total ☐ Total Rec)

Lab Sample Number	ICP Scan	PP Metals	TCLP Metals	Cd Cr Cu Ni Pb Zn	Mercury (Hg)	m-to/5(11)
298536						
8537						
8538						
8539						
8540						✓
8541						
8542						
8543						✓
8544						
8545						
8546						✓
8547						

Organic Chemistry

Lab Sample Number	BNA ☒ CLP TIC's ☐ No TIC's	BNA w/ extensive TIC's	PAH's	VOA ☐ CLP TIC's ☐ No TICs	VOA w/ extensive TIC's	BTEX	Organo Chlorine Pests/PCB's	PCB's only	Organophosphorous Pests	Chlorophenoxy Herbs	WTPH-HCID	WTPH-G	WTPH-D	WTPH-418.1 Modified	AED screen
298536															
8537															
8538															
8539															
8540	✓							✓							
8541															
8542															
8543	✓							✓							
8544															
8545															
8546	✓							✓							
8547															

Officer: Dale Norton
number: 407-6765
plers: Dale Norton
Dave Serdar
Bob Barnard

corder: Dale Norton
Date: 7/20/94

040-115 Rev. 12/93

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		94	07	20	15	00			
	Pam Covey	94	07	21	11	30			

Comments: See page 1

LABORATORY ANALYSES REQUIRED

ct ne: Elliott Bay Recontamination
D3C00
nd Results to: Dale Norton Mail Stop: 7710

☐ Preliminary Investigation
☒ Monitoring
☐ For HW Designation
☐ For NPDES

Results needed by 9/7/94

Sampling ate	Sampling Time Hr Mn	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers	☒ %Solids ☐ %Vol. Solids	TOC	Grain Size	Pb-210
		EB8-1AD	298548	40	40	1	✓			
		-1B	8549			1	✓			
		-2A	8550			1	✓			
		-2B	8551			1	✓			
		EB8-0C	8552			6		✓	✓	✓
		EB9-1A	8553			1	✓			
		-1B	8554			1	✓			
		-2A	8555			1	✓			
		-2B	8556			1	✓			
		EB9-0C	8557			6		✓	✓	✓

General Chemistry columns (no entries): Alkalinity, Conductivity, Hardness, pH, Turbidity, ☐ Chloride ☐ Sulfate, Cyanide ☐ Total ☐ Weak, Total Solids, Total Nonvolatile Solids, Total Suspended Solids, Total Nonvol Suspend, Total Dissolved Solids, BOD (5 day), Oil & Grease, Ammonia, Nitrate-Nitrite, Total Phosphorous, Orthophosphorous, Nitrate, Nitrite, ☐ TPN ☐ TKN

Micro (no entries): Fecal Coliforms ☐ MF ☐ MPN, Total Coliforms, E-Coli, %Klebsiella

Biology (no entries): Ceriodaphnia ☐ acute ☐ chron, D magna ☐ acute ☐ chron, D pulex ☐ acute ☐ chron, Fathead minnow, Microtox, Salmonid, Salmonid Haz Waste

Metals ☐ Total ☐ Total Rec: ICP Scan, PP Metals, TCLP Metals, Cd Cr Cu Ni Pb Zn, Mercury (Hg)

Organic Chemistry: BNA w/ extensive TIC's, PAH's, VOA ☐ CLP TIC's ☐ No TIC's, VOA w/ extensive TIC's, BTEX, Organo Chlorine Pests/PCB's, Organophosphorous Pests, Chlorophenoxy Herbs, WTPH-HCID, WTPH-G, WTPH-D, WTPH-418.1 Modified, AED screen

Field Station Identification	Lab Sample Number	Metals (11)	BNA ☒ CLP TIC's ☐ No TIC's	PCB's only
EB8-1AD	298548			
-1B	8549			
-2A	8550			
-2B	8551			
EB8-0C	8552	✓	✓	✓
EB9-1A	8553			
-1B	8554			
-2A	8555			
-2B	8556			
EB9-0C	8557	✓	✓	✓

Project Officer: Dale Norton
Scan number: 407-6765
Samplers: Dale Norton
Dave Serdar
Bob Barnard

Recorder: Dale Norton
Date: 7/20/94

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		94	07	20	15	00			
	Tom Cluy	94	07	21	11	30			

Comments: See page 1

ECY 040-115 Rev. 12/93

Particulate samples submitted for analysis October 1994 (4th Quarter) for Elliott Bay Recontamination Study.

Station ID	Sample #	Trap 1	Station ID	Sample #	Trap 2	Station ID	Sample #	Composite Traps 1 + 2
EB1-S (Surface)			EB1-S					
1A	428400	%S	2A	428402	%S	EB1-SOC	428404	TOC,Metals,Semiv.,PCBs,GS
1B	428401	%S	2B	428403	%S			
EB1-B (Bottom)			EB1-B					
1A	428405	%S	2A	- -		EB1-BOC	- -	
1B	428506	%S	2B	- -				
1C	428407	TOC,Metals,Semiv.,PCBs						
EB2-			EB2-					
1A	428408	%S	2A	428410	%S	EB2-OC	428412	TOC,Metals,Semiv.,PCBs,GS
1B	428409	%S	2B	428411	%S			
EB3-			EB3-					
1A	428413	%S	2A	428416	%S	EB3-OC	- -	
1B	428414	%S	2B	428417	%S			
1C	428415	TOC,Metals,Semiv.,PCBs,GS	2C	428418	TOC,Metals,Semiv.,PCBs,GS			
EB4-			EB4-					
1A	428419	%S	2A	428421	%S	EB4-OC	428423	TOC,Metals,Semiv.,PCBs,GS
1B	428420	%S	2B	428422	%S	EB4-OCD	428424	TOC,Metals,Semiv.,PCBs,GS
EB5-			EB5-					
1A	428425	%S	2A	428427	%S	EB5-OC	428429	TOC,Metals,Semiv.,PCBs,GS
1B	428426	%S	2B	428428	%S			
EB6-S (Surface)			EB6-S					
1A	428430	%S	2A	428432	%S	EB6-SOC	428434	TOC,Metals,Semiv.,PCBs,GS
1B	428431	%S	2B	428433	%S			
EB6-B (Bottom)			EB6-B					
1A	428435	%S	2A	428437	%S	EB6-BOC	428439	TOC,Metals,Semiv.,PCBs,GS
1B	428436	%S	2B	428438	%S			
EB7-			EB7-					
1A	428440	%S	2A	-		EB7-OC	428443	TOC,Metals,Semiv.,PCBs,GS
1B	428441	%S	2B	428442	%S			
EB8-			EB8-					
1A	428444	%S(dup)-428445	2A	428447	%S	EB8-OC*	428449	TOC,Metals,Semiv.,PCBs,GS
1B	428446	%S	2B	428448	%S			
EB9-			EB9-					
1A	428450	%S	2A	428452	%S	EB9-OC	428454	TOC,Metals,Semiv.,PCBs,GS
1B	428451	%S	2B	428453	%S			

-=No sample

Metals (11)- Al,As,Cd,Cr,Cu,Fe,Pb,Mn,Hg,Ag,Zn

Reference Materials (Organics)-analyzed in duplicate HS-2(PCB), HS-6(PAH)

Reference Material (Metals)- analyzed in duplicate ERA 216

*= Extra sample submitted for matrix spike and spike duplicate (semiv and PCBs)

LABORATORY ANALYSES REQUIRED

Page 1 of 5

Project Name: Elliott Bay Recontamination

IC: D3C00

Send Results to: Dale Norton   Mail Stop: 7710

☐ Preliminary Investigation
☒ Monitoring
☐ For HW Designation
☐ For NPDES

Results needed by Dec 5th (45 days)

Sampling Date Year: 94

General Chemistry: Alkalinity, Conductivity, Hardness, pH, Turbidity, ☐ Chloride ☐ Sulfate, Cyanide ☐ Total ☐ Weak, Total Solids, Total Nonvolatile Solids, Total Suspended Solids, Total Nonvol Suspend, Total Dissolved Solids, ☒ %Solids ☐ %Vol. Solids, [✓ TOC], BOD (5 day), Oil & Grease, Ammonia, Nitrate-Nitrite, Total Phosphorous, Orthophosphorous, Nitrate, Nitrite, ☐ TPN ☐ TKN, Grain Size

Micro: Fecal Coliforms ☐ MF ☐ MPN, Total Coliforms, E-Coli, %Klebsiella

Biology: Ceriodaphnia ☐ acute ☐ chron, D magna ☐ acute ☐ chron, D pulex ☐ acute ☐ chron, Fathead minnow, Microtox, Salmonid, Salmonid Haz Waste

Metals: ☒ Total ☐ Total Rec, ICP Scan, PP Metals, TCLP Metals, Cd Cr Cu Ni Pb Zn, Mercury (Hg), Metals (11)

Organic Chemistry: BNA ☒ [✓ CLP TIC's] ☐ No TIC's, BNA w/ extensive TIC's, PAH's, VOA ☐ CLP TIC's ☐ No TIC's, VOA w/ extensive TIC's, BTEX, Organo Chlorine Pests/PCB's, [✓ PCB's only], Organophosphorous Pests, Chlorophenoxy Herbs, WTPH-HCID, WTPH-G, WTPH-D, WTPH-418.1 Modified, AED screen

Mo	Da	Hr	Mn	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers	TOC	Grain Size	Metals (11)	BNA	PCB's only
	20			EB15-1A	428400	40	42	1	✓				
				-1B	8401			1	✓				
				-2A	8402			1	✓				
				-2B	8403			1	✓				
				-0C	8404			5	✓	✓	✓	✓	✓
				EB18-1A	8405			1	✓				
				-1B	8406			1	✓				
				-1C	8407			4	✓		✓	✓	✓
				EB2-1A	8408			1	✓				
				-1B	8409			1	✓				
				-2A	8410			1	✓				
				-2B	8411			1	✓				

*

ject Officer: D. Norton
n number: 407-6765
plers: Dale Norton
Craig Wilson

dor: Dale Norton
10/20/94

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		94	10	20	15	00			
	Pam Covey	94	10	21	09	15			

Comments: metals(11) = Al, As, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Ag, Zn
QA per previous Sample Sets - Refer to Alabel sheet for Reference Materials

LABORATORY ANALYSES REQUIRED

Page 2 of 5

roject Name: Elliott Bay Recontamination

IC: D3C00

end Results to: DN   Mail Stop: 7710

☐ Preliminary Investigation
☒ Monitoring

☐ For HW Designation
☐ For NPDES

Results needed by 12/5/94

General Chemistry: Alkalinity, Conductivity, Hardness, pH, Turbidity, ☐ Chloride ☐ Sulfate, Cyanide ☐ Total ☐ Weak, Total Solids, Total Nonvolatile Solids, Total Suspended Solids, Total Nonvol Suspend, Total Dissolved Solids, ☒ %Solids ☐ %Vol. Solids, [✓ TOC], BOD (5 day), Oil & Grease, Ammonia, Nitrate-Nitrite, Total Phosphorous, Orthophosphorous, Nitrate, Nitrite, ☐ TPN ☐ TKN, Grain size

Micro: Fecal Coliforms ☐ MF ☐ MPN, Total Coliforms, E-Coli, %Klebsiella

Biology: Ceriodaphnia ☐ acute ☐ chron, D magna ☐ acute ☐ chron, D pulex ☐ acute ☐ chron, Fathead minnow, Microtox, Salmonid, Salmonid Haz Waste

Metals: ☒ Total ☐ Total Rec, ICP Scan, PP Metals, TCLP Metals, Cd Cr Cu Ni Pb Zn, Mercury (Hg), Metals (11)

Organic Chemistry: BNA ☒ CLP TIC's ☐ No TIC's, BNA w/ extensive TIC's, PAH's, VOA ☐ CLP TIC's ☐ No TIC's, VOA w/ extensive TIC's, BTEX, Organo Chlorine Pests/PCB's, [✓ PCB's only], Organophosphorous Pests, Chlorophenoxy Herbs, WTPH-HCID, WTPH-G, WTPH-D, WTPH-418.1 Modified, AED screen

Date (Year: '9?) Da	Time Hr	Time Mn	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers	TOC	Grain size	Metals (11)	BNA	PCB's only
20			EB2-0C	428412	40	42	5	✓	✓	✓	✓	✓
			EB3-1A	8413			1	✓				
			-1B	8414			1	✓				
			-1C	8415			5	✓	✓	✓	✓	✓
			-2A	8416			1	✓				
			-2B	8417			1	✓				
			-2C	8418			5	✓	✓	✓	✓	✓
			EB4-1A	8419			1	✓				
			-1B	8420			1	✓				
			-2A	8421			1	✓				
			-2B	8422			1	✓				
			-0C	8423			5	✓	✓	✓	✓	✓

ct Officer: DN
number: 407-6765
ers: DN
CW

der: DN
10/20/94

Rev. 12/93

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		94	10	20	15	00			
	Pam Covey	94	10	21	09	15			

Comments: See Sheet #1 For QA   Metals(11) = See Sheet #1

LABORATORY ANALYSES REQUIRED

oject Name: Elliott Bay Recontamination

C: D3C00

nd Results to: DN

Mail Stop: 7710

☐ Preliminary Investigation
☒ Monitoring

☐ For HW Designation
☐ For NPDES

Results needed by 12/5/94

Sampling

Date	Time Hr	Time Mn	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers
			EB4-0CD	428424	40	42	5
			EB5-1A	8425			1
			-1B	8426			1
			-2A	8427			1
			-2B	8428			1
			-0C	8429			5
			EB6S-1A	8430			1
			-1B	8431			1
			-2A	8432			1
			-2B	8433			1
			-0C	8434			5
			EB6B-1A	8435			1

General Chemistry

Lab Sample Number	Alkalinity	Conductivity	Hardness	pH	Turbidity	☐ Chloride ☐ Sulfate	Cyanide ☐ Total ☐ Weak	Total Solids	Total Nonvolatile Solids	Total Suspended Solids	Total Nonvol Suspend	Total Dissolved Solids	☒ %Solids ☐ %Vol. Solids	TOC	BOD (5 day)	Oil & Grease	Ammonia	Nitrate-Nitrite	Total Phosphorous	Orthophosphorous	Nitrate	Nitrite	☐ TPN ☐ TKN	Grain Size
428424														✓										✓
8425													✓											
8426													✓											
8427													✓											
8428													✓											
8429														✓										✓
8430													✓											
8431													✓											
8432													✓											
8433													✓											
8434														✓										✓
8435													✓											

Micro / Biology

Lab Sample Number	Fecal Coliforms ☐ MF ☐ MPN	Total Coliforms	E-Coli	%Klebsiella	Ceriodaphnia ☐ acute ☐ chron	D magna ☐ acute ☐ chron	D pulex ☐ acute ☐ chron	Fathead minnow	Microtox	Salmonid	Salmonid Haz Waste
428424											
8425											
8426											
8427											
8428											
8429											
8430											
8431											
8432											
8433											
8434											
8435											

Metals (☒ Total ☐ Total Rec) / Organic Chemistry

Lab Sample Number	ICP Scan	PP Metals	TCLP Metals	Cd Cr Cu Ni Pb Zn	Mercury (Hg)	Metals (11)	BNA ☒ CLP TIC's ☐ No TIC's	BNA w/ extensive TIC's	PAH's	VOA ☐ CLP TIC's ☐ No TICs	VOA w/ extensive TIC's	BTEX	Organo Chlorine Pests/PCB's	PCB's only	Organophosphorous Pests	Chlorophenoxy Herbs	WTPH-HCID	WTPH-G	WTPH-D	WTPH-418.1 Modified	AED screen
428424						✓	✓							✓							
8425																					
8426																					
8427																					
8428																					
8429						✓	✓							✓							
8430																					
8431																					
8432																					
8433																					
8434						✓	✓							✓							
8435																					

Officer: DN
umber: 407-6765
pers: DN
CW

/94

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		94	10	20	15	00			
	Pam Covey	94	10	21	09	15			

Comments: See sheet #1 for QA and Metals (11)

Project Name: Elliott Bay Recontamination **LABORATORY ANALYSES REQUIRED**

D3C00

Results to: DN Mail Stop: 7710

☐ Preliminary Investigation
☒ Monitoring

☐ For HW Designation
☐ For NPDES

Results needed by 12/5/94

Sampling

Year:

Date Da	Time Hr	Time Mn	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers	Alkalinity	Conductivity	Hardness	pH	Turbidity	☐ Chloride ☐ Sulfate	Cyanide ☐ Total ☐ Weak	Total Solids	Total Nonvolatile Solids	Total Suspended Solids	Total Nonvol Suspend	Total Dissolved Solids	☒ %Solids ☐ %Vol. Solids	TOC	BOD (5 day)	Oil & Grease	Ammonia	Nitrate-Nitrite	Total Phosphorous	Orthophosphorous	Nitrate	Nitrite	☐ TPN ☐ TKN	Grain Size
20			EB6-1B	4128436	40	42	1													✓											
			-2A	8437			1													✓											
			-2B	8438			1													✓											
			-0C	8439			5														✓										✓
			EB7-1A	8440			1													✓											
			-1B	8441			1													✓											
			-2B	8442			1													✓											
			-0C	8443			5														✓										✓
			EB8-1A	8444			1													✓											
			-1AD	8445			1													✓											
			-1B	8446			1													✓											
			-2A	8447			1													✓											

Field Station Identification	Fecal Coliforms ☐ MF ☐ MPN	Total Coliforms	E-Coli	%Klebsiella	Ceriodaphnia ☐ acute ☐ chron	D magna ☐ acute ☐ chron	D pulex ☐ acute ☐ chron	Fathead minnow	Microtox	Salmonid	Salmonid Haz Waste	ICP Scan	PP Metals	TCLP Metals	Cd Cr Cu Ni Pb Zn	Mercury (Hg)	M-tals (11)	BNA ☒ CLP TIC's ☐ No TIC's	BNA w/ extensive TIC's	PAH's	VOA ☐ CLP TIC's ☐ No TICs	VOA w/ extensive TIC's	BTEX	Organo Chlorine Pests/PCB's [✓ PCB's only]	Organophosphorous Pests	Chlorophenoxy Herbs	WTPH-HCID	WTPH-G	WTPH-D	WTPH-418.1 Modified	AED screen
EB6-1B																															
-2A																															
-2B																															
-0C																	✓	✓						✓							
EB7-1A																															
-1B																															
-2B																															
-0C																	✓	✓						✓							
EB8-1A																															
-1AD																															
-1B																															
-2A																															

Officer: DN
Number: 07-6765
rs: DN
DW

ter DN
10/20/94

Rev. 12/93

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		94	10	20	15	00			
	Pam Covey	94	10	21	09	15			

Comments: ~~[illegible]~~ See Sheet #1 for QA and metals (11) ct Name: Elliott Bay Recontamination

D3C00

Results to: DN Mail Stop: 7710

LABORATORY ANALYSES REQUIRED

Page 5 of 5

☐ Preliminary Investigation
☒ Monitoring

☐ For HW Designation
☐ For NPDES

Results needed by 12/5/94

mpling

General Chemistry: Alkalinity, Conductivity, Hardness, pH, Turbidity, ☐ Chloride ☐ Sulfate, Cyanide ☐ Total ☐ Weak, Total Solids, Total Nonvolatile Solids, Total Suspended Solids, Total Nonvol Suspend, Total Dissolved Solids, ☒ %Solids ☐ %Vol. Solids, TOC, BOD (5 day), Oil & Grease, Ammonia, Nitrate-Nitrite, Total Phosphorous, Orthophosphorous, Nitrate, Nitrite, ☐ TPN ☐ TKN, Grain Size

Micro: Fecal Coliforms ☐ MF ☐ MPN, Total Coliforms, E-Coli, %Klebsiella

Biology: Ceriodaphnia ☐ acute ☐ chron, D magna ☐ acute ☐ chron, D pulex ☐ acute ☐ chron, Fathead minnow, Microtox, Salmonid, Salmonid Haz Waste

Metals: ☒ Total ☐ Total Rec; ICP Scan, PP Metals, TCLP Metals, Cd Cr Cu Ni Pb Zn, Mercury (Hg), Metals(11)

Organic Chemistry: BNA ☒ CLP TIC's ☐ No TIC's, BNA w/ extensive TIC's, PAH's, VOA ☐ CLP TIC's ☐ No TIC's, VOA w/ extensive TIC's, BTEX, Organo Chlorine Pests/PCB's, [✓ PCB's only], Organophosphorous Pests, Chlorophenoxy Herbs, WTPH-HCID, WTPH-G, WTPH-D, WTPH-418.1 Modified, AED screen

Time Hr	Time Mn	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers	%Solids	TOC	Grain Size	Metals(11)	BNA	PCB's only
		EB8-2B	428448	40	42	1	✓					
		-0C*	8449			5		✓	✓	✓	✓	✓
		EB9-1A	8450			1	✓					
		-1B	8451			1	✓					
		-2A	8452			1	✓					
		-2B	8453			1	✓					
		-0C	8454	↓	↓	5		✓	✓	✓	✓	✓

fficer: DN
mber: 467-6765
DN
CW

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Dale Norton		94	10	20	15	00			
	Pam Covey	94	10	21	08	15			

Comments: See Sheet #1 for QA and Metals(11)

*Note: 2 XTRA Jars Submitted for 8449 for PCB and Semi-V. Matrix Spike/Spike Dup

der: DN
te 10/20/94

Rev. 12/93

CORE
LOGS

[illegible]

Elliott Bay Recontamination Study
Sediment Core Log

No life

Date = 6-24-94
Time = ~~[illegible]~~ 12:20 pm
Station C1 = C1
Location = ~~[illegible]~~
Lat -
Long-
Not available

LORAN
279 93.3
423 01.6

Water Depth (~~total ft~~) = 8 meters (26')
Equipment = 4 in barrel corer
Sediment Penetration (~~cm~~) = ~~[illegible]~~ 137 cm

{2.54 cm = 1 in

Sediment Recovery (cm) = 84 cm
After extrusion = 88 cm

Core Description

Interval (cm)	Description	
Top 0-15	Black, silty, oily	No visable life
15-27	Black, silty	No visable life
27-32	black, silty w/oil	No visable life
32-43	Black, silty	To Bottom
43-52	shell fragments, black silty w oil band	
52 - bottom (88)	black silty w grey silt interior	

Sediment Core Sectioning Log

0-20	One 2cm section every 5cm
20-50	One 2cm section every 10cm
50-bottom	One 2cm section to be based on core length (Max 10 Sections)
Bottom	One 2cm section

Interval (cm)	Label	Sample No.	Analysis
✓ 0-3	C1 - 1	268500	Sample (%S, ~~TOC, Grain Size, Metals(7), PCBs~~; Pb-210, Cs-137)
3-5	C1 - 2	—	Archive
✓ 5-7	C1 - 3	26 8501	Sample (%S, Pb-210, Cs-137)
7-10	C1 - 4	—	Archive
✓ 10-12	C1 - 5	26 8502	Sample (%S, Pb-210, Cs-137)
12-15	C1 - 6	—	Archive
✓ 15-17	C1 - 7	26 8503	Sample (%S, Pb-210, Cs-137)
17-20	C1 - 8	—	Archive
✓ 20-22	C1 - 9	26 8504	Sample (%S, Pb-210, Cs-137)
22-30	C1 - 10	—	Archive
✓ 30-32	C1 - 11	268505	Sample (%S, Pb-210, Cs-137)
32-40	C1 - 12	—	Archive
✓ 40-42	C1 - 13	268506	Sample (%S, Pb-210, Cs-137)
42-50	C1 - 14	—	Archive

Sample Log (Station=   ) continued

Note- No Cs-137 below ~~50~~52cm, intervals based on total core length

	Interval (cm)	Label	Sample No.	Analysis
✓	50-52	C1-15	268507	Sample (%S, Pb-210) ^Cs-137
	52-60	C1-16	—	Archive
✓	60-62	C1-17	268508	%S, Pb-210
	62-70	C1-18	—	Archive
✓	70-72	C1-19	268509	%S, Pb-210
	72-80	C1-20	—	Archive
✓	80-82	C1-21	268510	%S, Pb-210
✓	86-88	C1-22	268511	%S, Pb-210

Chemistry Sections

					Section
✓	0-5	C1-A	268512	TOC, GS, PCB, metals 7	1-2
✓	5-10	C1-B	268513	PCBs, metals (7)	3-4
✓	10-20	C1-C	268514	PCBs, metals (7)	5-8
✓	20-50	C1-D	268515	PCBs, metals (7)	9-14
✓	50-80	C1-E	268516	PCBs, metals (7)	15-20
✓	80-88	C1-F	268517	PCBs, metals (7)	21-2

Elliott Bay Recontamination Study
Sediment Core Log

		Collected but Discarded	2nd Core
Date	=	6-24-94	
Time	=	1:20 pm	1:40 pm
Station	=	C2	C2
Location	=	13	14 (at end of gangway)
Lat -			47° 36.33' N
Long-			122° 20.46' W
Water Depth (total ft)	=	9 meters	10 meters (33')
Equipment	=		4 in barrel
Sediment Penetration (cm)	=	91 inches	86 inches → 218.44 cm
Sediment Recovery (cm)	=	42 inches	40 inches → 101.6 cm
Measurement after extrusion	=		98 cm

Core Description

Interval (cm)	Description
Top 0-18 Top	Black, silty, some shell fragments, no visible sheen
18 - 36	Black, silty, shell fragments. visible sheen some organic debris
36 - 54.	Black silty, visible sheen, shell fragments
54 - 98	Black, silty, limited shell fragments, silty sand

LORAN → 279 94.1
423 01.7

Sediment Core Sectioning Log

0-20	One 2cm section every 5cm
20-50	One 2cm section every 10cm
50-bottom	One 2cm section to be based on core length (Max 10 Sections)
Bottom	One 2cm section

Interval (cm)	Label	Sample No.	Analysis
✓ 0-3	C2-1	268518	Sample (%S, ~~TOC, Grain Size, Metals(7), PCBs,~~ Pb-210, Cs-137)
3-5	C2-2	—	Archive
✓ 5-7	C2-3	268519	Sample (%S, Pb-210, Cs-137)
7-10	C2-4	—	Archive
✓ 10-12	C2-5	268520	Sample (%S, Pb-210, Cs-137)
12-15	C2-6	—	Archive
✓ 15-17	C2-7	268521	Sample (%S, Pb-210, Cs-137)
17-20	C2-8	—	Archive
✓ 20-22	C2-9	268522	Sample (%S, Pb-210, Cs-137)
22-30	C2-10	—	Archive
✓ 30-32	C2-11	268523	Sample (%S, Pb-210, Cs-137)
32-40	C2-12	—	Archive
✓ 40-42	C2-13	268524	Sample (%S, Pb-210, Cs-137)
42-50	C2-14	—	Archive

Sample Log (Station=   ) continued

Note- No Cs-137 below ~~30~~ 52cm, intervals based on total core length

	Interval (cm)	Label	Sample No.	Analysis	
✓	50-52	C2-15	268525	Sample (%S, Pb-210, Cs-137)	
	52-60	C2-16	–	Archive	
✓	60-62	C2-17	268526	%S Pb-210	
	62-70	C2-18	–	Archive	
✓	70-72	C2-19	268527	%S, Pb-210	
	72-80	C2-20	–	Archive	
✓	80-82	C2-21	268528	%S, Pb-210	
	82-90	C2-22	–	Archive	
✓	90-92	C2-23	268529	%S, Pb-210	
	92-95	C2-24	–	Archive	
✓	95-98	C2-25	268530	%S, Pb-210	
	Chemistry Sections				Section
✓	0-5	C2-A	268531	TOC, GS, PCB, Metals(7)	1-
✓	5-10	C2-B	268532	PCB, Metals (7)	3-
✓	10-20	C2-C	268533	PCB, Metals (7)	5-
✓	20-50	C2-D	268534	PCB, Metals (7)	9-1
✓	50-80	C2-E	268535	PCB, Metals (7)	15-
✓	80-98	C2-F	268536	PCB, Metals (7)	21-

North of Terminal 48

LORAN: 279 91.1
423 01.7

Elliott Bay Recontamination Study
Sediment Core Log

Date = 6-24-94
Time = 2:50 pm
Station = C3
Location = 15
GPS Lat - 47°36.05'
Long- 122° 20.32' (NAD 1983)
Water Depth (total ft) = 13 meters (43')
Equipment = 4" barrell
Sediment Penetration (cm) = 79 in = 200.7 cm
Sediment Recovery (cm) = 61 in = 155 cm
After Extrusion = 153 cm

(silty clay throut)

Core Description

Interval (cm)	Description
Top - 0-5	organic shell fragments, silty sand, grey
5-10	grey silty sand, organic debris, some shell fragments
10-18	shell fragments, org debris red worms present
18-38	Grey silt, shell fragments
38-46	silty
46-50	shell fragments
50-93	silty, grey
93-97	shell fragments

Core Description (Station=)- continued

Interval (cm)	Description
97 - 153 (bottom)	grey, silt uniform, more silty sand

Sediment Core Sectioning Log

0-20	One 2cm section every 5cm
20-50	One 2cm section every 10cm
50-bottom	One 2cm section to be based on core length (Max 10 Sections)
Bottom	One 2cm section

Interval (cm)	Label	Sample No.	Analysis
✓ 0-3	C3-1	268537	Sample (%S, ~~TOC, Grain Size, Metals(7), PCBs,~~ Pb-210, Cs-137)
3-5	C3-2	—	Archive
✓ 5-7	C3-3	268538	Sample (%S, Pb-210, Cs-137)
7-10	C3-4	—	Archive
✓ 10-12	C3-5	268539	Sample (%S, Pb-210, Cs-137)
12-15	C3-6	—	Archive
✓ 15-17	C3-7	268540	Sample (%S, Pb-210, Cs-137)
17-20	C3-8	—	Archive
✓ 20-22	C3-9	268541	Sample (%S, Pb-210, Cs-137)
22-30	C3-10	—	Archive
✓ 30-32	C3-11	268542	Sample (%S, Pb-210, Cs-137)
32-40	C3-12	—	Archive
✓ 40-42	C3-13	268543	Sample (%S, Pb-210, Cs-137)
42-50	C3-14	—	Archive

Sample Log (Station =) continued

Note- No Cs-137 below ~~50~~ 52cm, intervals based on total core length

every 20

	Interval (cm)	Label	Sample No.	Analysis	
	50-52	C3-15	268544	Sample (%S, Pb-210) & CS-137	
	52-70	C3-16	—	Archive	
✓	70-72	C3-17	268545	%S, Pb-210	
	72-90	C3-18	—	Archive	
✓	90-92	C3-19	268546	%S, Pb-210	
	92-110	C3-20	—	Archive	
✓	110-112	C3-21	268547	%S, Pb-210	
	112-130	C3-22	—	Archive	
✓	130-132	C3-23	268548	%S, Pb-210	
	132-150	C3-24	—	Archive	
✓	150-153	C3-25	268549	%S, Pb-210	
	Chemistry Sections				
	0-5	C3-A	268550	TOC, GS, PCB, Metals (7)	1-2
	5-10	C3-B	268551	PCB, Metals (7)	3-4
	10-20	C3-C	268552	PCB, Metals (7)	5-8
	20-50	C3-D	268553	PCB, Metals (7)	9-14
	50-90	C3-E	268554	PCB, Metal (7)	15-18
	90-110	C3-F	268555	PCB, Metals (7)	19-2
	110-132	C3-G	268556	PCB, Metals (7)	21-23
	132-153	C3-H	268557	PCB, Metals (7)	24-2
	Duplicates				
✓	0-5	C3-AD	268558	TOC, GS	
✓	10-20	C3-CD	268559	PCB, Metals (7)	
✓	20-22	C3-9D	268560	Cs-137	
✓	10-12	C3-5D	268561	%S, Pb-210	

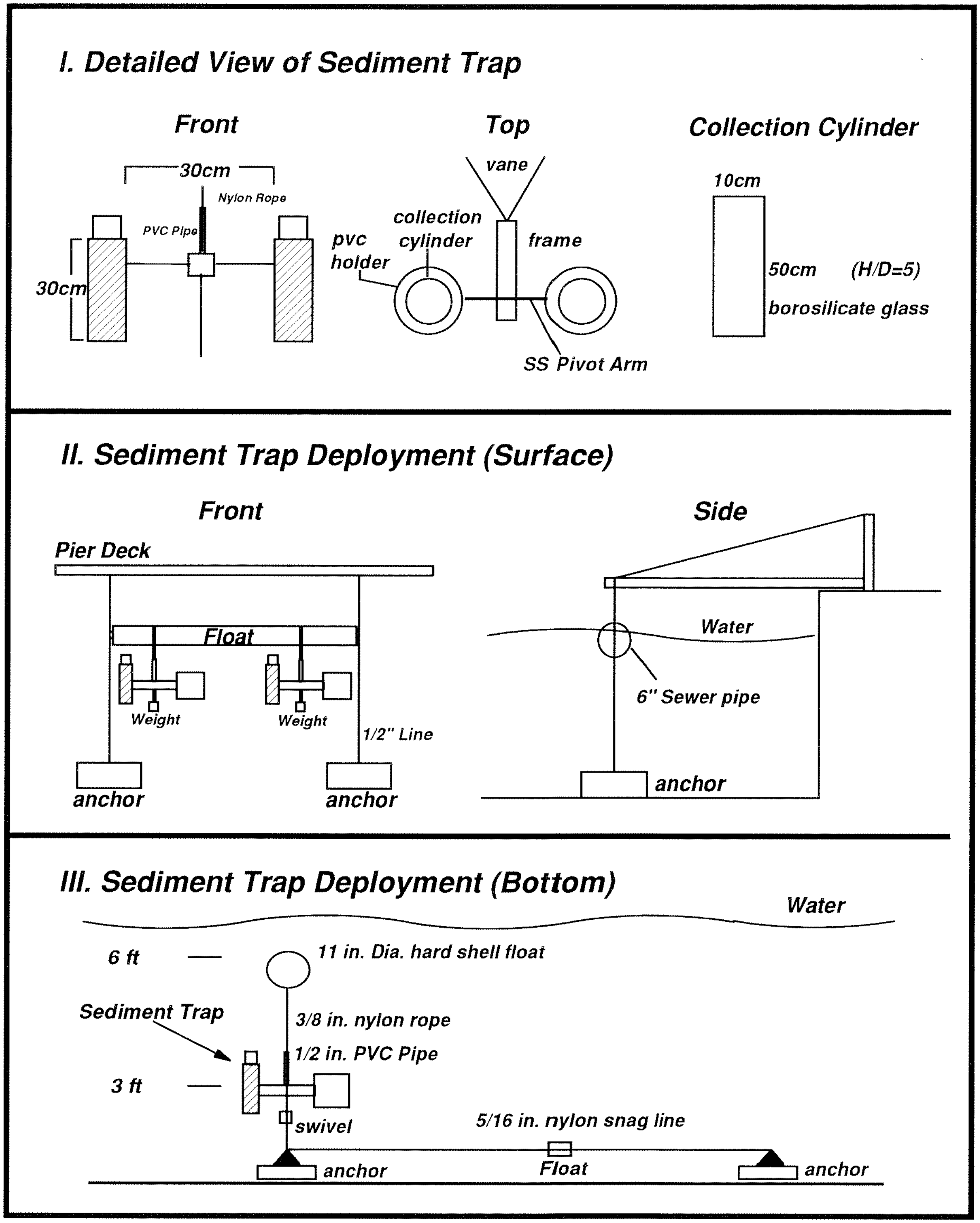

Figure B1: Schematic of Elliott Bay Sediment Traps and Moorings.

Appendix C - Quality Assurance Information

- Summary of Quality Assurance Samples Analyzed (Table C1)

- Quality Assurance Case Narratives
    - Chemistry
    - Current Meters (Aanderra Reports)

- Summary of Reference Materials
    - Metals (Table C2)
    - Organics (Table C3)

- Summary of Blind Field Duplicates (Table C4)

Table C1: Summary of quality assurance samples and frequency of analysis for the Elliott Bay Waterfront Recontamination Study.

Analyte	Internal Standards	Surrogate Spikes	Method Blank	Matrix Spike*	Reference Materials*	Field Duplicate*	Field Replicate
Percent Solids	-	-	-	-	-	2 Batch	1 Batch
Grain Size	-	-	-	-	-	2 Batch	1 Batch
Total Organic Carbon	-	-	1 Batch	2 Batch	-	2 Batch	1 Batch
Metals							
Aluminum	-	-	1 Batch	-	2 Batch	2 Batch	1 Batch
Arsenic	-	-	1 Batch	-	2 Batch	2 Batch	1 Batch
Cadmium	-	-	1 Batch	-	2 Batch	2 Batch	1 Batch
Chromium	-	-	1 Batch	-	2 Batch	2 Batch	1 Batch
Copper	-	-	1 Batch	-	2 Batch	2 Batch	1 Batch
Iron		-	1 Batch	-	2 Batch	2 Batch	1 Batch
Lead		-	1 Batch	-	2 Batch	2 Batch	1 Batch
Manganese		-	1 Batch	-	2 Batch	2 Batch	1 Batch
Mercury	-	-	1 Batch	-	2 Batch	2 Batch	1 Batch
Silver	-	-	1 Batch	-	2 Batch	2 Batch	1 Batch
Zinc	-	-	1 Batch	-	2 Batch	2 Batch	1 Batch
Organics							
Semivolatiles	1 sample	1 sample	1 Batch	2 Batch	(2 Batch)	2 Batch	1 Batch
PCBs	1 sample	1 sample	1 Batch	2 Batch	2 Batch	2 Batch	1 Batch
Pb-210	-	-	-	-	-	2 Batch	2 Batch
Cs-137	-	-	-	-	-	2 Batch	2 Batch

*= Samples are duplicates

( )= PAH only

Certified Reference Materials

Metals- NIST #1646 (Estuarine Sediment)
PAH- NRCC #HS-6 (Harbour Marine)
PCBs- NRCC #HS-2 (Harbour Marine)

CASE NARRATIVES

GRAIN SIZE
MAPPING

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr. East Port Orchard WA. 98366

Data Review
September 27, 1993

Project: **Elliot Bay Recon Study**

Samples: 368500 through 368570

Laboratory: Soil Technology J-418

By: Karin Feddersen KF

Case Summary

The review is for sediment grain size using Puget Sound Estuary Program (P.S.E.P.) protocol.

These samples were received at the Manchester Environmental Laboratory on September 8, 1993. They were transported to Soil Technology on September 8, 1993 for analysis.

These analyses were reviewed for qualitative and quantitative accuracy, validity, and usefulness. The results are acceptable for use as reported.

SOIL
TECHNOLOGY
SPECIALIZING IN PHYSICAL SOIL TESTING
7865 N.E. Day Road West
Bainbridge Island, WA 98110
(206) 842-8977 Fax 842-9014

LETTER OF TRANSMITTAL

TO:

Wa. State Dept. of Ecology
Manchester Laboratory
7411 Beach Drive East
Port Orchard, WA 98366-8204

DATE: 09-24-93
JOB NO: J-418

ATTENTION: **Stuart Magoon**

SUBJECT: **Elliott Bay Recon Study**

REFERENCE: **Sample ID No. 36-8500 through 36-8570**

We are sending the following items:

Date	Copies	Description
09-24-93	2	Apparent Sediment Grain Size Distribution (Page 1 through Page 18)
09-24-93	2	True Sediment Grain Size Distribution (Page 19 and 20)
09-24-93	2	Sediment Sample Case Narrative
09-24-93	2	Chain of Custody Records
09-24-93	2	Disk

These are transmitted for your use.

Remarks: Samples were tested in general accordance with Puget Sound Estuary Protocol (Conventional Sediment Variables Particle Size March 1986). Values reported are "apparent" particle size as organic material is included in the analysis and "true" particle size as organic material is excluded in the in the analysis. Because true and apparent distributions may differ, detailed comparisons between samples analyzed by these different methods are questionable. Please call if you have any questions regarding this submittal or presentation of the data.

Best Regards,
SOIL TECHNOLOGY, INC.

Richard G. Sheets,

Sediment Sample Case Narrative

Hydrogen Peroxide Digestion

Samples 36-8508, 36-8518, 36-8534, 36-8548, 36-8558

The "Weight of Solids" calculation does not account for organics lost in H_2O_2 digestion. Therefore, the amount of solids calculated using the water content and the amount of solids retained after digestion may vary. Resulting QaQc values may exceed 5%.

Sample 36-8551

The following is a description of quality control procedures used in weight of solids determination for sample 36-8551. Following analysis, a comparison of the weight of solids calculated by the standard method and the weight of solids calculated using a formula devised by Folk* revealed a discrepancy. The weight of solids is generally calculated using the standard formula:

$$\text{weight of solids} = \frac{\text{wet wt. of sample}}{1 + \text{water content}}$$

The Folk method alternatively determines the weight of solids by adding together the coarse fraction > U.S. Sieve #230 and the fine fraction < U.S. Sieve # 230:

$$\text{Wt solids} = \text{>\#230 material} + 50(\text{20 second pipet reading})$$

For a given sample, the resulting values from these equations should agree. When a discrepancy occurs, the standard procedure is to resample for a second water content. The sample mentioned above did not contain enough representative material for resampling. The Folk method was used to determine the weight of solids on the above sample.

*(R. L. Folk, Petrology of Sedimentary Rocks 1974, pp. 38-39)

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr. East Port Orchard WA. 98366

Data Review
October 13, 1993

Project: **Elliot Bay Recon Study**

Samples: 398571 through 398577

Laboratory: Soil Technology J-418

By: Karin Feddersen KF

Case Summary

The review is for sediment grain size using Puget Sound Estuary Program (P.S.E.P.) protocol.

These samples were received at the Manchester Environmental Laboratory on September 24, 1993. They were transported to Soil Technology on September 27, 1993 for Grain Size analysis. Samples 398571 through 398576 were analyzed according to apparent sediment grain size distribution. Sample 398577 was analyzed according to true sediment grain size distribution.

These analyses were reviewed for qualitative and quantitative accuracy, validity, and usefulness. The results are acceptable for use as reported.

SOIL
TECHNOLOGY
SPECIALIZING IN PHYSICAL SOIL TESTING
7865 N.E. Day Road West
Bainbridge Island, WA 98110
(206) 842-8977 Fax 842-9014

LETTER OF TRANSMITTAL

TO:

Wa. State Dept. of Ecology
Manchester Laboratory
7411 Beach Drive East
Port Orchard, WA 98366-8204

DATE: 10-07-93
JOB NO: J-418

ATTENTION: **Karin Feddersen**

SUBJECT: **Elliott Bay Recon Study**

REFERENCE: **Sample ID No. 39-8571 through 39-8577**

We are sending the following items:

Date	Copies	Description
10-07-93	2	Apparent Sediment Grain Size Distribution (Page 1 and 2)
10-07-93	2	True Sediment Grain Size Distribution (Page 3)
10-07-93	2	Standard Operating Procedure for Salt Correction (Page 4)
10-07-93	1	Chain of Custody Records
10-07-93	1	Disk

These are transmitted for your use.

Remarks: Samples were tested in general accordance with Puget Sound Estuary Protocol (Conventional Sediment Variables Particle Size March 1986). Values reported are "apparent" particle size as organic material is included in the analysis and "true" particle size as organic material is excluded in the in the analysis. Because true and apparent distributions may differ, detailed comparisons between samples analyzed by these different methods are questionable. Please call if you have any questions regarding this submittal or presentation of the data.

Best Regards,
SOIL TECHNOLOGY, INC.

Richard G. Sheets,
Vice President

FIRST QUARTER PARTICULATE MONITORING DATA

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr. East Port Orchard WA. 98366

Data Review
February 24, 1994

Project: **Elliot Bay Recontamination Study**

Samples: 038274

Laboratory: Soil Technology J-501

By: Karin Feddersen KF

Case Summary

The review is for sediment grain size using Puget Sound Estuary Program (P.S.E.P.) protocol.

This sample was received at the Manchester Environmental Laboratory on December 16, 1993, and transported to Soil Technology on December 16, 1993 for Grain Size analysis by Pipette only.
These analyses were reviewed for qualitative and quantitative accuracy, validity, and usefulness. The results are acceptable for use as reported.

SOIL
TECHNOLOGY
SPECIALIZING IN PHYSICAL SOIL TESTING
7365 N.E. Day Road West
Bainbridge Island, WA 98110
(206) 842-8977 Fax 842-[illegible]

LETTER OF TRANSMITTAL

TO:

Wa. State Dept. Of Ecology
7411 Beach Drive East
Port Orchard, WA 98366-8204

DATE: 02-16-94
JOB NO: J-501

ATTENTION: **Karin Feddersen**

SUBJECT: **Elliott Bay Recontamination Study**

RE: **Sample ID No. 038274**

We are sending the following items:

Date	Copies	Description
02-16-94	2	Grain Size Determination/Dissolved Solids Correction (Page 1)
02-16-94	1	Summary of Entry Values (1 page)
02-16-94	1	Chain of Custody Record
02-16-94	1	Original Invoice No. 696

These are transmitted for your use.

Remarks: Values reported are "apparent" particle size as organic material is included in the analysis. Samples were tested in general accordance with Puget Sound Estuary Protocol (Conventional Sediment Variables Particle Size, March 1986) and EPA, US Army Corps of Engineers "Dredge Material Testing Manual, February 1991". According to this method, the determination of parameters in sediment and water from estuarine or marine environments have to explicitly address steps taken to control salt interference. Steps were taken to correct for salt interference and these corrections are referred to as dissolved solids. Please call if you have any questions regarding this submittal or presentation of the data. Thank you.

Best Regards,
SOIL TECHNOLOGY, INC.

Richard G. Sheets,
Vice President

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr. East Port Orchard WA. 98366

February 24, 1994

Project: **Elliot Bay**

Samples: 038236, 038246, 038255, 038258, 038270 through 038276, 038278, 038279, 038279

Laboratory: Weyerhaeuser Analytical and Testing Services 13874

By: Karin Feddersen KF

These samples were received at the Manchester Laboratory on January 24, 1994, and were sent to Weyerhaeuser Analytical and Testing Services on January 24, 1994 for TOC analysis using PSEP.

HOLDING TIMES

The holding time for frozen sediments is six (6) months. There have been no studies performed to indicate the effect of holding time on samples that have not been stored frozen prior to analysis. Therefore an evaluation of the results with regard to holding time is not feasible. All samples were stored in the proper containers at 4 degrees C until analysis. All analyses were performed within seventeen (17) days of collection.

PROCEDURAL BLANKS

The procedural blanks associated with these samples demonstrated that the processes were free from contamination.

INITIAL CALIBRATION

The % Relative Standard Deviation (%RSD) was within QC limits of ≤20%.

CHECK STANDARDS

All Check Standard recoveries are reasonable, acceptable, and within QC limits of 90% to 100%.

DUPLICATES

The Relative Percent Difference (RPD) of the duplicate analyses to the original analyses are within QC limits of ≤10%.

SUMMARY

This data is acceptable for use as amended.

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE

March 24, 1994

Subject:	Elliott Bay Recontamination
Samples:	94 - 038228, -038229, --038236, -038258, -038270, -038272 to -038279
Case No.	DOE-966Y
Officer:	Dale Norton
By:	Dickey D. Huntamer Organics Analysis Unit

SEMIVOLATILE ORGANICS

ANALYTICAL METHODS:

The semivolatile soil samples were Soxhlet extracted with acetone following the Manchester modification of the EPA SW 846 8270 procedure with capillary GC/MS analysis of the sample extracts. The sample extracts were cleaned up prior to analysis using silica gel. By eluting with various mixtures of solvents the semivolatile target compounds could be recovered. Normal QA/QC procedures were performed with the analyses. A pair of Canadian reference materials (HS-6) sample numbers 94-038228 and -038229, were also analyzed with the samples.

HOLDING TIMES:

The samples were stored frozen until sample preparation following Puget Sound Estuary Program guidelines. All sample and extraction holding times were within the recommended limits.

BLANKS:

Low levels of some target compounds were detected in the laboratory blanks. The EPA five times rule was applied to all target compounds which were found in the blank. Compounds that were found in the sample and in the blank were considered real and not the result of contamination if the levels in the sample are greater than or equal to five times the amount of compounds in the associated method blank.

SURROGATES:

The normal surrogates compounds were added to the sample prior to extraction. Surrogate spike recoveries were within acceptable QC limits except for one of the laboratory blanks, 94-038272 LBK2 (BS4033), where all of the surrogate recoveries were low. The "J" data qualifier was added to the results for this blank. The other blank was okay and no additional qualifiers were added to the data because of surrogate recoveries.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Matrix spike recoveries were within acceptable limits for most of the compounds. A number of compounds, particularly the Polynuclear Aromatic Hydrocarbons (PAH) were found at high levels in the matrix source sample. Corrections to the matrix spikes for the native concentrations could not be made in all cases, resulting in high recoveries for some compounds. No qualifiers were added due to high recoveries. A "J" qualifier was added to results of matrix source sample, -038273, for those compounds where the recoveries were low.

SPECIAL ANALYTICAL PROBLEMS:

No special analytical problems were encountered in the semivolatile analyses other than the high PAH concentrations present in many of the samples. Almost every sample required a dilution to bring the highest concentrations within the calibration curve. The data is acceptable for use as qualified.

DATA QUALIFIER CODES:

U - The analyte was not detected at or above the reported value.

J - The analyte was positively identified. The associated numerical value is an estimate.

UJ - The analyte was not detected at or above the reported estimated result.

REJ - The data are unusable for all purposes.

EXP - The result is equal to the number before EXP times 10 to the power of the number after EXP. As an example 3EXP6 equals 3 X 10^6.

NAF - Not analyzed for.

N - For organic analytes there is evidence the analyte is present in this sample.

NJ - There is evidence that the analyte is present. The associated numerical result is an estimate.

E - This qualifier is used when the concentration of the associated value exceeds the known calibration range.

* - The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE

March 9, 1994

Subject: Elliott Bay Recontamination

Samples: 94 - 038226, -038227, --038236, -038258, -038270, -038272 to -038279

Case No. DOE-966Y

Officer: Dale Norton

By: Dickey D. Huntamer
Organics Analysis Unit

POLYCHLORINATED BIPHENYLS

ANALYTICAL METHODS:

The soil samples were Soxhlet extracted using acetone as the solvent. Analysis was done by EPA Method 8080 using dual column capillary GC analysis with Electron Capture Detectors (ECD).

HOLDING TIMES:

The samples were extracted within 14 days of collection and were analyzed within forty days of extraction.

BLANKS:

No target compounds were detected in the laboratory blanks.

SURROGATES:

Four surrogate compounds were analyzed with the PCB's. Dibutylchlorendate was removed during the Florisil cleanup step in most sample. Surrogates ranged from 48% to 104% recovery. Surrogate spike recoveries were within the acceptable QC limits of 50% to 150% for most of the samples. Only sample -038278 had recoveries less than 50% (48% and 49% for 4,4'-Dibromo-octafluorobiphenyl and Tetrachlorometaxylene respectively). The surrogate most representative of PCB's, Decachlorobiphenyl had 58% recovery. No data was qualified because of surrogate recoveries.

MATRIX SPIKE AND MATRIX SPIKE :

The matrix spikes recoveries ranged from 95% to 108%. The Relative Percent Differences (RPD) ranged from 6.7% to 7.1%. All recoveries and RPD were within acceptable QC limits.

SPECIAL ANALYTICAL PROBLEMS:

There were no significant problems with the Pesticide/PCB analysis except that sample -38272 was lost when the Soxhlet extracted cracked and the solvent was lost. Since all of the sample was used in the first extraction the sample could not be re-extracted. Two reference samples were analyzed with the sample set. These are identified as 94-038226 and -038227. Canadian reference material HS-2 was used in the analysis. Both PCB-1254 and PCB-1260 were detected in the reference samples. The RPD was 1.0% for PCB-1254 and 4.3% for PCB-1260.

DATA QUALIFIER CODES:

U - The analyte was not detected at or above the reported value.

J - The analyte was positively identified. The associated numerical value is an estimate.

UJ - The analyte was not detected at or above the reported estimated result.

REJ - The data are unusable for all purposes.

EXP - The result is equal to the number before EXP times 10 to the power of the number after EXP. As an example 3EXP6 equals 3 X 10^6.

NAF - Not analyzed for.

N - For organic analytes there is evidence the analyte is present in this sample.

NJ - There is evidence that the analyte is present. The associated numerical result is an estimate.

E - This qualifier is used when the concentration of the associated value exceeds the known calibration range.

* - The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive East • Port Orchard, Washington 98366-8204 • (206) 871-8860 • SCAN 871-8860

March 9, 1994

TO: Dale Norton

FROM: Bill Kammin, Environmental_Lab_Director

SUBJECT: Metals Quality Assurance memo for the Elliott Bay Recontamination Project

SAMPLE INFORMATION

These samples from the Elliott Bay Recontamination project were received by the Manchester Laboratory on 1/24/94 in good condition.

HOLDING TIMES

All analyses were performed within the USEPA Contract Laboratory Program (CLP) holding times for metals analysis (28 days for mercury, 180 days for all other metals).

INSTRUMENT CALIBRATION

Instrument calibration was performed before each analytical run and checked by initial calibration verification standards and blanks. Continuing calibration standards and blanks were analyzed at a frequency of 10% during the run and again at the end of the analytical run. All initial and continuing calibration verification standards were within the relevant USEPA (CLP) control limits. AA calibration gave a correlation coefficient (r) of 0.995 or greater, also meeting CLP calibration requirements.

PROCEDURAL BLANKS

The procedural blanks associated with these samples showed no analytically significant levels of analytes.

SPIKED SAMPLE ANALYSES

Spike and duplicate spike sample analyses were performed on this data set. All spike recoveries were within the CLP acceptance limits of +/- 25%, with the following exceptions: mercury. One mercury spike was low at 63%. Mercury data is qualified with N. Additionally, due to high sulfide content, one of the duplicate spikes was lost during the ICP spike microwave digestion (possibly squid related). Precision data is not available for ICP results.

LABORATORY CONTROL SAMPLE (LCS) ANALYSES

NIST 1646 and ERA solid material 216 were analysed three times for this project. Cadmium and silver results are qualified with J, denoting estimated values based on LCS recoveries. NIST 2704, Buffalo River sediment, was digested once and analyzed three times with acceptable recoveries for mercury analyses.

SUMMARY

Data generation for this data set was complicated by high sulfide levels found in some of the samples, possibly related to large marine organisms finding their way into the sediment traps.

A tabular compliation of LCS recoveries is provided as an attachment.

The data generated by the analysis of these samples can be used noting the data qualifications discussed in this memo.

Please call Bill Kammin at SCAN 206-871-8801 to further discuss this project.

WRK:wrk

attachment

[illegible]

Battelle
Pacific Northwest Division
Marine Sciences Laboratory
1529 West Sequim Bay Road
Sequim, Washington 98382-9099
Telephone (206) 683-4151
Facsimile (206) 681-3699

May 9, 1994

Mr. Stuart Magoon
Washington State Department
of Ecology
Manchester Laboratory
7411 Beach Drive East
Port Orchard, WA 98366-8204

Dear Stuart:

Enclosed are the results for Pb-210 in sediment samples received in January 1994. The data is late because we had to reanalyze due to initially spiking samples with the wrong internal standard.

The blanks are low (1 to 4 counts/day). The blank spike recovery of Po208 (the internal standard) is consistent with these samples and previous batches of samples. The check samples are consistent with previous analyses. The precision for the duplicate is 12% RPD.

The calculations used to reduce the data consist of:

1. Blank subtraction.

2. Correction of decay of the Po208 internal standard certified at 1435 dpm/mL on June 11, 1986. Samples were spiked with 0.025 mL which is about 5.52 dpm/sample.

3. The counting efficiency is the ratio of Po208 spike 5.52 dpm/Po208 counted. For Check R-1, Po208 counted is 219c/day or 0.1521 cpm.

   5.52 dpm/0.1521 cpm = 36.26 d/c

4. The Po210 counts are multiplied by the d/c such as 553 c/day or 0.384 cpm x 36.26 = 13.93 dpm.

5. The activity of check R-1 13.93 is divided by sample digestion dry weight then corrected for decay of Po210 since digestion and decay of Po210 since log-in time.

If you have any questions about the calculations, call Rob Cuello or me.

Enclosed are the raw data, digestion logs, and an invoice for the amount of $1,350.

Sincerely,

Brenda Lasorsa for EAC

Eric Crecelius
Technical Group Manager
Marine and Environmental Chemistry

:at

Enclosures

SECOND QUARTER
PARTICULATE
MONITORING
DATA

2E [illegible]

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr. East Port Orchard WA. 98366

Data Review
May 10, 1994

Project: **Elliot Bay Study**

Samples: 168404,09,14,15,19,23,28,36,39,45,50

Laboratory: Soil Technology

By: Pam Covey

Case Summary

The review is for sediment grain size using Puget Sound Estuary Program (P.S.E.P.) protocol.

These samples were received at the Manchester Environmental Laboratory on April 21, 1994. They were transported to Soil Technology on April 25, 1994 for Grain Size analysis. These analyses were reviewed for qualitative and quantitative accuracy, validity, and usefulness.

The results are acceptable for use as reported.

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr. East Port Orchard WA. 98366

May 16, 1994

Project:	**Elliot Bay Recontamination Study**	
Samples:	168404, 168409, 168414, 168415, 168419, 168423, 168428, 168431, 168436, 168439, 168445, 168450	
Laboratory:	Analytical Resources Inc.	H037
By:	Karin Feddersen KF	

These samples were received at Manchester Laboratory on April 21, 1994, and were transported to Analytical Resources, Inc. on April 25, 1994 for TOC analysis using the following method: Puget Sound Ambient Monitoring Program.

DATA QUALIFIER DEFINITIONS

U -	The analyte was not detected at or above the reported result.
J -	The associated numerical result is an estimated quantity.

HOLDING TIMES
All analyses were performed within the method holding times.

CHECK STANDARDS
All recoveries are reasonable, acceptable, and within QC limits of 75% to 125%.

TRIPLICATE
Sample 168409 was analyzed in triplicate. The replicate analyses are within QC limits of 80% to 120% of the concentration of the original analysis.

MATRIX SPIKES
The matrix spike recovery is reasonable, acceptable, and within QC limits of 75% to 125%.

SUMMARY
All non-detect results have been qualified with a "U" to maintain consistency with Manchester Laboratory reporting protocol. This data is acceptable for use as amended.

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive East • Port Orchard, Washington 98366-8204 • (206) 871-8860 • SCAN 871-8860

June 13, 1994

TO: Dale Norton

FROM: Bill Kammin, Environmental_Lab_Director BK

SUBJECT: Metals Quality Assurance memo for the Elliott Bay Project

SAMPLE INFORMATION

These samples from the Elliott Bay project were received by the Manchester Laboratory on 4/21/94 in good condition.

HOLDING TIMES

All analyses were performed within the USEPA Contract Laboratory Program (CLP) holding times for metals analysis (28 days for mercury, 180 days for all other metals).

INSTRUMENT CALIBRATION

Instrument calibration was performed before each analytical run and checked by initial calibration verification standards and blanks. Continuing calibration standards and blanks were analyzed at a frequency of 10% during the run and again at the end of the analytical run. All initial and continuing calibration verification standards were within the relevant USEPA (CLP) control limits. AA calibration gave a correlation coefficient (r) of 0.995 or greater, also meeting CLP calibration requirements.

PROCEDURAL BLANKS

The procedural blanks associated with these samples showed no analytically significant levels of analytes.

SPIKED SAMPLE ANALYSES

Spike and duplicate spike sample analyses were performed on this data set for mercury. For all other analytes, there was sufficient sample to perform only one spike, so no precision data is available. All spike recoveries were within the CLP acceptance limits of +/- 25%, with the following exceptions: silver, antimony and arsenic. For arsenic, the one spike was recovered at 74%, and all arsenic results are qualified with

N. The silver spike was recovered at 34%. The antimony spike was not recovered. Silver and antimony were qualified J, denoting estimates.

PRECISION DATA

Mercury spike/spike dup results showed acceptable precision. No spike/spike dup precision is available for other analytes.

LABORATORY CONTROL SAMPLE (LCS) ANALYSES

LCS analyses were within the windows established for each parameter, with the following exceptions: silver and antimony. Results for these analytes are qualified J, denoting esimated values.

SUMMARY

For all ICP and graphite furnace analytes, NIST 1646 and ERA #216 reference materials were analyzed. The ICP results are provided as attachments. For mercury NIST 2704 was analyzed several times. Furnace and mercury recoveries are as follows:

element	**1646 % recovery**	**ERA #216 % recovery**
arsenic	44%	110%
arsenic	42%	109%
cadmium	91%	102%
cadmium	80%	95%
	2704 % recovery	
mercury	97%	1.40 ⟩ 1.36
mercury	91%	1.31

The data generated by the analysis of these samples can be used noting the data qualifications discussed in this memo.

Please call Bill Kammin at SCAN 206-871-8801 to further discuss this project.

WRK:wrk

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE

June 17, 1994

Subject:	Elliott Bay WF Recontamination
Samples:	94 - 168404, -168409, -168419, -168423, -168428, -168436, -168445, -168450
Case No.	DOE-080X
Officer:	Dale Norton
By:	Dickey D. Huntamer Organics Analysis Unit

POLYCHLORINATED BIPHENYLS

ANALYTICAL METHODS:

The soil samples were Soxhlet extracted with acetone following the Manchester modification of the EPA Method 8080 using dual column capillary GC analysis with Electron Capture Detectors (ECD). Normal QA/QC procedures were performed with the analyses. A pair of Canadian reference materials (HS-2) sample numbers 94-168453 and -168454, were also analyzed with the samples.

HOLDING TIMES:

The samples were extracted eleven days after they were received at the laboratory. All sample and extraction holding times were within the recommended limits.

BLANKS:

No target compounds were detected in the laboratory blanks.

SURROGATES:

All surrogate spike recoveries were within acceptable QC limits. Surrogates ranged from 43% to 114% recovery.

MATRIX SPIKE AND MATRIX SPIKE :

The matrix spikes recoveries ranged from 128% to 149%. The Relative Percent Differences (RPD) ranged from 0% to 4.6%. All recoveries and RPD were within acceptable QC limits.

SPECIAL ANALYTICAL PROBLEMS:

There were no significant problems with the Pesticide/PCB analysis. PCB-1260 was the only PCB detected and it was found in all of the samples.

DATA QUALIFIER CODES:

U	-	The analyte was not detected at or above the reported value.
J	-	The analyte was positively identified. The associated numerical value is an <u>estimate</u>.
UJ	-	The analyte was not detected at or above the reported estimated result.
REJ	-	The data are <u>unusable</u> for all purposes.
EXP	-	The result is equal to the number before EXP times 10 to the power of the number after EXP. As an example 3EXP6 equals 3 X 10^6.
NAF	-	Not analyzed for.
N	-	For organic analytes there is evidence the analyte is present in this sample.
NJ	-	There is evidence that the analyte is present. The associated numerical result is an estimate.
E	-	This qualifier is used when the concentration of the associated value exceeds the known calibration range.
*	-	The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE

June 14, 1994

Subject: Elliott Bay WF Recontamination

Samples: 94 - 168404, -168409, -168414 to -168415, -168419, -168423, -168428, -168431, -168436,

-168445, -168450

Case No. DOE-080X

Officer: Dale Norton

By: Dickey D. Huntamer
Organics Analysis Unit

SEMIVOLATILE ORGANICS

ANALYTICAL METHODS:

The semivolatile soil samples were Soxhlet extracted with acetone following the Manchester modification of the EPA SW 846 8270 procedure with capillary GC/MS analysis of the sample extracts. The sample extracts were cleaned up prior to analysis using silica gel. By eluting with various mixtures of solvents the semivolatile target compounds could be recovered. Normal QA/QC procedures were performed with the analyses. A pair of Canadian reference materials (HS-6) sample numbers 94-168451 and -168452, were also analyzed with the samples.

HOLDING TIMES:

The samples were extracted eleven days after they were received at the laboratory. All sample and extraction holding times were within the recommended limits.

BLANKS:

Low levels of some target compounds were detected in the laboratory blanks. The EPA five times rule was applied to all target compounds which were found in the blank. Compounds that were found in the sample and in the blank were considered real and not the result of contamination if the levels in the sample are greater than or equal to five times the amount of compounds in the associated method blank.

SURROGATES:

The normal surrogates compounds were added to the sample prior to extraction. Surrogate spike recoveries were within acceptable QC limits. One surrogate, 1,2-dichlorobenzene-d4, dropped below 20% recovery in several samples. Since the remaining surrogates were acceptable no qualifiers were added.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Matrix spike recoveries were within acceptable limits for most of the compounds. A number of the Polynuclear Aromatic Hydrocarbons (PAH) were found at high levels in the matrix source sample. Corrections to the matrix spikes for the native concentrations could not be made in all cases, resulting in erratic recoveries for some compounds. No qualifiers were added due to high recoveries. A "J" qualifier was added to results of matrix source sample, -168428, for those compounds where the recoveries were low.

Hexachlorocyclopentadiene was flagged as "REJ" since it was not recovered in the matrix spikes.

SPECIAL ANALYTICAL PROBLEMS:

As with the previous Elliott Bay sediment traps PAH's were the primary organic chemicals detected. The high concentrations of PAH in the matrix spike source sample -168428, interfered with the recovery calculations for some PAH's in the matrix spikes. The data is acceptable for use as qualified.

DATA QUALIFIER CODES:

U	-	The analyte was not detected at or above the reported value.
J	-	The analyte was positively identified. The associated numerical value is an estimate.
UJ	-	The analyte was not detected at or above the reported estimated result.
REJ	-	The data are unusable for all purposes.
EXP	-	The result is equal to the number before EXP times 10 to the power of the number after EXP. As an example 3EXP6 equals 3 X 10^6.
NAF	-	Not analyzed for.
N	-	For organic analytes there is evidence the analyte is present in this sample.
NJ	-	There is evidence that the analyte is present. The associated numerical result is an estimate.
E	-	This qualifier is used when the concentration of the associated value exceeds the known calibration range.
*	-	The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)

Battelle
Pacific Northwest Division

Marine Sciences Laboratory
1529 West Sequim Bay Road
Sequim, Washington 98382-9099
Telephone (206) 683-4151
Facsimile (206) 681-3699

July 25, 1994

Mr. Stuart Magoon
Washington State Department
of Ecology
Manchester Laboratory
7411 Beach Drive East
Port Orchard, WA 98366-8204

Dear Stuart:

Enclosed are the results for Pb-210 in sediment samples received in May 1994.

The blanks are low. The blank spike recovery of Po208 (the internal standard) is consistent with these samples and previous batches of samples. The check sample is consistent with previous analyses. The precision for the duplicate is 14% RPD.

If you have any questions about the calculations, call Rob Cuello or me.

Enclosed are the raw data, digestion logs, and an invoice for the amount of $1,650.

Sincerely,

Eric Crecelius
Technical Group Manager
Marine and Environmental Chemistry

:mkw

Enclosures

THIRD QUARTER PARTICULATE MONITORING DATA

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr. East Port Orchard WA. 98366

August 26, 1994

Project:	**Elliot Bay Recontamination Study**
Samples:	298504, 298509, 298514, 298519, 298524, 298525, 298530, 298535, 298540, 298543, 298546, 298552, 298557
Laboratory:	Weyerhaeuser Analytical and Testing Services 15472
By:	Karin Feddersen KF

These samples were received at the Manchester Laboratory on July 20, 1994, and were sent to Weyerhaeuser Analytical and Testing Services on July 25, 1994 for TOC analysis using PSEP.

HOLDING TIMES

The holding time for frozen sediments is six (6) months. There have been no studies performed to indicate the effect of holding time on samples that have not been stored frozen prior to analysis. Therefore an evaluation of the results with regard to holding time is not feasible. All samples were stored in the proper containers at 4 degrees C until analysis. All analyses were performed within twenty-nine (29) days of collection.

PROCEDURAL BLANKS

The procedural blanks associated with these samples demonstrated that the processes were free from contamination.

INITIAL CALIBRATION

The % Relative Standard Deviation (%RSD) was within QC limits of ≤20%.

CHECK STANDARDS

All Check Standard recoveries are reasonable, acceptable, and within QC limits of 90% to 110%.

REPLICATES

The Relative Percent Difference (RPD) of the replicate analyses to the original analyses are within QC limits of ≤10%.

SUMMARY

This data is acceptable for use as amended.

[illegible]
Particulars

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr. East Port Orchard WA. 98366

September 6, 1994

Project: Elliott Bay Recontamination

Samples: 298504,09,14,19,24,25,30,35,40,43,46,52,57

Laboratory: Soil Technology

By: Pam Covey

The Elliott Bay Recontamination samples required thirteen (13) Grain Size analyses on sediment using Puget Sound Estuary Protocol (P.S.E.P) protocol with salt correction.

These samples were received at the Manchester Environmental Laboratory on July 21, 1994 and transported to Soil Technology on July 26, 1994 for Grain Size analyses. These analyses were reviewed for qualitative and quantitative accuracy, validity and usefullness.

The results are acceptable for use as reported.

S.O.P. Salt Correction Pipette Total Dissolved Solids

The following protocol is used for correction of dissolved solids (salt correction) in the pipette portion of grain size determination. Upon completion of the silt-clay fractions by the pipette technique, a subsample of approximately 200 ml of water is taken from the 1 liter graduated flask and placed in a centrifuge bottle and spun at 9000 rpm for 15 minutes. Then a 20 ml subsample of the supernatant is filtered through a .45 micron filter into a pre-weighed container. This sample is dried overnight at 90° C and re-weighed. The resultant residue represents the amount of dissolved salts and dispersant present in a 20 ml sample. This weight of dispersant and dissolved solids is subtracted from the weight of each sediment fraction at the end of the pipette analysis.

Samples were tested in general accordance with Puget Sound Estuary Protocol (Conventional Sediment Variables Particle Size, March 1986) and EPA, US Army Corps of Engineers "Dredge Material Testing Manual, February 1991". According to this method, the determination of parameters in sediment and water from estuarine or marine environments have to explicitly address steps taken to control salt interference. Steps were taken to correct for salt interference and these corrections are referred to as dissolved solids.

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive East • Port Orchard, Washington 98366-8204 • (206) 871-8860 • SCAN 871-8860

September 8, 1994

TO: Dale Norton

FROM: Bill Kammin, Environmental_Lab_Director BK

SUBJECT: Metals Quality Assurance memo for the Week 29 Elliott Bay Sampling Project

SAMPLE INFORMATION

These samples from the Week 29 Elliott Bay project were received by the Manchester Laboratory on 7/21/94 in good condition.

HOLDING TIMES

All analyses were performed within the USEPA Contract Laboratory Program (CLP) holding times for metals analysis (28 days for mercury, 180 days for all other metals).

INSTRUMENT CALIBRATION

Instrument calibration was performed before each analytical run and checked by initial calibration verification standards and blanks. Continuing calibration standards and blanks were analyzed at a frequency of 10% during the run and again at the end of the analytical run. All initial and continuing calibration verification standards were within the relevant USEPA (CLP) control limits. AA calibration gave a correlation coefficient (r) of 0.995 or greater, also meeting CLP calibration requirements.

PROCEDURAL BLANKS

The procedural blanks associated with these samples showed no analytically significant levels of analytes.

SPIKED SAMPLE ANALYSES

Spike and duplicate spike sample analyses were performed on this data set. Several spike recoveries were outside the CLP acceptance limits of +/- 25%. Analyte levels for the sample chosen for the ICP spike were higher than the spiking levels for several analytes. Also, the sample chosen for spiking shows some degree of non-homogeniety.

Several analytes are qualified with N, denoting low spike recoveries. In addition, the concentration of several analytes was greater than four times the spiking level used. In these cases, per EPA protocol, spike recoveries are not calculated.

In some cases, sample levels were two to three times the spiking level used. This also may contribute to the poor spike recovery found.

PRECISION DATA

The results of the spike and duplicate spike samples were used to evaluate precision on this sample set. The Relative Percent Difference (RPD) for all analytes was within the 20% CLP acceptance window for duplicate analysis.

LABORATORY CONTROL SAMPLE (LCS) ANALYSES

LCS (Environmental Resource Associates (ERA) lot number 216) analyses were within the acceptance windows established for each parameter, with one exception: silver. Silver results for this project are qualified J, denoting estimated values. Spreadsheets of the ICP evaluation of the ERA LCS are provided with this report.

REFERENCE MATERIAL ANALYSES

NIST 1646 was analyzed in duplicate by project officer request. Results were typical for the environmental digestion methods on this geologically evaluated reference material. Spreadsheets of the ICP evaluation of NIST 1646 are provided with this report. For mercury, NIST 2704 was analyzed in replicate, with recoveries at 100%, 100%, 100%, 98%, 99%, and 97%. Also for mercury, NIST 1646 was analyzed, with recoveries at 118% and 119%. For this project, cadmium and arsenic were analyzed by GFAA. For cadmium, recoveries of NIST 1646 were 96% and 98%. For arsenic, recoveries of NIST 1646 were at 51% and 51%.

SUMMARY

Dale, next time we analyze Elliott Bay samples we will use a higher level spike, because of the spiking issues associated with this project. It's possible that high sulfide in the sample spiked could have interfered with the spike recoveries.

The data generated by the analysis of these samples can be used noting the data qualifications discussed in this memo.

Please call Bill Kammin at SCAN 206-871-8801 to further discuss this project.

WRK:wrk

MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE

August 12, 1994

Subject:	Elliott Bay Recontamination
Samples:	94 - 298504, -298509, -298514, -298519, -298524, -298525, -298530, -298535, -298540, -298543, -298546, -298552, and -298557 to -298559
Case No.	DOE-155W
Officer:	Dale Norton
By:	Dickey D. Huntamer Organics Analysis Unit

POLYCHLORINATED BIPHENYLS

ANALYTICAL METHODS:

The samples were Soxhlet extracted using acetone as the solvent. Analysis was done by EPA Method 8080 using dual column capillary GC analysis with Electron Capture Detectors (ECD).

HOLDING TIMES:

All sample extraction and analysis holding times were met.

BLANKS:

No target compounds were detected in the laboratory blanks.

SURROGATES:

The surrogate spike recoveries ranged from 38% to 108%. Sample -298535 had two surrogate compounds below 50% and samples, -298530 LMX1, -298558 and -298559 each had one surrogate below 50% recovery. Since at least two surrogates had acceptable recoveries in each sample no qualifiers were added to sample results.

MATRIX SPIKE AND MATRIX SPIKE :

The matrix spikes recoveries ranged from 62% to 94%. The Relative Percent Differences (RPD) ranged from 25% to 27%. All recoveries and RPD were within acceptable QC limits.

ANALYTICAL COMMENTS:

There were no significant problems with the PCB analysis and the data is acceptable for use as qualified. Samples -298558 and -298559 were Canadian reference material analyzed in duplicate.

DATA QUALIFIER CODES:

U - The analyte was not detected at or above the reported value.

J - The analyte was positively identified. The associated numerical value is an <u>estimate</u>.

UJ - The analyte was not detected at or above the reported estimated result.

REJ - The data are <u>unusable</u> for all purposes.

EXP - The result is equal to the number before EXP times 10 to the power of the number after EXP. As an example 3EXP6 equals 3×10^6.

NAF - Not analyzed for.

N - For organic analytes there is evidence the analyte is present in this sample.

NJ - There is evidence that the analyte is present. The associated numerical result is an estimate.

E - This qualifier is used when the concentration of the associated value exceeds the known calibration range.

* - The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE

September 26, 1994

Subject: Elliott Bay Recontamination

Samples: 94 - 29804, -298509, -298514, -298519, -298524, -298525, -298530, -298535, -298540, -298543, -298546, -298552, -298557, -298560 and -298561.

Case No. DOE-155W

Officer: Dale Norton

By: Dickey D. Huntamer
Organics Analysis Unit

SEMIVOLATILE ORGANICS

ANALYTICAL METHODS:

The semivolatile sediment samples were Soxhlet extracted with acetone following the Manchester modification of the EPA SW 846 8270 procedure with capillary GC/MS analysis of the sample extracts. Normal QA/QC procedures were performed with the analyses.

HOLDING TIMES:

All sample and extraction holding times were within the recommended limits.

BLANKS:

Low levels of some target compounds were detected in the laboratory blanks. The EPA five times rule was applied to all target compounds which were found in the blank. Compounds that were found in the sample and in the blank were considered real and not the result of contamination if the levels in the sample are greater than or equal to five times the amount of compounds in the associated method blank.

SURROGATES:

The normal surrogates compounds were added to the sample prior to extraction. No surrogate recovery limits have been established for semivolatile analysis using the silica gel cleanup procedure. Generally the silica gel cleanup would result in lower recoveries of the more polar compounds. This appears to be the case for the phenolic surrogates, 2-fluorophenol and d5-phenol, which fell below the CLP lower recovery limits of 25% and 24% respectively. Since these samples had the additional cleanup no data qualifiers were added due to surrogate recoveries.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Matrix spikes were extracted with these samples however one matrix spike was lost in a laboratory accident and consequently only one matrix spike is reported. Recoveries were generally good with the exception of a few compounds such as the nitroanilines, hexachloroethane and hexchlorocyclopentadiene. A number of the polynuclear aromatic hydrocarbon (PAH) compounds had elevated recoveries due to the high native concentrations present in the matrix source sample which could not be subtracted out.

ANALYTICAL COMMENTS:

High PAH concentrations were found in the samples. Other than the problem with the loss of the one matrix spike no special analytical problems were encountered in the semivolatile analyses. Samples, -298560 and -298561 are Canadian Reference Material HS-6 analyzed in duplicate.

DATA QUALIFIER CODES:

U	-	The analyte was not detected at or above the reported value.
J	-	The analyte was positively identified. The associated numerical value is an estimate.
UJ	-	The analyte was not detected at or above the reported estimated result.
REJ	-	The data are unusable for all purposes.
EXP	-	The result is equal to the number before EXP times 10 to the power of the number after EXP. As an example 3EXP6 equals 3 X 10^6.
NAF	-	Not analyzed for.
N	-	For organic analytes there is evidence the analyte is present in this sample.
NJ	-	There is evidence that the analyte is present. The associated numerical result is an estimate.
E	-	This qualifier is used when the concentration of the associated value exceeds the known calibration range.
*	-	The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)

Kn

3rd quarter particulate for Pb-210

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr. East Port Orchard WA. 98366
December 16, 1994

Project: **Elliot Bay Recontamination**

Samples: 268500 - 268511,268518 - 268530, 268537 - 268549, 268560, 268561, 298504, 298509, 298514, 298519, 298524, 298525, 298530, 298535, 298540, 298543, 298546, 298552, 298557

Laboratory: Battelle Marine Sciences Laboratory 747EB

By: Karin Feddersen KF

These samples arrived at Manchester Environmental Laboratory on June 29 and July 21, 1994, and were sent to Battelle on June 30 and July 26, 1994, for Lead 210 and Cesium 137 analysis.

PROCEDURAL BLANKS:
There was a considerable amount of background noise observed for those samples analyzed for Cs 137. An air blank was not analyzed for Pb 210 with the samples from week 26. For the necessary blank correction, the air blank analyzed with the week 29 samples several months earlier was used. Some instrument adjustments occurred in the intervening time which may have affected the results for these analyses.

CHECK STANDARDS:
QC limits for these recoveries have not been established for these analyses.

REPLICATE:
Samples 268507, 268538, and 298552 were analyzed in duplicate for Pb 210. Samples 268537 and 268560 were analyzed in duplicate for Cs 137. Precision and accuracy data have not been established for these analyses. The replicate Cs 137 result for sample 268537 appeared much lower than the original result. The analyst explained that although the RPD was 75%, since the results were "so low", she did not judge it necessary to reanalyze the sample. She offered to reanalyze one of the more active samples in duplicate, and send the results next week.

SAMPLE SUMMARY:
Samples 268528, 268538R (replicate), and 268530 exhibited poor peak response and have therefore each been qualified with a "J" (estimated results). This data is acceptable for use as amended.

FOURTH QUARTER
PARTICULATE
MONITORING
DATA

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr. East Port Orchard WA. 98366
November 17, 1994

Project: **Elliot Bay Recontamination Study**

Samples: 428404, 42847, 428412, 428415, 428418, 428423, 428424, 428429, 428434, 428443, 428449, 428454

Laboratory: Sound Analytical Services, Inc. 44115

By: Karin Feddersen KF

These samples were received at the Manchester Laboratory on October 21, 1994, and were sent to Sound Analytical Services, Inc. on October 26, 1994 for TOC analysis using the following methods: Puget Sound Estuary Program.

HOLDING TIMES

The PSEP TOC holding time for frozen sediments is six (6) months. No studies to my knowledge have been performed to indicate the effect of holding time on samples that have not been stored frozen prior to analysis. Therefore an evaluation of the results with regard to holding time is not feasible. The samples were stored in the proper containers at 4 degrees C until analysis.

PROCEDURAL BLANKS

The procedural blanks associated with these samples have demonstrated that the processes are free from contamination.

CHECK STANDARDS

All recoveries were within QC limits of 75% to 125% of the true value.

TRIPLICATE:

Samples 428404 was analyzed in triplicate. The % Relative Standard Deviation (RSD) is within QC limits of 20%.

SUMMARY

For consistency with Manchester Laboratory reporting protocol, all non-detect results have been qualified with a "U" - "The analyte was not detected at or above the reported result". This data is acceptable for use as amended.

H Quality
Particulates

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr. East Port Orchard WA. 98366

November 17, 1994

Project: Elliott Bay

Samples: 42-8404,12,15,18,23,24,29,34,39,43,49,54

Laboratory: Soil Technology

By: Pam Covey

Case Summary

The Elliott Bay samples required twelve (12) Grain Size analyses on sediment using Puget Sound Estuary Program Protocol.

These samples were received at the Manchester Environmental Laboratory on October 21, 1994 and transported to Soil Technology on October 27, 1994 for Grain Size analyses. These analyses were reviewed for qualitative and quantitative accuracy, validity and usefullness.

The results are acceptable for use as reported.

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE

December 28, 1994

Subject: Elliott Bay Recontamination

Samples: 94 - 428404. -428407, -428412, -428415, -428418, -428423, -428424, -428429, -428434, -428439, -428443, -428449 and -428454

Case No. 150094

Officer: Dale Norton

By: Dickey D. Huntamer
Organics Analysis Unit

SEMIVOLATILE ORGANICS

ANALYTICAL METHODS:

The semivolatile sediment samples were Soxhlet extracted with acetone following the Manchester modification of the EPA SW 846 8270 procedure including a full semivolatile silica-gel cleanup procedure with capillary GC/MS analysis of the sample extracts. Normal QA/QC procedures were performed with the analyses.

HOLDING TIMES:

All sample and extraction holding times were within the recommended limits.

BLANKS:

Low levels of some target compounds were detected in the laboratory blanks. The EPA five times rule was applied to all target compounds which were found in the blank. Compounds that were found in the sample and in the blank were considered real and not the result of contamination if the levels in the sample are greater than or equal to five times the amount of compounds in the associated method blank.

SURROGATES:

The normal surrogates compounds were added to the sample prior to extraction. No surrogate recovery limits have been established for semivolatile analysis using the silica gel cleanup procedure. Generally the silica gel cleanup would result in lower recoveries of the more polar compounds. Surrogate recoveries were within acceptable limits for all samples except -428407 which had no recovery of d5-phenol, 2-fluorophenol and d4-2-chlorophenol. All results for the phenols in sample -428407 were given the "J" qualifier.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Matrix spikes were generally acceptable except for 1,3 and 1,2 dichlorobenzenes, benzyl alcohol, hexachloroethane, 3-nitroaniline, 4-nitrophenol, and 4-nitroaniline which were given the "J" qualifier in the matrix source sample, -428449. Results for two other compounds, 4-chloroaniline and hexachlorocyclopentadiene in sample -428449, were rejected "REJ" due to no recoveries.

ANALYTICAL COMMENTS:

High PAH concentrations were found in the samples and were primarily responsible for the elevated quantitation limits. There appeared to be some carry over into the blank, possibly from the GPC or the GC autosampler. This resulted in the raising of quantitation limits for some compounds. Samples, HS-6A and HS-6B are Canadian Reference Material HS-6 analyzed in duplicate. The data is acceptable for use as qualified.

DATA QUALIFIER CODES:

U	-	The analyte was not detected at or above the reported value.
J	-	The analyte was positively identified. The associated numerical value is an estimate.
UJ	-	The analyte was not detected at or above the reported estimated result.
REJ	-	The data are unusable for all purposes.
EXP	-	The result is equal to the number before EXP times 10 to the power of the number after EXP. As an example 3EXP6 equals 3 X 10^6.
NAF	-	Not analyzed for.
N	-	For organic analytes there is evidence the analyte is present in this sample.
NJ	-	There is evidence that the analyte is present. The associated numerical result is an estimate.
E	-	This qualifier is used when the concentration of the associated value exceeds the known calibration range.
bold	-	The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)

MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE

December 13, 1994

Subject: Elliott Bay Recontamination

Samples: 94 - 428404, -428407, -428412, -428415, -428418, -428423, -428424, -428429
-428434, -428439, -428443, -428449, -428454 to -428456

Case No. DOE-155Y

Officer: Dale Norton

By: Dickey D. Huntamer
Organics Analysis Unit

POLYCHLORINATED BIPHENYLS

ANALYTICAL METHODS:

The soil sample was Soxhlet extracted using acetone as the solvent. Analysis was done by EPA Method 8080 using dual column capillary GC analysis with Electron Capture Detectors (ECD).

HOLDING TIMES:

All sample extraction and analysis holding times were met.

BLANKS:

No target compounds were detected in the laboratory blanks.

SURROGATES:

Surrogates ranged from 13% to 86% recovery. Surrogate recovery for Dibutylchlorendate (DBC) is not reported in the matrix spikes. DBC is prone to interference from high PCB sample or spike concentrations and has low recoveries in the normal Florisil PCB clean up procedure. Decachlorobiphenyl (DCB) is the surrogate most representative of the PCB target compounds. All recoveries for DCB were acceptable and consequently no additional qualifiers were added to the data..

MATRIX SPIKE AND MATRIX SPIKE :

The matrix spikes recoveries ranged from 69% to 96%. The Relative Percent Differences (RPD) ranged from 4.3% to 8.7%. All recoveries and RPD were within acceptable QC limits.

ANALYTICAL COMMENTS:

No analytical problems were encountered in the analysis. the data is acceptable for use as qualified.

DATA QUALIFIER CODES:

U - The analyte was not detected at or above the reported value.

J - The analyte was positively identified. The associated numerical value is an estimate.

UJ - The analyte was not detected at or above the reported estimated result.

REJ - The data are unusable for all purposes.

EXP - The result is equal to the number before EXP times 10 to the power of the number after EXP. As an example 3EXP6 equals 3 X 10^6.

NAF - Not analyzed for.

N - For organic analytes there is evidence the analyte is present in this sample.

NJ - There is evidence that the analyte is present. The associated numerical result is an estimate.

E - This qualifier is used when the concentration of the associated value exceeds the known calibration range.

* - The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive East • Port Orchard, Washington 98366-8204 • (206) 895-4737 • SCAN 744-4737

November 30, 1994

TO: Dale Norton, Project Officer

FROM: Myrna McIntosh, Metals Analyst

SUBJECT: Metals Quality Assurance memo for the Elliot Bay Recontamination Project
Sample Numbers: 94428404 - 94428454

SAMPLE INFORMATION

The samples from the Elliot Bay Recontamination project were received by the Manchester Laboratory on 10/21/94 in good condition. The samples were analyzed by the following methods: ICP EP1-200.7, Arsenic EP1-206.2, Cadmium EP1-213.2, Mercury EP1-245.5.

HOLDING TIMES

All analyses were performed within the USEPA Contract Laboratory Program (CLP) holding times for metals analysis (28 days for mercury, 180 days for all other metals).

INSTRUMENT CALIBRATION

Instrument calibration was performed before each analytical run and checked by initial calibration verification standards and blanks. Continuing calibration standards and blanks were analyzed at a frequency of 10% during the run and again at the end of the analytical run. All initial and continuing calibration verification standards were within the relevant USEPA (CLP) control limits. AA calibration gave a correlation coefficient (r) of 0.995 or greater, also meeting CLP calibration requirements.

PROCEDURAL BLANKS

The procedural blanks associated with these samples show no analytically significant levels of analytes.

SPIKED SAMPLE ANALYSES

Spiked and duplicate spiked sample analyses were performed on this data set. All spike recoveries are within the CLP acceptance limits of +/- 25%, except for silver and arsenic. The arsenic values are qualified with "N". The silver results are qualified with "J" since the recoveries had poor precision and the LCS was low.

PRECISION DATA

The results of the spiked and duplicate spiked samples are used to evaluate precision on this sample set. The Relative Percent Difference (RPD) for all analytes, except silver is within the 20% CLP acceptance window for duplicate analysis.

LABORATORY CONTROL SAMPLE (LCS) ANALYSES

LCS analyses are within the windows established for each parameter, with the exception of silver.

SUMMARY

The data generated by the analysis of these samples can be used noting the data qualifications discussed in this memo.

Please call Bill Kammin at SCAN 206-871-8801 to further discuss this project.

MMM:mmm

BOTTOM CORE
MONITORING
DATA

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr. East Port Orchard WA. 98366

Data Review
July 26, 1994

Project: **Elliott Bay Recontamination**

Samples: 268512, 8531, 8550, 8558

Laboratory: Soil Technology

By: Pam Covey

Case Summary

The review is for sediment grain size using Puget Sound Estuary Program (P.S.E.P.) protocol.

These samples were received at the Manchester Environmental Laboratory on June 29, 1994. They were transported to Soil Technology on July 1, 1994 for Grain Size analysis. These analyses were reviewed for qualitative and quantitative accuracy, validity, and usefulness.

The results are acceptable for use as reported.

Elliott Bay Recon.

Case Narrative
Due to variations in water content between the subsamples taken for moisture content and grain size analysis, sample **268558** required calculation of the weight of solids using Folk's method (*Petrology of Sedimentary Rocks*, R.L. Folk, 1974). Insufficient sample quantity prohibited resampling for determination of solids by the standard method (based on subsample water content). Folk's weight of solids calculation adds the dry weight of the sample retained on the sieves (+ #230 sieve; > 62.5 microns) to the dry weight of the first pipet (4 phi) corrected for the volume of the cylinder and dispersant concentration.

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr. East Port Orchard WA. 98366
August 8, 1994

Project:	**Elliot Bay Recontamination Study**
Samples:	268512, 268531, 268550, 268558
Laboratory:	Sound Analytical Services, Inc. 41453
By:	Karin Feddersen KF

These samples were received at the Manchester Laboratory on June 28, 1994, and were sent to Sound Analytical Services, Inc. on June 30, 1994 for TOC analysis using the following method: Puget Sound Estuary Program

DATA QUALIFIER DEFINITIONS

U - The analyte was not detected at or above the reported result.

HOLDING TIMES

The PSEP TOC holding time for frozen sediments is six (6) months. No studies to my knowledge have been performed to indicate the effect of holding time on samples that have not been stored frozen prior to analysis. Therefore an evaluation of the results with regard to holding time is not feasible. The samples were stored in the proper containers at 4 degrees C until analysis.

PROCEDURAL BLANKS

The procedural blanks associated with these samples have demonstrated that the process is free from contamination.

CHECK STANDARDS

All recoveries were within QC limits of +/- 20%.

TRIPLICATE

Sample 268512 was analyzed in triplicate. The triplicate analyses are in acceptable agreement with the original analysis. The Relative Percent Difference (RPD) was within the +/- 20% window for triplicate analyses.

SUMMARY

For consistency with Manchester Environmental Laboratory reporting requirements, all non-detect values have been modified to reflect the detection limit and have been qualified with a "U".

This data is acceptable for use as amended.

MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE

August 12, 1994

Subject: Elliott Bay Recontamination

Samples: 94 - 268512 to -268517, -268531 to -268536, -268550 to -268558 and -268559

Case No. DOE-155X

Officer: Dale Norton

By: Dickey D. Huntamer
Organics Analysis Unit

POLYCHLORINATED BIPHENYLS

ANALYTICAL METHODS:

The sediment samples were Soxhlet extracted using acetone as the solvent. Analysis was done by EPA Method 8080 using dual column capillary GC analysis with Electron Capture Detectors (ECD).

HOLDING TIMES:

All sample extraction and analysis holding times were met.

BLANKS:

No target compounds were detected in the laboratory blanks.

SURROGATES:

The surrogate spike recoveries were generally within acceptable QC limits. Surrogates ranged from 49% to 110% recovery for all samples except, -268535 where decachlorobiphenyl (DCB) had 145% recovery. Surrogate recoveries for sample, -268551, were low due to a crack in the Soxhlet extractor and some sample extract loss. The results for sample, -268551 were given the "J" qualifier to indicate that the quantification results are estimates.

MATRIX SPIKE AND MATRIX SPIKE :

The matrix spikes recoveries ranged from 64% to 71%. The Relative Percent Differences (RPD) ranged from 10.4% to 17%. All recoveries and RPD were within acceptable QC limits.

ANALYTICAL COMMENTS:

There were no significant problems with the PCB analysis and the data is acceptable for use as qualified. Sample -268512 exhibited a strong creosote like odor and had an oily extract.

DATA QUALIFIER CODES:

U	-	The analyte was not detected at or above the reported value.
J	-	The analyte was positively identified. The associated numerical value is an estimate.
UJ	-	The analyte was not detected at or above the reported estimated result.
REJ	-	The data are unusable for all purposes.
EXP	-	The result is equal to the number before EXP times 10 to the power of the number after EXP. As an example 3EXP6 equals 3 X 10^6.
NAF	-	Not analyzed for.
N	-	For organic analytes there is evidence the analyte is present in this sample.
NJ	-	There is evidence that the analyte is present. The associated numerical result is an estimate.
E	-	This qualifier is used when the concentration of the associated value exceeds the known calibration range.
*	-	The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)

BOTTOM CORE
METALS

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive East • Port Orchard, Washington 98366-8204 • (206) 871-8860 • SCAN 871-8860

August 19, 1994

TO: Dale Norton

FROM: Bill Kammin, Environmental_Lab_Director

SUBJECT: Metals Quality Assurance memo for the Elliott Bay Project

SAMPLE INFORMATION

These samples from the Elliott Bay project were received by the Manchester Laboratory on 6/29/94 in good condition.

HOLDING TIMES

All analyses were performed within the USEPA Contract Laboratory Program (CLP) holding times for metals analysis (28 days for mercury, 180 days for all other metals).

INSTRUMENT CALIBRATION

Instrument calibration was performed before each analytical run and checked by initial calibration verification standards and blanks. Continuing calibration standards and blanks were analyzed at a frequency of 10% during the run and again at the end of the analytical run. All initial and continuing calibration verification standards were within the relevant USEPA (CLP) control limits. AA calibration gave a correlation coefficient (r) of 0.995 or greater, also meeting CLP calibration requirements.

PROCEDURAL BLANKS

The procedural blanks associated with these samples showed no analytically significant levels of analytes.

SPIKED SAMPLE ANALYSES

Spike and duplicate spike sample analyses were performed on this data set. All spike recoveries were within the CLP acceptance limits of +/- 25%, with the following exception: lead and zinc. The spiked sample for lead showed considerable non-homogeneity, with precision at 22%. (RPD). Lead results are qualified with J, denoting estimated values. One of the zinc spikes was recovered outside the +/- 25%

acceptance window, so zinc results were qualified with N. Per EPA CLP protocols, the major analytes aluminum, iron, and magnesium were not spiked.

For mercury, the initial spiking level was miniscule in relation to the level of mercury in the sample. The analyst respiked one of the samples at 20 times the lab normal spiking level and found acceptable recoveries.

PRECISION DATA

The results of the spike and duplicate spike samples were used to evaluate precision on this sample set. The Relative Percent Difference (RPD) for all analytes was within the 20% CLP acceptance window for duplicate analysis, with the following exception: lead.

REFERENCE MATERIAL ANALYSES

The project requested analysis of NIST 1646, a highly mineralized estuarine sediment, in support of this project. NIST 1646 is generally not well recovered by the environmental sample preparation methods for metals. ICP recoveries for 1646 were typical (see attached spreadsheets). ALso analyzed by ICP was ERA material #216. Recoveries for ERA material 216 were acceptable.

For mercury in sediment NIST 2704 (Buffalo River Sediment) is analyzed with every run. 2704 recoveries for this run were 106%, 105%, 106% and 105%. NIST 1646 was also analyzed, giving slighly high recoveries, 139% and 137%. It is possible that this standard needs recertification for mercury, as these results are very similar to results that Battelle Sequim is obtaining for this same standard.

SUMMARY

The data generated by the analysis of these samples can be used noting the data qualifications discussed in this memo.

Please call Bill Kammin at SCAN 206-871-8801 to further discuss this project.

WRK:wrk

		Hg	% Rec
1.44	2704	1.53	106
		1.51	105
			106
			105
	x	1.52	
.003	1646	.083	
		.056	
		.027	

AANDERRA
CURRENT
METERS

FIRST QUARTER

DATA QUALITY EVALUATION

AANDERAA INSTRUMENTS LTD.
ALPHA STREET
TORIA, BRITISH COLUMBIA
CANADA V8Z 1B2
TELEPHONE (604) 386-7783

CUSTOMER Washington State Department of Ecology
Olympia, WA 98504-7612
Atten: Dale Norton

Instrument RCM4 Serial No. 7207 Tape No. 1

Words 52662 Samples 8777 Errors 0 Sync errors 0

Expected number of samples (calculated from start/ stop times) Uncertain of correct start/cast/stop times.

Physical tape problem(s) None ☒

Insufficient leader/ trailer (should have 15 turns) ☐

Other

Instrument problem None ☒

Problem

Probable cause

Recommended action

Date February 3, 1994

Signed David R Bauer

DATA QUALITY EVALUATION

AANDERAA INSTRUMENTS LTD.
ALPHA STREET
TORIA, BRITISH COLUMBIA
CANADA V8Z 1B2
TELEPHONE (604) 386-7783

CUSTOMER Washington State Department of Ecology
Olympia, WA 98504-7612
Atten: Dale Norton

Instrument RCM4 Serial No. 7228 Tape No. 1

Words 47376 Samples 7896 Errors 0 Sync errors 0

Expected number of samples (calculated from start/ stop times) Uncertain of correct start/cast/stop times.

Physical tape problem(s) None ☒

Insufficient leader/ trailer (should have 15 turns) ☐

Other

Instrument problem None ☒

Problem

Probable cause

Recommended action

Date February 3, 1994

Signed

DATA QUALITY EVALUATION

AANDERAA INSTRUMENTS LTD.
ALPHA STREET
TORIA, BRITISH COLUMBIA
CANADA V8Z 1B2
TELEPHONE (604) 386-7783

CUSTOMER Washington State Department of Ecology
Olympia, WA 98504-7612
Atten: Dale Norton

Instrument RCM4 Serial No. 7689 Tape No. 1

Words 48492 Samples 8082 Errors 1 Sync errors 3

Expected number of samples (calculated from start/ stop times) Uncertain of correct start/cast/stop times.

Physical tape problem(s) None ☐

Insufficient leader/ trailer (should have 15 turns) ☐

Other Edge of tape was slightly stretched - caused signal strength to vary.
Sample # 3696 - speed channel had word error and sync error.
(likely due to imperfection in tape)
Sample # 7856 - temperature reading missed - inserted '527'
(same number as above and below sample # 7856)
Sample # 8073 - reference reading dropped - inserted '54'

Instrument problem None ☐

Problem

Probable cause

Recommended action Advise check of tape transport alignment/spoolholder tensions.

Date February 3, 1994 Signed David R. Bauer

DATA QUALITY EVALUATION

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CUSTOMER Washington Department of Ecology
Olympia, WA 98504-7612
Atten: Dale Norton

Instrument RCM4 Serial No. 7690 Tape No. 1

Words 45144 Samples 7524 Errors 0 Sync errors 35

Expected number of samples (calculated from start/ stop times) Uncertain of correct start/cast/stop times.

Physical tape problem(s) None ☒

Insufficient leader/ trailer (should have 15 turns) ☐

Other

Instrument problem None ☐

Problem Lack of sync pulse. Without a sync pulse, instrument did not stop recording to wait for next interval. Caused excess data to be recorded in between proper data sets - lead to tape running out before deployment end. Excess data removed from samples # 965/967/969/1008/1075/1076/1077/1108/1995/2220/3769/4354/4397/4401/4402/4545/4546/4548/4920/5407/5409/5476/5533/5574/5576/5638/7509/7510/7512/7513/7515/7517/7521/7523/7524. Original and altered files stored.

Probable cause

Channel selector/encoder alignment changed during shipment or deployment due to excess vibration.

Recommended action Re-adjust channel selector/encoder alignment - center channel selector in mounting hole and test.

Date February 3, 1994 Signed David R. Bauer

DATA QUALITY EVALUATION

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TORIA, BRITISH COLUMBIA
CANADA V8Z 1B2
TELEPHONE (604) 386-7783

CUSTOMER Washington State Department of Ecology
Olympia, WA 98504-7612
Atten: Dale Norton

Instrument RCM4 Serial No. 7693 Tape No. 1

Words 52086 Samples 8681 Errors 2 Sync errors 3

Expected number of samples (calculated from start/ stop times) Uncertain of start/cast/stop times.

Physical tape problem(s) None ☐

Insufficient leader/ trailer (should have 15 turns) Tape ran out or was cut too close to end of data. ☐

Other Unable to read last 8" of tape. Only errors occured at end of tape when tape tension on readout head was lost.

Instrument problem None ☒

Problem

Probable cause

Recommended action Ensure at least 15 turns of tape are left at beginning and end of data.

Date February 3, 1994 Signed David R. Bauer

DATA QUALITY EVALUATION

AANDERAA INSTRUMENTS LTD.
ALPHA STREET
ORIA, BRITISH COLUMBIA
CANADA V8Z 1B2
TELEPHONE (604) 386-7783

CUSTOMER Washington State Department of Ecology
Olympia, WA 98504-7612
Atten: Dale Norton

Instrument RCM4 Serial No. 7695 Tape No. 1

Words 47970 Samples 7995 Errors 0 Sync errors 0

Expected number of samples (calculated from start/ stop times) Uncertain of start/cast/stop times.

Physical tape problem(s) None ☒

Insufficient leader/ trailer (should have 15 turns) ☐

Other

Instrument problem None ☒

Problem

Probable cause

Recommended action

Date February 3, 1994

Signed David R. Bauer

SECOND QUARTER

2nd quarter Monitoring Results

Tape Translation Data Quality Evaluation
for
Washington State Department of Ecology

May 8, 1994

After reading the data from the seven (7) tapes sent for translation, a data quality evaluation was performed. Enclosed are the graph printouts for the temperature, conductivity, direction and speed raw data.

The data disk contains 3 self-extracting compressed files. The data can be retrieved by copying the file to the directory you wish the data to be stored and executing the file. The 3 files are as follows:

rcm-raw.exe - contains data as read from tape.
rcm-mod.exe - contains error 'corrected' data.
rcm-eng.exe - contains engineering data files.

Following are descriptions of data quality:

RCM 7207 - 8717 samples read, 1 word and 1 sync errors. Sample # 4296 missed conductivity reading - inserted 0 to align remaining columns.

RCM 7228 - 9024 samples read, 0 word and 1 sync errors. Sample # 1 missed reference and temperature readings - suspect that channel selector was advanced past channel 2 on start up. Inserted reference and average temperature reading.

RCM 7689 - 8757 samples read, 52362 word and 34 sync errors. Almost every word was marked as error indicating inconsistent bit pulse width. Data looks consistent and usable - suspect encoder cap geometry has changed due to vibration or age. Suggest full servicing for instrument.

Sample #/Changes
3716 - inserted ref.
8278 - removed 511 in ch. 5
8529 - inserted 1023 in ch. 4
8587 - inserted ref.
8601 - inserted ref. and 418 in ch. 3
8607 - deleted extra data.
8621 - inserted ref.
8622 - deleted 1023 before ref.
8623 - inserted ref, 505 in ch. 2, 417 in ch. 3
8629 - repaired ref.
8631 - repaired ref.
8635 - deleted extra data.
8657 - inserted ref.

8658 - inserted ref.
8671 - deleted extra data.
8672 - inserted ref.
8678 - inserted ref.
8685 - inserted ref.
8692 - inserted ref. and temp.
8700 - inserted ref. and temp.
8701 - deleted extra data.
8702 - deleted extra data.
8707-8 - inserted ref.
8715-6 - reconstructed sample.
8723-4 - inserted ref.
8731 - deleted extra data.
8739 - reconstructed sample.
8746 - deleted extra data.
8751 - deleted extra data.
8752-4 - deleted sample.

RCM 7690a - 3696+ samples read, 4 word and 144 sync errors. Reference reading fluctuates 1 bit. Channel selector past channel 1 on start - inserted reference reading. After sample # 2512, sync pulse missed causing instrument to continue to run until valid sync pulse was recorded. Instrument was later repaired by re-centering channel selector so brushes would make good contact with stop segments and clock was replaced due to erratic interval timing.

Deleted extra data after sample #: 2514, 2518, 2521, 2522, 2530, 2542, 2545, 2550, 2567, 2571, 2575, 2576, 2577, 2578, 2594, 2615, 2655, 2656, 2657, 2659, 2663, 2667, 2668, 2674, 2682, 2683, 2684, 2685, 2687, 2692, 2696, 2697, 2702, 2703, 2709, 2712, 2724, 2733, 2748, 2751, 2774, 2775, 2782, 2799, 2802, 2805, 2808, 2813, 2814, 2815, 2816, 2823, 2827, 2832, 2860, 2885, 2888, 2891, 2893, 2898, 2906, 2910, 2914, 2915, 2918, 2924, 2926, 2935, 2948, 2949, 2954, 2961, 2964, 2965, 2966, 2972, 2973, 2974, 3005, 3006, 3007, 3008, 3009, 3018, 3020, 3026, 3034, 3036, 3037, 3040, 3043, 3048, 3049, 3052, 3054, 3055, 3072, 3073, 3075, 3076, 3077, 3087, 3089, 3094, 3097, 3111, 3114, 3176, 3178, 3179, 3180, 3181, 3182, 3197, 3515, 3520, 3522, 3524, 3529, 3532, 3550, 3560, 3564, 3570, 3667, 3672, 3673, 3674, 3677, 3678, 3679

3697 deleted.

RCM 7690b - 4163 samples read, 1 word and 2 sync errors. First sample error - deleted. Sample # 17 missed temperature - inserted 650.

RCM 7693 - 9099 samples read, 0 word and 1 sync errors. First sample contained 2 sets of data - deleted second set.

RCM 7695 - 8637 samples read, 1 word and 0 sync errors. Reference reading fluctuates 1 bit on deployment. First word error - suspect tape tension on start up.

THIRD QUARTER

Barbara Nitus

Tape Translation Data Quality Evaluation
for
Washington State Department of Ecology

August 30, 1994

After reading the data from the six (6) tapes sent for translation, a data quality evaluation was performed. Enclosed are the graph printouts of the raw data for the temperature, conductivity, direction and speed channels.

The enclosed data diskette contains 2 self-extracting compressed files. The data can be retrieved by copying the file to the directory on a hard drive you wish the data to be stored and executing the file. The 2 files are as follows:

RCM-RAW.EXE - contains raw data read from tape, including the altered file for RCM 7689 (RCM7689.RAB).
RCM-ENG.EXE - contains engineering data files.

Following are descriptions of data quality:

RCM 7207 - 8776 samples read, 1 word error on start up and 0 sync errors. Data quality good.

RCM 7228 - 8547 samples read, 3 word errors and 0 sync errors. 1 word error on start up, 2 word errors at start of sample # 4162 caused by bent tape. Data quality good.

RCM 7689 - 8029 samples read, 59025 word errors and 21 sync errors. Almost every word marked as error indicating inconsistent bit pulse width. Data looks consistent and usable - suspect encoder cap geometry has changed due to age or vibration/impact. Similar data quality as previous tape translations performed on this instrument. Numeric errors appear beyond 7945 samples. Error indicators removed from data and samples beyond # 7945 removed - file saved as RCM7689.RAB

RCM 7690 - 8632 samples read, 0 word errors and 1 sync error due to pressure word missing from sample # 8006. Data quality good.

RCM 7693 - 8459 samples read, 0 word errors and 0 sync errors. Minor reference reading fluctuations of 1 bit. Data quality good.

RCM 7695 - 6422 samples read, 0 word errors and 0 sync errors. Minor reference reading fluctuations of 1 bit. Data quality good.

FOURTH QUARTER

Tape Translation Data Quality Evaluation for Washington State Department of Ecology

November 2, 1994

After reading the data from the six (6) tapes sent for translation, a data quality evaluation was performed. Enclosed are the graph printouts of the raw data for the temperature, conductivity, direction and speed channels.

The enclosed data diskette contains a self-extracting compressed file. The data can be retrieved by copying the file to the directory on a hard drive you wish the data to be stored and executing the file.

Following are descriptions of data quality:

RCM 7207 - 8436 samples read, 0 word errors and 0 sync errors. Data quality good.

RCM 7228 - 8654 samples read, 0 word errors and 0 sync errors. Data quality good.

RCM 7689 - 7361 samples read, 59025 word errors and 3 sync errors. Almost every word marked as error indicating inconsistent bit pulse width. Data looks consistent and usable - suspect encoder cap geometry has changed due to age or vibration/impact. Similar data quality as previous tape translations performed on this instrument. Numeric errors appear beyond 7354 samples. Data samples beyond # 7354 removed - original file saved as RCM7689.ORG

RCM 7690 - 8639 samples read, 1 word error on start and 0 sync errors. Data quality good.

RCM 7693 - 8823 samples read, 1 word error on start and 0 sync errors. Minor reference reading fluctuations of 1 bit. Data quality good.

RCM 7695 - 8653 samples read, 3 word errors and 7 sync errors - occurred at end of tape due to tape damage. Minor reference reading fluctuations of 1 bit. Data quality good.

Table C2: Results of analysis of certified reference materials for metals in marine sediment (mg/kg,dry).

Material*	Acceptable	ERA #216					Certified	NIST-1646					Certified	NIST 2704				
Quarter	Range	1	2	BC	3	4	Range	1	2	BC	3	4	Range	1	2	BC	3	4
Aluminum	3600-8400	6897	6705	5400	6350	6240	60500-64500	19633	19500	18500	20700	-	-	-	-	-	-	-
Arsenic	41-105	74.5	69.4	76.7	80	81.4	10.3-12.9	12.1	3.0	13.2	21.6	-	-	-	-	-	-	-
Cadmium	55-166	449	78.5	107	107	106	0.29-0.43	0.96	1.13	0.4	0.3	-	-	-	-	-	-	-
Chromium	95-265	193	186	178	187	192	73-79	39.8	37.2	37.5	40.4	-	-	-	-	-	-	-
Copper	84-200	128	125	126	125	134	15-21	19.1	16.1	16.6	14.8	-	-	-	-	-	-	-
Iron	7020-15100	9480	8055	8320	9300	9390	32500-34500	23600	19600	22600	23500	-	-	-	-	-	-	-
Lead	55-140	88.5	84.9	87.6	81.4	90.4	26.4-30.0	21.3	16.6	21.3	20.3	-	-	-	-	-	-	-
Mercury	-	-	-	-	-	-	0.051-0.075	-	-	0.087	-	-	1.37-1.51	1.64	1.36	1.52	1.43	-
Manganese	206-383	267	261	263	258	272	355-395	228	208	220	224	-	-	-	-	-	-	-
Silver	62-186	2.68	4.45	2.23	5.1	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	98-280	181	180	179	176	182	132-144	111	110	106	112	-	-	-	-	-	-	-

*=All values reported as mean of duplicate analysis

ERA #216= Environmental Resource Associates, lot #216- Laboratory Control Sample

NIST-1646=Estuarine Sediment- National Institute of Standards and Technology

-=Not analyzed

BC=Bottom Cores

▨ =Outside acceptable range by more than 10%

Table C3: Result of analysis of certified reference materials for polynuclear aromatic hydrocarbons (PAH) and polychlorinated biphenyls (PCBs) in marine sediment (ug/kg, dry).

Material*	HS-6				Certified
Quarter	1	2	3	4	Range
Napthalene	3300	-	4000	3400	3000-5200
Acenaphthylene	▨ 370	-	▨ 560	▨ 760 uj	140-240
Acenapthene	130	-	180	▨ 760 uj	160-300
Flourene	390	-	600	470 j	350-590
Phenanthrene	2600	-	4000	3000	2400-3600
Anthracene	850	-	1300	▨ 890 uj	700-1500
Flouranthene	3000	-	4800	3400	2890-4190
Pyrene	2200	-	3200	2500	2400-3600
Benzo(a)athracene	1300	-	2000	1500	1500-2100
Chrysene	1900	-	▨ 3000	2200	1700-2300
Benzo(a)pyrene	▨ 1300	-	1800	▨ 1400	1800-2600
Benzo(b)flouranthene	2900	-	▨ 4100	3200	2400-3400
Benzo(k)flouranthene	1100	-	1700	1300	1280-1580
Benzo(g,h,i)perylene	880	-	1400	1400	1060-2500
Dibenzo(a,h)anthracene	410	-	630	270	330-650
Indeno(1,2,3-cd)pyrene	1500	-	2200	1400	1370-2530

Material*	HS-2				Certified
Quarter	1	2	3	4	Range
Aroclor 1254	97	-	96	▨ 160	109.3-114.3

*=All values reported as means of duplicate analysis

uj=Estimated detection limit

j=Estimated concentration

HS-6= PAH in Marine Sediment- National Research Council of Canada

HS-2= PCBs in Marine Sediment- National Research Council of Canada

▨ =Exceeds certified range by more than 20%.

Table C4: Summary of blind field duplicate results for conventionals, metals and radiodating of settling particulate matter and bottom sediments from Elliott Bay collected October 1993 to October 1994 (mg/kg, dry).

Sample No.	8272	8273		8414	8415		8524	8525		8423	8424		8552	8559	
Quarter	1	1		2	2		3	3		4	4		-	-	
Sample Type	SPM	SPM	RPD	SPM	SPM	RPD	SPM	SPM	RPD	SPM	SPM	RPD	BS	BS	RPD
Conventionals															
Percent Solids	27	27	0	27	27	0	23	24	-4	23	21	9	66	66	0
TOC (%)	8.8	8.5	3	7.7	5.8	28	8.6	8.5	1	8.7	8.7	0	6.7	7.8	-15
Grain Size (%)															
Gravel	NA	NA	-	0	0	0	2	1	67	0	0	0	14	9	43
Sand	NA	NA	-	10	9	11	6	6	0	15	13	14	29	17	52
Silt	NA	NA	-	54	56	-4	39	44	-12	43	44	-2	47	57	-19
Clay	NA	NA	-	36	35	3	53	49	8	42	43	-2	10	17	-52
Metals															
Arsenic	25	27	-7.7	17 j	18 j	-5.7	15 j	14 j	6.9	16 j	17 j	-6.1	NA	NA	-
Cadmium	1.5 j	1.9 j	-23.5	2.4	2.7	-11.8	1.8	1.6	11.8	2	2.2	-9.5	NA	NA	-
Chromium	71	87	-20.3	65	70	-7.4	42 j	36 j	15.4	36	37	-2.7	NA	NA	-
Copper	150	150	0.0	190	190	0.0	130 j	120 j	8.0	120	130	-8.0	63	73	-14.7
Lead	130	140	-7.4	180	180	0.0	120 j	110 j	8.7	110	110	0.0	160 j	120 j	28.6
Mercury	0.25 j	0.25 j	0.0	0.45	0.41	9.3	0.31	0.32	-3.2	0.25	0.18	32.6	1.2	1.1	8.7
Silver	1.4 j	1.7 j	-19.4	3 j	2.3 j	26.4	3.4 j	2 j	51.9	0.88 j	1.1 j	-22.2	0.5 j	0.6 j	-18.2
Zinc	230	250	-8.3	310	300	3.3	220 j	200 j	9.5	190	190	0.0	110	110 j	0.0
Aluminum	23000	26000	-12.2	20000	20000	0.0	18000	16000	11.8	15000	15000	0.0	12000	10000	18.2
Iron	35000	36000	-2.8	32000	31000	3.2	28000	25000	11.3	24000	24000	0.0	21000	20000	4.9
Manganese	1200	1200	0.0	690	690	0.0	480 j	450 j	6.5	550	570	-3.6	170	156	8.6
Radiodating															
Pb-210	8.2	7.3	11.6	8.0	7.6	5.1	1.4	0.94	39.3	NA	NA	-	0.32	0.53	-49.4
Cs-137	NA	NA	-	NA	NA	-	NA	NA	-	NA	NA	-	0.14 u	0.14 u	-

RPD=Relative Percent Difference=[(x-y)/((x+y)/2)*100]

j=Estimated concentration

NA= Not Analyzed

-=No data

SPM= Settling particulate matter

BS= Bottom sediment

Table C4(cont.): Summary of blind field duplicate results for conventionals, metals and radiodating of settling particulate matter and bottom sediments from Elliott Bay collected October 1993 to October 1994 (mg/kg, dry).

Sample No.	8272	8273		8414	8415		8524	8525		8423	8424		8550	8558	
Quarter	1	1		2	2		3	3		4	4		-	-	
Sample Type	SPM	SPM	(%)	SPM	SPM	(%)	SPM	SPM	(%)	SPM	SPM	(%)	BS	BS	(%)
Sum LPAH	-	170000	-	85000	67000	24	100000	120000	-18	160000	200000	-22	NA	NA	-
Sum HPAH	-	210000	-	140000	130000	7	110000	120000	-8.7	150000	210000	-33	NA	NA	-
Pentachlorophenol	-	540 j	-	1800 j	1300 j	32	8400 u	6600 u	-	3800 u	390 u	-	NA	NA	-
Bis(2EH)phthalate	-	5800 u	-	9700	8000	19	4600 u	6000 u	-	3800 u	3900 u	-	NA	NA	-
Total PCBs	-	540	-	NA	NA	-	570	500	13	560	450	22	66	76 u	-

RPD=Relative Percent Difference=[(x-y)/((x+y)/2)*100]

-=No data

u=Not detected at detection limit shown

j=Estimated concentration

NA= Not Analyzed

SPM= Settling particulate matter

BS= Bottom sediment

Appendix D - Individual Chemicals in Settling Particulate Matter and Bottom Cores, dry weight basis

Metals in Settling Particulate Matter (Table D1)

Organics in Settling Particulate Matter (Table D2)

Metals and Organics in bottom cores (Table D3)

Table D1: Results of conventionals and metals analysis of settling particulate matter (SPM) collected between October 1993 and October 1994, Elliott Bay Waterfront Recontamination Study (mg/kg, dry weight unless otherwise noted).

			Grain Size (%)				Total Metals										
Station	Quarter	Solids (%)	Sand >62um	Silt 62-4um	Clay <4um	TOC (%)	As	Cd	Cr	Cu	Pb	Hg	Ag	Zn	Al	Fe	Mn
EB1-Surface	1	27	-	-	-	7.5	41	1.6 j	74	200	140	0.41 j	0.3 uj	390	21000	41000	1300
	2	28	10	31	59	4.8	23 j	1.5	43	130	100	0.30	0.3 uj	290	20000	34000	960
	3	16	11	33	56	8.4	14 j	1.3	24 j	100	70	0.25 j	0.3 uj	200 j	9500	22000	400 j
	4	15	27	23	50	8.6	12 j	1.1	26	88	63	0.32 j	0.3 uj	170	8600	16000	390
EB1-Bottom	1	31	-	-	-	6.3	18	1.0 j	80	110	130	0.71 j	1.1 j	200	25000	33000	1000
	2	33	8	48	44	3.4	13 j	1.1	54	120	110	0.54	0.6 j	220	21000	31000	720
	3	20	8	37	55	6.1	12 j	1.0	30 j	86 j	93 j	0.61	1 j	150 j	11000	21000	340 j
	4	23	-	-	-	6.8	15 j	1.5	47	130	130	0.74	0.6 j	200	16000	29000	520
EB2	1	25	-	-	-	18.7	17	4.5 j	66	390	130	2.4 j	2.0 j	280	17000	26000	260
	2	28	10	40	50	6.8	18 j	2.6	68	190	180	1.6	2.0 j	310	20000	32000	690
	3	24	11	37	52	9.7	16 j	2.7	42 j	150 j	160 j	4.4 j	3.7 j	260 j	15000	25000	350 j
	4	23	19	42	39	11	19 j	3.7	48	190	170	2.0	0.64 j	300	16000	27000	370
EB3	1	29	-	-	-	6.7	22	1.4 j	80	130	140	0.86 j	1.4 j	220	27000	30000	1100
	2	32	9	43	48	6.3	16 j	1.2	70	120	110	0.80	1.3 j	200	22000	28000	1000
	3	24	8	35	57	7	12 j	1.3	38 j	110 j	100 j	0.94	1.8 j	170 j	17000	24000	7800
	4	22	13	37	50	8.4	15 j	1.7	41	120	120	0.79	0.96 j	210	17000	26000	560
EB4	1	27	-	-	-	8.7	26	2.0 j	79	150	130	0.92 j	1.5 j	240	25000	35000	1200
	2	30	10	34	56	5.1	18 j	1.7	59	140	120	0.70	1.4 j	250	23000	33000	1100
	3	23	7	34	59	8.5	15 j	1.7	39 j	130 j	120 j	1.4	2.7 j	210 j	17000	27000	470 j
	4	22	14	33	53	8.7	16 j	2.1	36	120	110	0.96	0.99 j	190	15000	24000	560
EB5	1	27	8	41	51	10.7	26	2.8 j	88	190	150	1.1 j	2.5 j	280	24000	35000	620
	2	25	8	45	47	6.4	18 j	2.1	57	170	140	0.94	2.2 j	270	19000	30000	670
	3	23	7	40	53	9.5	16 j	2.7	49 j	170 j	140 j	1.3	3 j	260 j	18000	29000	390 j
	4	25	16	39	45	9.9	19 j	3.2	55	170	150	1.1	2 j	270	20000	30000	340

j= Estimated value

uj= Estimated detection limit

Table D1(cont.): Results of conventionals and metals analysis of settling particulate matter (SPM) collected between October 1993 and October 1994, Elliott Bay Waterfront Recontamination Study (mg/kg, dry weight unless otherwise noted).

			Grain Size (%)														
		Solids	Sand	Silt	Clay	TOC	Total Metals										
Station	Quarter	(%)	>62um	62–4um	<4um	(%)	As	Cd	Cr	Cu	Pb	Hg	Ag	Zn	Al	Fe	Mn
EB6–Surface	1	26	–	–	–	–	22	2.0 j	650	140	150	0.38 j	0.5 j	280	24000	35000	300
	2	22	–	–	–	4.2	18 j	1.0	56	130	100	0.71	0.3 j	350	21000	33000	520
	3	20	6	36	58	7.3	8.6 j	1.4	25 j	85 j	63 j	1.1	0.52 j	170 j	11000	18000	130 j
	4	19	14	27	59	9.8	13 j	1.5	32	90	77	0.33	0.53 j	170	12000	18000	440
EB6–Bottom	1	28	–	–	–	6.4	23	1.4 j	98	130	120	0.93 j	1.2 j	210	22000	35000	1300
	2	27	11	41	48	4.7	14 j	1.0	50	120	100	0.66	1.1 j	200	19000	29000	790
	3	21	10	37	53	7.1	12 j	1.2	36 j	110 j	90 j	0.75	1.5 j	170 j	15000	24000	410 j
	4	23	24	36	40	7.6	11 j	1.6	39	120	100	0.63	1.5 j	180	16000	23000	370
EB7	1	29	–	–	–	7.3	23	0.98 j	83	140	150	0.86 j	2.2 j	240	24000	36000	860
	2	32	19	38	43	3.8	14 j	1.3	61	150	130	0.64	1.7 j	240	21000	31000	740
	3	23	15	38	47	7.1	12 j	1.4	40 j	110 j	110 j	0.86	2.4 j	190 j	14000	23000	360 j
	4	25	18	42	40	7.0	12 j	2.2	48	140	150	0.96	0.65 j	230	17000	26000	290
EB8	1	32	–	–	–	8.9	12	1.6 j	67	340	190	1.2 j	5.2 j	280	19000	31000	270
	2	34	12	47	41	4.5	16 j	1.3	61	190	200	1.2	3.0 j	240	20000	27000	460
	3	36	11	44	45	5.1	12 j	1.0	41 j	120 j	150 j	1.1	3.3 j	170 j	14000	22000	260 j
	4	36	23	47	30	4.5	5.2 j	1.7	40	130	200	1.4	3.1 j	220	13000	14000	330
EB9	1	35	–	–	–	4.2	15	0.65 j	100	180	98	0.66 j	1.5 j	190	22000	29000	1200
	2	33	10	46	44	3.2	10 j	0.56	51	100	94	0.63	1.2 j	170	21000	24000	860
	3	20	12	39	49	4.5	7.7 j	1.3	30 j	96 j	65 j	0.5	1.8 j	130 j	14000	19000	370 j
	4	22	10	42	48	7.7	11 j	0.95	42	120	94	0.67	1.7 j	170	20000	25000	850
Overall Mean		25	12	39	49	7.2	16 j	1.7 j	67	140 j	120 j	0.96 j	1.6 j	230 j	18000	28000	780 j

j= Estimated value

uj= Estimated detection limit

Table D2: Summary of organic compounds detected in settling particulate matter (SPM) collected between October 1993 and October 1994, Elliott Bay Waterfront Recontamination Study (ug/kg, dry unless otherwise noted).

Station	EB1				EB1				EB2			
Depth	Surface	–	–	–	Bottom	–	–	–	Bottom	–	–	–
Quarter	1	2	3	4	1	2	3	4	1	2	3	4
Acenaphthene	2100	640	700 j	810	–	1800	1600	3000	–	5200	4200	5500
Acenaphthylene	600	270 j	210 j	540 uj	–	510	450 j	520 uj	–	1400	830	1500
Naphthalene	2800	250 j	310 j	350 j	–	550	740 j	1100	–	2400	3300	2900
Fluorene	2600	1100	880 j	1600	–	2600	2200	3000	–	9200	5700	8500
Anthracene	4100	2500	2200	4300	–	6600	4500	6700	–	20000	9300	16000
Phenanthrene	17000	6100	5600	8800	–	13000	10000	18000	–	36000	21000	33000
Sum LPAH	29000	11000 j	9900 j	16000 j	–	25000	20000 j	32000	–	74000	44000	67000
Fluoranthene	21000	8900	8100	12000	–	16000	12000	21000	–	38000	20000	34000
Benzo(a)anthracene	5600	3400	3300	4400	–	7400	5800	8400	–	15000	7200	13000
Chrysene	8400	5000	5200	7100	–	9900	8600	13000	–	20000	11000	19000
Pyrene	15000	4500	5600	7000	–	12000	8500	15000	–	25000	13000	23000
Benzo(b)Fluoranthene	8000	4700	4000	6200	–	8700	6500	11000	–	16000	7800	16000
Benzo(k)Fluoranthene	2700	1900	1500	2500	–	3800	2800	4800	–	6200	2800	6700
Benzo(a)pyrene	4300	2400	2400	3800	–	4900	4100	7700	–	9500	4400	9800
Dibenzo(a,h)anthracene	870	560	1100 u	700	–	1200	850 j	1500	–	1600	660	1400
Ideno(1,2,3-cd)pyrene	3100	1900	1800	2700	–	3700	2700	4800	–	5300	2300	5300
Benzo(g,h,i)perylene	2000	700	1200	2000	–	1100	2100	3800	–	2500	1500	4300
Sum HPAH	71000	34000	33000	48000	–	69000	54000 j	91000	–	140000	71000	130000
Total PAH	100000	45000 j	43000 j	64000 j	–	94000	74000 j	120000	–	210000	120000	200000
2-Methylnaphthalene	1200	310 j	320 j	420 j	–	780	860 j	1700	–	2900	3100	3200 uj
Dibenzofuran	1800	570	570 j	740	–	1300	1200	2300	–	4900	3800	4700
Carbazole	1600	380 u	1100 u	1300	–	1500	990	1500	–	3500	1600	2900
Isophorone	140 u	380 u	590 j	540 u	–	350 u	940 u	520 u	–	600 u	180 j	270 u
Retene	140 u	410	1100 u	540 u	–	660	560 j	490 j	–	1700	1400	1700
1,4-Dichlorobenzene	140 u	380 u	1100 u	540 u	–	350 u	940 u	520 u	–	440 j	400 j	540
Phenol	120 j	79 j	1100 u	540 uj	–	140 j	940 uj	520 uj	–	600 u	640 uj	3200
4-Methylphenol	97 j	380 u	1100 u	540 u	–	350 u	940 uj	520 uj	–	600 u	640 uj	5100
Pentachlorophenol	1900	1300	1200 j	6500 uj	–	350 j	9400 uj	5200 uj	–	1600 j	6400 uj	1400 uj
4,6-Dinitro-2-methylphenol	5500 u	380 u	11000 u	5400 u	–	350 u	9400 uj	5200 uj	–	600 u	6400 uj	2700 uj
Benzyl Alcohol	81 j	380 uj	2100 u	540 u	–	13000 j	1900 u	520 uj	–	600 u	1300 u	270 u
Benzoic Acid	6800	2600 uj	6900 j	16000 uj	–	350 uj	2700 j	5200 uj	–	600 uj	2300 j	8800
Di-n-butylphthalate	200 uj	450 uj	1100 uj	540 u	–	350 u	940 u	520 u	–	600 u	640 uj	270 u
Di-n-octylphthalate	140 u	500	2100 u	2700 uj	–	350 u	4200	2600 uj	–	600 u	1300 u	1400 uj
Butylbenzylphthalate	140 u	450 uj	1100 u	2700 uj	–	350 u	940 u	2600 uj	–	600 u	680	1400 uj
Bis(2-EH)phthalate	9500 uj	11000	99000 u	2100 uj	–	2800	4600 uj	1000 uj	–	8900	6400 uj	7200 j
PCBs												
1254	260	190 u	270	170 j	–	170 u	430	580	–	–	390	420
1260	240	480	270	300 j	–	400	240	560 j	–	–	320	430
Total PCBs	500	480	540	470 j	–	400	670	1100 j	–	–	710	850

u=Not detected at detection limit shown

j=Estimated concentration

uj=Estimated detection limit

–=No sample

Table D2 (cont.): Summary of organic compounds detected in settling particulate matter (SPM) collected between October 1993 and October 1994, Elliott Bay Waterfront Recontamination Study (ug/kg, dry unless otherwise noted).

Station	EB3				EB4				EB5			
Depth	Bottom	–	–	–	Bottom	–	–	–	Bottom	–	–	–
Quarter	1	2	3	4	1	2	3	4	1	2	3	4
Acenaphthene	7400	7500	5100	7600	14000	9000	13000	22000	8900	6600	5800	4200
Acenaphthylene	1100	1100	700 j	910	1800	1500	1200	1800	2200	1800	1000	1300
Naphthalene	3600	4200	5100	6100	8000	4400	10000	21000	6800	3900	4100	2500
Fluorene	10000	11000	7400	9300	20000	14000	16000	27000	14000	11000	7300	5900
Anthracene	13000	16000	11000	11000	33000	24000	15000	26000	39000	29000	15000	15000
Phenanthrene	53000	47000	30000	34000	97000	48000	52000	81000 j	63000	43000	26000	24000
Sum LPAH	88000	87000	59000 j	69000	170000	100000	110000	180000 j	130000	95000	59000	53000
Fluoranthene	45000	43000	23000	29000	70000	40000	36000	54000	57000	42000	24000	28000
Benzo(a)anthracene	11000	11000	6800	9200	18000	14000	11000	18000	16000	14000	8700	9300
Chrysene	15000	17000	11000	14000	26000	21000	16000	26000	28000	19000	14000	15000
Pyrene	30000	27000	13000	18000	46000	24000	22000	36000	39000	27000	19000	17000
Benzo(b)Fluoranthene	13000	13000	8000	11000	19000	16000	11000	18000	18000	15000	9600	13000
Benzo(k)Fluoranthene	4900	4500	3100	4400	6700	5300	4100	7400	6900	5300	4200	5200
Benzo(a)pyrene	7500	6900	6800	7300	12000	8200	6500	11000	11000	8500	5900	8000
Dibenzo(a,h)anthracene	1300	1100	800 j	1100	1800	1600	1100	1600	1500	1400	960	1100
Ideno(1,2,3-cd)pyrene	4300	4100	2900	4200	6400	4900	3300	5800	5300	4400	3000	4200
Benzo(g,h,i)perylene	2300	2000	2200	3400	3400	1200	2500	4600	2100	1800	2100	3300
Sum HPAH	130000	130000	78000 j	100000	210000	140000	110000	180000	180000	140000	91000	100000
Total PAH	220000	220000	137000 j	170000	380000	240000	220000	360000	310000	240000	150000	150000
2-Methylnaphthalene	4000	4100	3700	4800	8200	5200	9600	17000	5800	4400	4200	2600
Dibenzofuran	6500	6800	4600	6100	1300	8800	11000	19000	8200	6600	5000	3800
Carbazole	3000	3400	2900	2000	5900	4100	2700	4500	5200	4500	1800	2000
Isophorone	130 u	450 u	820 u	440 u	210 u	580 u	750 u	390 uj	140 u	890 u	290 j	320 uj
Retene	130 u	920	1200	930	210 u	1100	22000	1100	140 u	1400	1400	910
1,4-Dichlorobenzene	130 u	450 u	820 u	60 j	210 u	580 u	750 uj	390 u	89 j	890 u	780 u	320 u
Phenol	82 j	76 j	820 uj	800 uj	110 j	120 j	750 uj	390 uj	160	890 u	780 uj	320 u
4-Methylphenol	74 j	450 u	820 u	870 j	120 j	580 u	730 j	390 uj	2100	890 u	780 uj	340 uj
Pentachlorophenol	440 j	320 j	8200 uj	2900 uj	540 j	340 j	7500 uj	2100 uj	690 u	890 u	480 j	3200 uj
4,6-Dinitro-2-methylphenol	4700 u	450 u	8200 uj	4400 uj	8300 u	580 u	7500 uj	3900 uj	5600 u	890 u	8000 uj	3200 uj
Benzyl Alcohol	150 j	450 u	1700 u	440 u	210 u	7600 uj	1500 u	390 u	140 u	4700 uj	1600 u	320 u
Benzoic Acid	3500	2500 uj	3700 j	6900 uj	6600	580 u	5600 j	4600 uj	3400	890 u	6000 j	3200 uj
Di-n-butylphthalate	39000 j	450 u	820 u	980 uj	510 uj	580 u	750 uj	950 uj	8500 uj	890 u	1700	410 uj
Di-n-octylphthalate	120 u	450 u	1700 u	2200 uj	210 uj	580 u	1500 u	1900 uj	140 uj	890 u	1600 u	670 uj
Butylbenzylphthalate	210 uj	450 u	820 u	2200 uj	260 uj	580 uj	750 u	1900 uj	140 u	32000	780 u	1600 uj
Bis(2EH)phthalate	3500 uj	18000	16000 uj	2700 uj	5800 uj	7000	5300 uj	3900 uj	8400 uj	10000	9000	5700 uj
PCBs												
1254	210	230 u	230	260	270	290 u	290	240	330	440 u	320	280
1260	190	360	240	360 j	270	410	250	270	230	430 j	300	270
Total PCBs	400	360	470	620 j	540	410	560	510	560	430 j	620	550

u=Not detected at detection limit shown
j=Estimated concentration

uj=Estimated detection limit
–=No sample

Table D2 (cont.): Summary of organic compounds detected in settling particulate matter (SPM) collected between October 1993 and October 1994, Elliott Bay Waterfront Recontamination Study (ug/kg, dry unless otherwise noted).

Station	EB6				EB6				EB7			
Depth	Surface	–	–	–	Bottom	–	–	–	Bottom	–	–	–
Quarter	1	2	3	4	1	2	3	4	1	2	3	4
Acenaphthene	–	510 j	3200	5500	6000	4900	2700	3900	5900	4200	5200	3500
Acenaphthylene	–	760 j	680 j	1000 uj	1200	1100	580 j	880 uj	1500	940	810 j	1100
Naphthalene	–	300 j	1400	4700	2700	1600	1600	1900	3200	3900	3300	2200
Fluorene	–	1900	4500	6800	8700	8100	3600	5300	8100	6400	6400	4800
Anthracene	–	9000	7000	14000	19000	18000	7100	11000	17000	12000	8600	9400
Phenanthrene	–	9700	16000	26000	41000	31000	15000	22000	38000	24000	26000	21000
Sum LPAH	–	22000 j	33000 j	57000	79000	65000	31000 j	44000	74000	51000	50000 j	42000
Fluoranthene	–	20000	13000	26000	37000	29000	14000	21000	41000	27000	28000	30000
Benzo(a)anthracene	–	8000	4600	7200	10000	9400	5100	6800	13000	10000	9300	9800
Chrysene	–	16000	6500	15000	16000	14000	7600	10000	19000	14000	13000	15000
Pyrene	–	11000	7700	15000	25000	18000	9200	12000	26000	15000	17000	18000
Benzo(b)Fluoranthene	–	8900	4000	10000	13000	10000	5300	8900	15000	9900	8700	11000
Benzo(k)Fluoranthene	–	3000	1800	3400	4000	4200	2300	2900	5100	4400	3400	4900
Benzo(a)pyrene	–	4400	2300	5300	7000	5400	3100	5300	8600	5600	4900	6900
Dibenzo(a,h)anthracene	–	850	460 j	810	1000	920	550 j	830	1300	940	830 j	970
Ideno(1,2,3-cd)pyrene	–	2500	970	2900	3700	3000	1700	2900	4200	2900	2500	3500
Benzo(g,h,i)perylene	–	1700 j	840 j	2500	2800	1200	1100	2300	2600	820	1900	2800
Sum HPAH	–	76000 j	42000 j	88000	120000	95000	50000 j	73000	140000	91000	90000 j	100000
Total PAH	–	98000 j	75000 j	150000	200000	160000	81000 j	120000	210000	140000	140000 j	140000
2-Methylnaphthalene	–	250 j	1900	4200	3200	2300	1800	2200	3200	2300	3100	1700
Dibenzofuran	–	720 j	3000	4900	5700	5000	2500	3400	5200	1900	4300	3100
Carbazole	–	1500	950	2400	3300	2700	1100	1500	2800	4000	1400	1200
Isophorone	–	1900 u	860 u	550 u	130 u	450 u	880 u	450 u	52 j	470 u	920 u	350 u
Retene	–	510 j	860 u	360 j	130 u	800	810 j	670	120 u	820	1000	870
1,4-Dichlorobenzene	–	1900 u	860 u	550 u	130 u	450 u	880 u	450 u	120 u	470 u	920 u	350 u
Phenol	–	1900 u	860 uj	2600	100 j	110 j	880 u	650 uj	54 j	120 j	920 u	670 uj
4-Methylphenol	–	1900 u	860 u	550 uj	130 u	450 u	880 u	14000	130	470 u	920 u	4600
Pentachlorophenol	–	1900 u	8600 uj	5500 u	660 u	450 u	8800 u	4500 u	620 u	470 u	9200 uj	3500 u
4,6-Dinitro-2-methylphenol	–	1900 u	8600 uj	5500 u	5300 u	450 u	8800 u	4500 uj	5000 u	9500	9200 uj	3500 uj
Benzyl Alcohol	–	1900 u	1700 u	550 u	130 u	450 u	1800 u	450 u	120 u	470 u	1800 u	350 u
Benzoic Acid	–	76000 uj	3000 j	15000 uj	2200 uj	3400 uj	6700 j	4500 u	2700	2000 uj	4900 j	3100 uj
Di-n-butylphthalate	–	1900 u	860 u	1000 uj	3300 uj	450 u	880 u	800 uj	200 uj	470 u	960 uj	360 uj
Di-n-octylphthalate	–	1900 u	1700 u	2800 uj	130 u	450 u	1800 u	2300 uj	120 u	470 u	1800 u	1800 uj
Butylbenzylphthalate	–	1900 u	860 u	2800 uj	130 u	450 u	880 u	2300 uj	210	470 u	920 u	1800 uj
Bis(2EH)phthalate	–	11000	4300 uj	3500 uj	4600	6200	3200 uj	2300 uj	4100 uj	4900	47000 uj	2200 uj
PCBs												
1254	–	–	T	160 j	210	230 u	220	250	260	–	230 j	240
1260	–	–	T	280 j	170	300	190 j	310	200	–	180 j	240
Total PCBs	–	–	–	440 j	380	300	410 j	560	460	–	410 j	480

u=Not detected at detection limit shown

j=Estimated concentration

uj=Estimated detection limit

–=No sample

Table D2 (cont.): Summary of organic compounds detected in settling particulate matter (SPM) collected between October 1993 and October 1994, Elliott Bay Waterfront Recontamination Study (ug/kg, dry unless otherwise noted).

Station	EB8				EB9			
Depth	Bottom	–	–	–	Bottom	–	–	–
Quarter	1	2	3	4	1	2	3	4
Acenaphthene	900	1200	970	1200	660	1300	1500	1700
Acenaphthylene	560	720	360 j	460	210	390 j	200 j	430
Naphthalene	1100	1200	930	980	310	620	1100	1200
Fluorene	1300	2100	1100	1400	120 uj	1800	1600	2200
Anthracene	2700	5000	2100	2900	1700	2900	1500	3000
Phenanthrene	5100	9200	4700	5700	4000	8100	6800	8400
Sum LPAH	12000	19000	10000 j	13000	6900	15000 j	13000 j	17000
Fluoranthene	5000	9500	5800	6700	4100	9100	8000	8000
Benzo(a)anthracene	2400	3900	2400	2500	1400	2800	2400	2800
Chrysene	3400	5800	4100	4200	2200	4600	3500	4800
Pyrene	4500	6600	4800	5800	2600	5900	5000	5000
Benzo(b)Fluoranthene	3500	5800	3700	4200	2000	3900	2600	4000
Benzo(k)Fluoranthene	1400	2400	1300	1800	650	1400	870	1700
Benzo(a)pyrene	2100	2900	2200	2700	1000	2100	1500	2500
Dibenzo(a,h)anthracene	120	580	340 j	470	210	380 j	320 j	430
Ideno(1,2,3-cd)pyrene	120	1900	1300	1500	620	1300	850	1500
Benzo(g,h,i)perylene	120	720	940	1200	380	600	750 j	1300
Sum HPAH	23000	40000	27000 j	32000	15000	32000 j	26000 j	32000
Total PAH	35000	59000	37000 j	45000	22000	47000 j	39000 j	49000
2-Methylnaphthalene	630	710	590	570	430	730	1100	1300
Dibenzofuran	880	1300	830	960	630	1100	1100	1500
Carbazole	1000	750	350 j	430	340	690	810 u	450 u
Isophorone	120 u	440 u	490 u	210 u	120 u	570 u	810 u	310 j
Retene	120 u	720	790	760	120 u	440 j	810 u	450 u
1,4-Dichlorobenzene	120 u	440 u	490	210 u	120 u	570 u	810 u	450 u
Phenol	5100	240 j	490 uj	210 uj	51 j	570 u	810 uj	450 uj
4-Methylphenol	380000	440 u	920	210 uj	520	570 u	810 uj	450 u
Pentachlorophenol	590 u	440 u	4900 u	2100 u	560 u	570 u	8100 uj	4500 u
4,6-Dinitro-2-methylphenol	4700 u	8800 uj	4900 u	2100 u	4700 u	570 u	8100 uj	4500 uj
Benzyl Alcohol	120 u	440 u	980 u	210 u	120 u	570 u	1600 u	450 u
Benzoic Acid	3600	2500 uj	1600 j	5100 uj	2700	570 u	7800 j	6400 uj
Di-n-butylphthalate	120 u	440 u	490 uj	260 uj	120 uj	570 u	810 u	1300 uj
Di-n-octylphthalate	120 uj	440 u	980 u	1100 uj	120 uj	1800 j	1600 u	2300 uj
Butylbenzylphthalate	120 u	440 u	490 u	1100 uj	120 uj	570 u	810 u	2300 uj
Bis(2EH)phthalate	2600 uj	4500	140 uj	91000 j	46000 uj	5300	850 uj	1900 uj
PCBs								
1254	370	450 j	240	310	120	280 u	200 u	170 j
1260	370	540	240	410	120	300	130 j	280
Total PCBs	740	990 j	480	720	240	300	130 j	450 j

u=Not detected at detection limit shown

j=Estimated concentration

uj=Estimated detection limit

–=No sample

Table D3: Summary of metals and organics analysis of bottom cores collected June 1994 for Elliott Bay Waterfront Recontamination Study.

Sample*			Grain Size														
Interval		TOC	Sand	Silt	Clay	Total Metals (mg/kg, dry)								PCBs (ug/kg, dry)			
(cm)	%Solids	(%)	(>62.5um)	(62.5–4um)	(<4um)	Cu	Pb	Ag	Hg	Zn	Al	Fe	Mn	1242	1254	1260	Total
Core #: C1 (Between Piers 54 and 55)																	
0–8	25	7.7	13	51	36	210	260 j	4.5 j	2.2	380 j	20000	31000	230	340 j	760	580	1700 j
8–16	31	–	–	–	–	280	330 j	4.7 j	2.5	420 j	23000	33000	270	230 j	1300	750	2300 j
16–32	33	–	–	–	–	290	480 j	3.7 j	5.5	590 j	22000	29000	230	500 j	2900	1480	4900 j
32–80	39	–	–	–	–	270	580 j	4.9 j	5.1	530 j	21000	27000	220	220 j	560	480	1300 j
80–128	44	–	–	–	–	180	510 j	5.1 j	3.4	400 j	22000	29000	250	100 u	100 u	100 u	100 u
128–140	49	–	–	–	–	90	280 j	0.9 j	2.9	280 j	25000	28000	300	79 u	79 u	79 u	79 u
Core #: C2 (Between Piers 56 and 57)																	
0–11	24	7.0	10	49	41	340	430 j	4.4 j	5.3	590 j	26000	30000	260	370 j	1900	2100	4400 j
11–21	27	–	–	–	–	300	540 j	3.8 j	7.0	710 j	24000	28000	240	680 j	2500	1300	4500 j
21–42	23	–	–	–	–	690	590 j	1.4 j	9.6	1000 j	46000	34000	210	1500 j	5500	1800	8800 j
42–105	21	–	–	–	–	300	400 j	6.2 j	12	1200 j	8500	13000	76	1400 j	4300	1100	6800 j
105–168	25	–	–	–	–	360	470 j	5.2 j	16	950 j	10000	20000	100	990 j	2700	1000	4700 j
168–206	29	–	–	–	–	1100	490 j	3.8 j	11	1700 j	11000	20000	130	300 j	150	580	1000 j
Core #: C3 (North of Pier 48)																	
0–7	58	7.3	34	46	20	160	2100 j	3.3 j	1.8	340 j	19000	28000	220	100 j	560	330	990 j
7–13	63	–	–	–	–	76	250 j	1.2 j	1.1	140 j	12000	32000	210	67 uj	56 j	47 j	100 j
13–26	62	–	–	–	–	68	140 j	0.53 j	1.2	110 j	11000	21000	160	71 u	71 u	71 u	71 u
26–65	65	–	–	–	–	45	290 j	0.3 u	0.82	230 j	13000	17000	140	56 u	56 u	56 u	56 u
65–117	68	–	–	–	–	24	7.4 j	0.3 u	0.054 j	34 j	12000	15000	120	44 u	44 u	44 u	44 u
117–143	68	–	–	–	–	23	6.3 j	0.3 u	0.038 j	29 j	8700	12000	110	62 u	62 u	62 u	62 u
143–172	66	–	–	–	–	24	4.8 j	0.3 u	0.036 j	34 j	9500	13000	110	58 u	58 u	58 u	58 u
172–199	65	–	–	–	–	30	4.8 j	2.9 j	0.052 j	35 j	10000	14000	120	72 u	72 u	72 u	72 u

Sample Interval= Depths corrected for core compaction