Pre-Construction Sediment Characterization Study
Denny Way/Lake Union CSO Control Project

Sampling and Analysis Plan

Prepared for the

King County Department of Natural Resources
Wastewater Treatment Division

by the

King County Department of Natural Resources
Water and Land Resources Division

King County Department of Natural Resources
Wastewater Treatment Division
201 South Jackson Street, Suite 501
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March 2001

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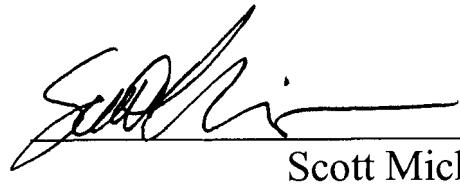

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1 INTRODUCTION

This sampling and analysis plan (SAP) presents project information and sampling and analytical methodologies that will be employed to perform a pre-construction characterization study of sediment quality and the marine environment in the vicinity of King County's Denny Way/Lake Union combined sewer overflow (CSO) control project. This work is being performed as part of a long-term sediment monitoring program to meet requirements of the Biological Opinion WSB-00-039 (NMFS, 2000) issued for the project by the National Marine Fisheries Service (NMFS) under the Endangered Species Act (16 U.S.C. 1531 et seq.).

The SAP includes a description of the project, sampling and analytical methodologies, and reporting requirements. All figures referenced in this narrative may be found in Appendix A, at the end of the document. This SAP has been prepared in accordance with specifications recommended in Washington State Department of Ecology (Ecology) and Army Corps of Engineers (ACOE) SAP preparation guidance documents (Ecology, 1991 and 1995a and ACOE, 2000) as well as Chapter 173-204 WAC, the Washington State Sediment Management Standards (Ecology, 1995b).

2 PROJECT DIRECTIVES

The Denny Way/Lake Union CSO Control Project is a joint effort of King County's Wastewater Treatment Division and Seattle Public Utilities to control City and County CSO discharges into Lake Union and the Denny Way CSO into Elliott Bay. The project will include construction of two outfalls into Elliott Bay: a 490-foot outfall at a depth of approximately 60 to 70 feet referenced to mean lower low water (MLLW) that will discharge treated CSO effluent during moderately heavy storm events; and a 100-foot extension of the existing outfall to a depth of approximately 20 feet MLLW that will discharge untreated CSO effluent to Elliott Bay during the once-per-year event when flows exceed system capacity. Additional project information may be found in the project environmental impact statement/environmental assessment document (King County, City of Seattle, and EPA, 1998).

Pursuant to the Biological Opinion referenced in Section 1, King County developed a sediment monitoring plan to monitor the environment surrounding the CSO outfalls. The primary goal of the sediment monitoring plan is to produce scientific data of known quality that can be used to determine whether implementation of the Denny Way/Lake Union CSO control project and future operation of the facility has caused an impact to the biological communities in the marine environment surrounding the CSO outfalls. If operation of the CSO facility causes increased contamination of marine sediments in the surrounding area to levels that exceed published sediment quality criteria, the monitoring program will identify such contamination and help King County and associated agencies develop a response plan.

The sampling event described in this SAP is intended to evaluate the chemical and biological conditions of marine sediment in the vicinity of the CSO outfalls, prior to construction.

3 Site Description and History

The Denny Way/Lake Union CSO control project outfall and sediment monitoring site is located on the northeast side of Elliott Bay, adjacent to Myrtle Edwards Park in Seattle, Washington (Figure 1). The existing Denny Way CSO outfall is located in the intertidal zone and discharges directly onto the beach during storm events occurring during low tides. The shoreline around the CSO is heavily armored with riprap. Bathymetry in the area is gently sloping.

The existing Denny Way CSO is the largest in King County's system and large volumes of combined storm water runoff and untreated sewage have historically been discharged at this location. In 1986, King County (then Metro) began a trial program to identify and reduce toxicant inputs to the sewer system discharging through the Denny Way CSO. The Denny Way Sediment Cap project was instigated in 1990 as a demonstration project to remediate nearby contaminated sediments. The cap is a 3-foot thick layer of clean sediment placed over three acres of contaminated sediment offshore of the outfall.

Sediment data from the Denny Way Cap monitoring program showed that surface sediments in the center of the cap were gradually becoming recontaminated with elevated concentrations of phthalate compounds, the highest concentrations detected at the monitoring station closest to the existing Denny Way CSO outfall (Striplin Environmental Associates (SEA), 1997). Elevated chemical concentrations in sediments surrounding the cap have also been detected (SEA, 1998). Chemicals of concern include polychlorinated biphenyls (PCBs), phthalate compounds, and mercury.

Five areas of concern requiring some kind of remediation have been identified in the vicinity of the Denny Way CSO outfall (SEA, 1999). Two of these areas are located inshore of the sediment cap and three are located offshore of the cap. Dredging and disposal of contaminated sediment following outfall construction was identified as the preferred remedial alternative for the inshore areas of concern. Containment by thin-layer sediment capping was identified as the preferred alternative for the offshore areas. Sediment monitoring related to site remediation will be addressed in a future project document.

4 Sampling Design

The primary goals of the pre-construction sediment characterization study are to establish baselines for sediment quality and benthic community assemblages in the vicinity of the CSO control project. These baselines will be used as benchmarks to which results from post-construction and post-remediation sediment monitoring and future sediment monitoring during facility operation will be compared.

4.1 Data Quality Objectives

The data quality objectives (DQOs) of the pre-construction sediment study necessary to meet the sediment monitoring program goals are to:

- evaluate the areal extent and spatial variations of sediment chemical concentrations in the vicinity of the existing Denny Way CSO and new outfalls, as well as a nearby reference/evaluation station;
- evaluate sediment chemical concentrations in the study area relative to current marine sediment quality standards of Chapter 173-204 WAC (Ecology, 1995b); and
- characterize the benthic and epibenthic communities in the vicinity of the existing Denny Way CSO and compare them to a nearby reference/evaluation station.

4.1.1 Precision, Accuracy, and Bias

Precision is the agreement of a set of results among themselves and is a measure of the ability to reproduce a result. Accuracy is an estimate of the difference between the true value and the determined mean value. The accuracy of a result is affected by both systematic and random errors. Bias is a measure of the difference, due to a systematic factor, between an analytical result and the true value of an analyte. Precision, accuracy, and bias for analytical chemistry may be measured by one or more of the following quality control (QC) procedures:

- collection and analysis of field replicate samples (field replicate results should exhibit a relative percent difference less than 150% in order for the evaluation of the spatial and areal chemical concentrations to be meaningful);
- analysis of various laboratory QC samples such as method blanks, matrix spikes, certified reference materials, and laboratory duplicates or triplicates (laboratory QC results will be evaluated against the control limits presented in Section 12.1).

Precision, accuracy, and bias for benthic community analysis will be measured by the collection of three replicate samples at each station and statistical analysis of the benthic community results.

4.1.2 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at the sampling point, or an environmental condition. Samples for chemistry and benthic community analysis will be collected from stations with preselected coordinates to represent specific site locations and/or fill data gaps. Chemistry and benthic community analysis will be performed on samples collected simultaneously and homogenized, to minimize variations in the chemical, biological, and physical composition of the sediments. Following the guidelines described for sampler decontamination, sample acceptability criteria, and sample processing (Section 8) will help ensure that samples are representative.

4.1.3 Completeness

Completeness is defined as the total number of samples analyzed for which acceptable analytical data are generated, compared to the total number of samples to be analyzed. Sampling at stations with known position coordinates in favorable conditions, along with adherence to standardized sampling and testing protocols will aid in providing a complete set

of data for this project. The goal for completeness is 100%. If 100% completeness is not achieved, the study director will evaluate if the data quality objectives can still be met or if additional samples may need to be collected and analyzed.

4.1.4 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. This goal is achieved through using standard techniques to collect and analyze representative samples, along with standardized data validation and reporting procedures. By following the guidance of this SAP, the goal of comparability will be achieved. Historical sediment data from the Denny Way study area will be compared with data generated from this study to enhance the baseline information. Previous data will be used if comparable sampling and analytical techniques have been employed and if sediment samples were collected from a similar location and depth.

4.2 Sampling Strategy

The experimental design of this monitoring program is an integrated effort that includes video surveys of the nearshore and subtidal habitats, the use of a Sediment Profile Imaging (SPI) camera to collect *in situ* vertical images of the substrate, collection of sediment samples for chemical analysis, and collection of sediment samples for analysis of the benthic community assemblages. All field work will be conducted on board the King County research vessel *Liberty*, staffed by King County personnel and project consultants.

4.3 Location of Video Surveys and Sampling Stations

Video surveys will be conducted along six transect lines (Figure 2). The transect lines run parallel to the shoreline, spaced roughly 150 feet apart with each transect line approximately 1,500 feet in length. Location of the transect lines provides video survey coverage of the entire study area and will facilitate analysis of the epibenthic flora and surface macroinvertebrate fauna. Coordinates for the start and finish points of each transect line are shown in the following table.

Video Survey Transect Line Coordinates (NAD83)

Station	Start - Northing	Start - Easting	Finish -Northing	Finish - Easting
VT-1	229790	1263188	228690	1264168
VT-2	229697	1263050	228601	1264056
VT-3	229608	1262938	228507	1263949
VT-4	229501	1262809	228405	1263825
VT-5	229434	1262702	228303	1263700
VT-6	229349	1262586	228231	1263580

Samples will be collected for analysis of sediment chemistry and benthic community assemblages from 16 stations in the study area (Figure 3). The 16 stations are arranged around the new CSO outfalls in a grid pattern consisting of transect lines running perpendicular to the shoreline. The two outer transect lines consist of four stations each, with the two inner transect lines consisting of three stations each. The final two stations are located near the future location of the terminus of the new 490-foot CSO outfall. Fourteen of the 16 sediment sampling locations are positioned on stations at which previous sediment samples were collected as part of the Denny Way Sediment Characterization (SEA, 1998).

Previous chemistry data from these stations will enhance the database for the monitoring program and provide a more robust baseline characterization of sediment quality in the study area. Coordinates and water depth for the 16 chemistry/benthic community sampling stations are shown in the following table.

Chemistry/Benthic Community Sampling Stations Coordinates and Water Depths

Station	Northing (NAD83)	Easting (NAD83)	Depth (ft MLLW)
DWMP-01	228813	1264047	35
DWMP-02	228770	1263919	41
DWMP-03	228638	1263846	56
DWMP-04	228546	1263631	81
DWMP-05	229041	1263836	13
DWMP-06	228839	1263542	66
DWMP-07	228660	1263350	96
DWMP-08	228907	1263341	81
DWMP-09	228806	1263215	95
DWMP-10	229326	1263565	20
DWMP-11	229156	1263272	68
DWMP-12	228963	1263055	90
DWMP-13	229640	1263317	18
DWMP-14	229553	1263228	42
DWMP-15	229444	1263053	72
DWMP-16	229353	1262966	82

SPI camera images will be collected from the 16 chemistry/benthic community stations as well as an additional 16 stations (Figure 4). Coordinates and water depth for the additional 16 SPI stations are shown in the following table.

Additional SPI Camera Station Coordinates and Water Depths

Station	Northing (NAD83)	Easting (NAD83)	Depth (ft MLLW)
SPC-01	229429	1263357	38
SPC-02	229302	1263472	40
SPC-03	229194	1263570	40
SPC-04	229081	1263662	40
SPC-05	228969	1263772	43
SPC-06	228849	1263902	40
SPC-07	228858	1263692	52
SPC-08	228987	1263584	53
SPC-09	229113	1263473	60
SPC-10	229217	1263381	55
SPC-11	229331	1263252	60
SPC-12	229166	1263046	82
SPC-13	229025	1263346	67
SPC-14	228887	1263461	68
SPC-15	228680	1263682	64
SPC-16	228624	1263508	84

4.4 Location of Benthic Community Reference/Evaluation Station

Proper selection of a viable evaluation or "reference" station, relative to a given sampling area, is an important consideration when comparing chemistry results. This is also true when evaluating the relative differences between benthic community assemblages. One reference/evaluation station has been selected for this study (Figure 5). The benthic reference/evaluation station DWMP-BREF1 is located near Seacrest Park on the opposite side of Elliott Bay. King County has collected previous chemical and benthic community data at this site. The approximate depth of this station is 82 feet MLLW. Coordinates for the benthic reference/evaluation station are 218630N and 1259459E (NAD83).

4.5 Sample Acquisition and Analytical Parameters

Chemical analysis will be performed on sediment samples collected from 16 stations in the outfall study area and a nearby reference/evaluation station. Chemistry samples will be collected from the top two centimeters (cm) of sediment recovered from a minimum of three deployments of a van Veen grab sampler. Sampling the top two cm of sediment will allow evaluation of sediment quality in the most recently deposited material for establishment of the baseline and for comparison from year to year. Samples will be homogenized and split into laboratory containers in the field. Parameters of interest will include trace metals and organic compounds, as well as conventional sediment chemistry and physical properties. Analytical parameters have been chosen based on Ecology and USACOE recommendations for conducting baseline sediment quality studies (Ecology, 1995a and 1995b and USACOE, 2000). Analytical parameters for sediment chemistry will include:

- conventionals - percent solids, percent volatile solids, grain size distribution, total organic carbon, ammonia, and total sulfides;
- metals - arsenic, antimony, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc; and
- organics - volatile organic compounds, semivolatile organic compounds, chlorinated pesticides, and PCBs (the complete list of organic parameters is shown in Section 11.3).

Benthic community samples will be collected concurrently with chemistry samples from the 16 study area stations and nearby reference/evaluation station. Each of these sediment samples will consist of the entire contents of a single van Veen grab sampler. As a test for environmental variability, three separate replicate grabs will be collected at each station for benthic community analysis. Two van Veen grab samplers will be deployed in tandem at each station, which will allow for concurrent collection of the chemistry and benthic community analysis samples.

4.6 Data Analysis

Video transect data will be will be tabulated in two ways: by distance along each transect; and at each synoptic SPI camera station. Environmental constituents to be tabulated include: surface features of the physical environment in the study area; eel grass and kelp beds; and large macroinvertebrates and fish.

SPI camera data will be analyzed by evaluating the following parameters: prism penetration depth; boundary roughness; sediment grain size; apparent redox potential discontinuity; infaunal successional stage; and sedimentary methane.

Chemistry data will be evaluated by comparison to sediment chemical criteria from Tables I and III in the Washington State Sediment Management Standards (SMS) as well as Table 5-1 in the PSDDA users manual (ACOE, 2000).

Sediment data for some organic compounds are generally normalized to organic carbon content for comparison to SMS criteria. Normalization to organic carbon can produce biased results, however, when the organic carbon content of the sample is very low (Ecology, 1992). When the organic carbon content of a sample is near 0.1 or 0.2% (1,000 to 2,000 milligrams/kilogram (mg/Kg) dry weight), even background concentrations of certain organic compounds can exceed sediment quality criteria. If the organic carbon content at any particular station is below 0.5% dry weight, then dry weight-normalized results for non-ionizable organic compounds will be compared to Lowest Apparent Effects Threshold (LAET) or Second Lowest Apparent Effects Threshold (2LAET) criteria (EPA, 1988), rather than SMS criteria.

Benthic community analytical results from the 16 sampling stations will be compared to a nearby reference/evaluation station. These data will be used to calculate diversity indices, species abundance (total abundance as well as abundance in each major taxa group), and biomass.

5 STUDY SCHEDULE

Sampling for the pre-construction sediment characterization study is anticipated to require one week of field time and will be completed in mid-April 2001. Analytical results for sediment chemistry will be available by June 15, 2001. Validated chemistry data packages and electronic data files will be ready for release by July 31, 2001. Analysis of the video transects and SPI work is also anticipated to be completed by July 31, 2001. Results of the benthic community analysis are expected to be available by October 31, 2001. Analysis of the benthic taxonomy and abundance data should require an additional month and be available by November 30, 2001.

6 VIDEO SURVEYS

Video surveys of the monitoring area will be conducted to confirm or deny the presence of eel grass and kelp beds. The video survey equipment will also be attached to a sediment profile camera (see Section 7) and the two systems will be used in concert to characterize the epibenthic community and to identify the large macroinvertebrates inhabiting the monitoring area.

Video surveys will be performed along six transect lines, parallel to the shoreline. The transect lines will be approximately 1,500 feet in length and spaced approximately 150 feet apart (refer to Figure 2). During the surveys, a DeepSea Power & Light SeaCam 4000™

color video camera will be towed behind the *Liberty* at a speed of between 1 and 3 knots. The video camera will be towed a few feet above the sediment surface: higher in the water if visibility is good, to get a wider view; or nearer the bottom if visibility is poor.

7 SEDIMENT PROFILE CAMERA

A Hulcher Model 200-SEA™ Sediment Profile Camera (SPC) will be used to collect all sediment profile images. A schematic of this camera is shown in Figure 6. The SPC is designed to acquire two images per deployment, one at 5 seconds after the camera contacts the seafloor and another at 20 seconds after seafloor contact. The video camera referenced in Section 6 will be attached to the SPC frame to record real-time, plan-view video of the sediment surface during acquisition of sediment profile images.

To acquire data at the designated SPC stations, the *Liberty* will be piloted to the station and the camera package deployed outboard. The camera package will be lowered and suspended above the bottom until the vessel is within 50 feet of the target station. Once within this 50-foot radius, the camera package will be lowered to the seafloor and the images acquired. At the end of each survey day, film from the SPC will be developed to ensure adequate image acquisition. Visual "quick-look" measurements of physical and biological SPC parameters will be made of two replicate images from each station. Specific measurement protocols and interpretive criteria for the SPC parameters are discussed below.

7.1 Prism Penetration Depth

Prism penetration depth is the mean penetration of the prism observed in an image and is measured from the bottom of image to the sediment-water interface. Average penetration depth across the entire SPC photo will be visually estimated to the nearest centimeter. Because the weight of the descending camera prism is fixed throughout a survey, differences in penetration depths across the survey area provide a relative measure of sediment-water content (porosity) and shear strength.

7.2 Boundary Roughness

Boundary roughness is qualified as either high, medium, or low. When apparent, surface relief is designated as being derived from either physical (e.g., sand ripples) or biological processes (e.g., feeding pockets). Boundary roughness can be indicative of bedform heights or the relief of biogenic structures such as fecal mounds or surface burrows.

7.3 Sediment Type and Grain Size

SPC grain size is reported as the grain size major-mode. The grain size major-mode is the grain size class that comprises the largest percentage of the optical sample. Grain-size major mode is estimated from the SPC images by comparing, at the same scale, the SPC survey photographs to photographs of known unimodal grain size classes (Udden-Wentworth or phi classes, Folk 1974). Grain-size ranges are reported as phi units. The limit of this optical technique for differentiating individual grains is approximately 0.062 mm, or 4 phi, which corresponds to the break between very fine sand and silt. Using this technique, silts and clays are combined as the ≥4 phi-size fraction, as particles >4 phi (silts and finer) cannot be optically differentiated.

7.4 Apparent Redox Potential Discontinuity Depth

Oxidized sediments at the sediment-water interface have a higher reflectance and, frequently, a different color than underlying reduced sediments. Typically, oxidized sediments exist as a thin surface band of olive to tan sediment overlying reduced grey to black sediment at depth. This thin band of olive to tan oxidized sediment is called the apparent redox potential discontinuity (RPD). The apparent RPD is visually measured to the nearest 0.5 cm as the estimated average thickness of this band of oxidized sediments across the entire width of the SPC image. In addition to the average RPD, minimum and maximum RPD depths will also be measured. The apparent RPD depth differs from the true RPD depth, typically slightly greater.

The depth to which the apparent RPD persists into the sediment column is an important indicator of dissolved oxygen conditions in the sediment pore waters. When there is no bioturbation, oxygenation of the sediment column proceeds by diffusion of oxygen from the overlying water column into surface sediments. Apparent RPD depths associated with oxygenation by the diffusion of molecular oxygen are typically on the order of one to three millimeters. In sediments that are enriched with organic material, the consumption of oxygen by the sediment and the associated microflora may exceed the rate of diffusional supply and minimal or no sediment-column RPD will develop, even in the presence of oxygenated bottom waters.

In the presence of bioturbating infauna, the apparent RPD may extend to a depth of several centimeters in the sediment column. Many benthic infaunal organisms mix the upper portions of the sediment column by moving reduced, subsurface particles into the zone of oxygenated pore waters and transporting oxidized surface sediments downward into the zone of reduced sediment. Also, the benthos irrigate subsurface sediments through their burrowing and feeding activities. This particle mixing and irrigation (e.g., bioturbation) increases the flux of oxygenated water to the sediment column.

Another important characteristic of the apparent RPD is the contrast in reflectance and color between the oxygenated surface sediment and the reduced subsurface sediment. The contrast is related to the inventory of labile organic matter in the sediment column. Sediments that have a pronounced RPD contrast, with tan sediments overlying dark gray or black sulfidic sediments, are generally indicative of excess labile organic material; more than can be remineralized by the benthic infaunal and microbial community.

7.5 Infaunal Successional Stage

The identification of infaunal successional stages in SPC images is based on observations that animal-sediment interactions follow a predictable sequence after a seafloor disturbance. This succession is characterized by the appearance of predictable functional types of infauna following a disturbance rather than specific species of infauna. These functional infaunal types interact with the sediment column in very specific ways, such as filter feeding tube-builders, deep burrowing head-down deposit, and surface feeding detritivores.

Seafloor disturbance factors may be natural, such as wind-wave induced sediment resuspension and erosion and demersal predator foraging, or anthropogenic such as dredging activity, chemical discharges, and anchor or trawl scour. In a disturbed or defaunated

sediment, the pioneering assemblage usually consists of near-surface living, tube-dwelling polychaetes (worms) with short life cycles. These pioneering, near-surface dwelling infauna are designated a Stage 1 assemblage. Because Stage 1 functional types are typically surface-dwelling and shallow bioturbators, they are usually associated with shallow RPDs.

Without further disturbance, these Stage 1 fauna are either accompanied or replaced by burrowing surface detritivores and shallow deposit feeders such as shallow-dwelling bivalves. These functional groups are designated Stage 2 assemblages. Tubicolus amphipods and some tubicolus polychaetes, occurring in dense mats, may also be designated as stage 2 assemblages.

Stage 3 assemblages represent the highest order of succession and are characterized by the presence of relatively deep burrowing, head-down, deposit feeders. These fauna generally ingest particles at depth and in the process excavate distinct feeding voids within the sediment column, which are the primary diagnostic criteria in the SPC analysis for determining the presence of a Stage 3 assemblage. Stage 3 fauna derive their nutrition from the sediment column and typically are the longest lived of the functional types. In the absence of further disturbance, stage 3 infauna are interpreted to represent the equilibrium or end-member assemblage in most fine-grained benthic habitats.

7.6 Sedimentary Methane

As pore-water oxygen, nitrate, and sulfate are depleted, methanogenesis occurs (methane is a by-product of organic matter decomposition when CO_2 used as the electron acceptor). In SPC images, the process of methanogenesis is detected by the appearance of methane bubbles in the sediment column. The gas-filled voids are readily discernible in SPC photographs because of their irregular or circular aspect and glassy texture (due to the reflection of the strobe off the wall of the gas-filled void). The presence of methane in the sediment column can indicate an oxygen-stressed environment. Oxygen stress may be caused by either low dissolved oxygen conditions in the overlying water column, or alternatively, by high sediment oxygen demand associated with bacterial decomposition of organic matter.

8 Sampling Procedures for Chemistry and Benthic Community Analysis

All sampling will be performed according to guidelines recommended by the Puget Sound Estuary Program's (PSEP) Puget Sound Protocols (PSEP 1987, 1996a, 1998). Marine sediment samples will be collected using a 0.1 m^2 modified, stainless steel van Veen grab sampler deployed via hydrowire and hydraulic winch from the King County research vessel *Liberty*.

Chemistry samples will be collected from the top two centimeters (cm) of sediment from the contents of a minimum of three deployments of the grab sampler. Sediment samples will be stored on ice in coolers while in the field, then transported to the King County Environmental Laboratory at the end of each sampling day.

Benthic organisms will be extracted from the entire contents of each of three replicate grabs. Qualified King County Environmental Laboratory and subcontracted personnel will be responsible for the sample collection, sieving, and preservation.

Established chain of custody (COC) procedures will be followed for this sampling event.

8.1 Station Positioning

Station positioning will employ a Trimble® Differential Global Positioning System (DGPS). Prior to the sampling event, the prescribed station coordinates will be entered into the shipboard DGPS laptop computer. During the sampling event, the shipboard navigational system will utilize the differential data transmissions from regional Coast Guard base stations to automatically correct its GPS satellite data. The GPS antenna is boom-mounted above the sampler descent line to achieve a more accurate coordinate fix above the sampling point.

Upon contact of the grab sampler with the bottom, the coordinate data representing the actual sediment grab impact point will be electronically recorded in real time. Positioning information will include local time and date that a position is recorded, comments, and coordinate data in both latitude/longitude and NAD 83 State Plane formats.

Previous DGPS usage indicates that an average precision of plus-or-minus two meters can usually be expected. Sample collection is expected to take place within a 6-meter radius of each station's prescribed position and samples will not be collected if outside of this limit.

8.2 Sampler Deployment and Retrieval

Two 0.1 m^2 modified, stainless steel van Veen grab samplers will be deployed in tandem at each sampling station. The grab sampler will be lowered at a controlled speed of approximately four feet per second until it is near the bottom, at which time the speed will be decreased to approximately one foot per second to minimize potential bow wake activity and subsequent bottom disturbance.

After the grab has tripped upon reaching the bottom, it will be raised slowly to allow gentle and complete closure of the sampler jaws to avoid sample disturbance and loss. Once clear of the bottom, the ascent speed will be increased to approximately four feet per second. Care will be taken to ensure that minimal sample disturbance occurs when swinging the grab on board. Collection of undisturbed sediment requires that the grab sampler:

- creates a minimal bow wake when descending;
- forms a leak-proof seal upon closure of the jaws;
- is carefully retrieved to prevent excessive sample disturbance; and
- allows easy access to the sediment within the grab.

8.3 Sample Acceptability Criteria

When the grab sampler has been secured on board, the hinged top flaps will be opened and the sample examined for acceptability. Acceptability criteria will include:

- the grabs are not overfilled to the point where there is evidence of sample loss around the access doors;
- overlying water is present, indicating minimal leakage;
- overlying water is not excessively turbid, indicating minimal sample disturbance; and
- a minimum acceptable sample penetration depth of four cm has been achieved (10 cm for benthic samples).

Sediment samples for chemical analysis will be collected from the top two cm of each sediment grab, so a minimum penetration depth of four cm will be required for these samples. Care will be taken to extract sediment from the most undisturbed center portion of each grab without collecting sediment that has touched the sides of the grab.

Benthic community analysis will be performed on the entire contents of a single grab. A target minimum penetration depth of 10 cm will be specified for benthic samples to allow assessment of the entire biologically active zone. Penetration depth will be determined by measuring and recording the depth of sediment recovered in each grab.

8.4 Sample Processing - Chemistry

Overlying water within the grab will be carefully siphoned off of the sediment surface for all acceptable samples. Prior to any subsampling, a sediment aliquot will be collected for analysis of volatile organic compounds (VOC). The VOC sample will be collected from the top two cm of sediment with a stainless steel spoon and place in the appropriate sample container. This material will always be collected from the first grab and will not be homogenized in any way, to prevent volatilization of any VOCs present in the sample. The remaining top two cm of undisturbed sediment will be collected from the first grab, as well as two subsequent grabs, with a stainless steel "cookie cutter" and spatula and placed in a stainless steel bowl for homogenization after which sediment aliquots will be transferred to appropriate laboratory containers. Prior to homogenization, collected sediment will be stored covered with aluminum foil in coolers between grab deployments. Head space will be left in all lab containers, with the exception of total sulfides and volatile organic compounds, to allow further mixing at the laboratory and for expansion should the containers be stored frozen. All sample containers will be stored in insulated, ice-filled coolers while in the field.

Volatile organic compounds and total sulfides will be the only parameters that require no headspace in the sampling container. Total sulfide samples also require the use of a preservative. After the 4-ounce total sulfides lab container has been filled completely, 5 milliliters (ml) of 2N zinc acetate will be added to the top of the sediment prior to sealing the container.

Sample containers, storage conditions, and hold times are summarized in the following table.

Sample Containers, Storage Conditions, and Analytical Hold Times

Analyte	Container	Preferred Storage Conditions	Hold Time	Acceptable Storage Conditions	Hold Time
Volatile Organics	4 oz. Glass No Headspace	refrigerate at 4°C	14 days to analyze	N/A	N/A
Semivolatile Organics	8 oz. Glass	freeze at -18°C	1 year to extract 40 days to analyze	refrigerate at 4°C	14 days to extract 40 days to analyze
Pesticides/PCBs	8 oz. Glass	freeze at -18°C	1 year to extract 40 days to analyze	refrigerate at 4°C	14 days to extract 40 days to analyze
Mercury	250 ml HDPE	freeze at -18°C	28 days to analyze	N/A	N/A
Other Metals	250 ml HDPE	freeze at -18°C	2 years to analyze	refrigerate at 4°C	6 months to analyze
Ammonia	4 oz. Glass	refrigerate at 4°C	7 days to analyze	freeze at -18°C	6 months to analyze
Total Solids (w/ volatile solids)	4 oz. Glass	freeze at -18°C	6 months to analyze	refrigerate at 4°C	14 days to analyze
Total Volatile Solids (w/ solids)	4 oz. Glass	freeze at -18°C	6 months to analyze	refrigerate at 4°C	14 days to analyze
Total Organic Carbon	4 oz. Glass	freeze at -18°C	6 months to analyze	refrigerate at 4°C	14 days to analyze
Total Sulfides	4 oz. Glass No Headspace	refrigerate at 4°C w/ 2 N Zn acetate	7 days to analyze	N/A	N/A
Particle Size Distribution	8 oz. Glass	refrigerate at 4°C	6 months to analyze	N/A	N/A

8.5 Sample Processing – Benthic Community Analysis

Sediment from acceptable grabs will be flushed with ambient seawater through a 1.0-millimeter sieve to remove all fine material. The remaining sediment will then be transferred into 1-liter plastic containers using a minimum amount of seawater.

A 10% solution of buffered formalin will be added to the sample to preserve all tissues prior to sealing the container. Samples will be labeled both on the inside and outside of the container, then recorded on chain of custody forms, and placed in coolers for at least 24 hours, but not exceeding 96 hours, prior to rescreening by contract laboratory personnel.

Benthic samples will be rescreened at the contract laboratory from the 10% buffered formalin solution to 70% ethanol as recommended by Puget Sound Estuary Program (PSEP) protocols (PSEP, 1987).

8.6 Sampling Equipment Decontamination

The grab sampler will be decontaminated between sampling stations by scrubbing with a brush and ambient sea water, followed by a thorough *in situ* rinsing. A separate stainless steel bowl, cookie cutter, spatula, and spoon will be dedicated to each sampling station, precluding the need for decontamination of this equipment.

8.7 Sample Storage and Delivery

All sample containers will be stored in an insulated cooler with ice immediately after collection to maintain the samples at a temperature of approximately 4° Celcius until delivery to the laboratory. Sample containers from each station will be grouped and placed in plastic

bags to facilitate sample receipt and login. At the end of each sampling day, all samples will be transported back to the King County Environmental Laboratory. After the benthic taxonomy samples have been released to the taxonomy contractor, he/she will then be responsible for the custody, transportation, storage, and final disposal of these samples.

8.8 Chain of Custody

Chain of custody (COC) will commence at the time that each sample is collected. While in the field, all samples will be under direct possession and control of King County Environmental Laboratory field staff. For chain of custody purposes, the research vessel will be considered a 'controlled area.' Each day, all sample information will be recorded on a COC form (Figure 7). This form will be completed in the field and will accompany all samples during transport and delivery to the laboratory each day.

Upon arrival at the King County Environmental Laboratory, the sample delivery person will relinquish all samples to the sample login person. The date and time of sample delivery will be recorded, and both parties will then sign off in the appropriate sections on the COC form at this time. Once completed, the original will be archived in the project file.

Samples delivered after regular business hours will be stored in a locked chain of custody refrigerator until the next day. Samples delivered to a subcontracted laboratory will be accompanied by a properly-completed King County Environmental Laboratory COC form and custody seals will be placed on the cooler if samples are delivered by an outside courier. Subcontracted laboratories will be expected to provide a copy of the completed COC form as part of their analytical data package.

8.9 Sample Disposal

All sediment chemistry sample material will be disposed according to established King County Environmental Laboratory procedures after analysis has been completed. The benthic taxonomy subcontractor will be responsible for the final disposal of the benthic samples.

9 Sample Documentation

Sample information will be documented through the following means:

- Field sheets generated by the Laboratory Information Management System (LIMS) that will include information such as:
    1. sample ID number
    2. station name
    3. station bottom depth
    4. sediment depth (i.e., sampler penetration depth)
    5. physical sediment characteristics
    6. date and time of sample collection
    7. condition and height of tide
    8. name of recorder

- LIMS-generated container labels will identify each container with a unique sample number, station and site names, collect date, analyses required, and preservation method.
- The vessel's logbook will contain records of all shipboard activities, destinations, arrival and departure times, general weather and positioning information, the names of shipboard personnel.
- The vessel's cruise plan will list the prescribed stations to be sampled, along with their respective coordinates and other associated locating information.
- Electronic DGPS coordinate data will be electronically logged for each grab sample using both latitude/longitude and NAD 83 State Plane formats.
- COC documentation will consist of the Lab's standard COC form which is used to track release and receipt of each sample from collection to arrival at the lab.

The standard field sheet used by the King County Environmental Laboratory is included as Figure 8.

10 Field Measurements and Observations

The following field measurements and observations will be recorded on the appropriate field sheet/log for each sample:

- sample (bottom) depth - measured as keel depth by vessel's fathometer;
- sediment depth (grab penetration depth) - measured by ruler inside the grab;
- sediment sampling range (0 to 2 cm for chemistry samples, 0 to 10 cm minimum for benthic community samples);
- sediment type (a mnemonic code indicating color, gross grain size, odor, and debris);
- tide condition and height; and
- collect date, start time, and sampling personnel.

11 Analytical Parameters and Methods

Analytical parameters for chemical and biological analyses are presented in the following sections. Parameters have been selected based on guidance for conducting baseline sediment characterizations (Ecology, 1995a and ACOE, 2000) and will allow comparison with published sediment quality criteria (Ecology, 1995b and ACOE, 2000). All analyses will follow guidelines suggested in the Puget Sound Protocols (PSEP 1986, 1987, 1996b, 1996c).

The terms MDL and RDL, used in the following chemistry analysis sections, refer to *method detection limit* and *reporting detection limit*, respectively. The MDL is defined as *the minimum concentration of a chemical constituent that can be detected*, while the RDL is defined as *the minimum concentration of a chemical constituent that can be reliably quantified*. The MDL and RDL are based on routine method-concentration factors, assuming 50% total solids by weight.

11.1 Conventionals Analytical Methods and Detection Limits

Conventional sediment parameters analyzed at the King County Environmental Laboratory include total solids, total volatile solids (TVS), total organic carbon (TOC), and ammonia nitrogen. Analysis of total sulfides and particle size distribution (PSD) will be subcontracted to AmTest, Inc., an Ecology-accredited analytical laboratory located in Redmond, Washington. The analytical methods and detection limits for conventional parameters analyzed at the King County Environmental Laboratory are summarized in the following tables.

Conventionals Methods and Detection Limits (King County Environmental Lab)

Parameter	Method	MDL	RDL	Units
Total Solids	SM 2540-G	0.005	0.01	percent wet wt.
Total Volatile Solids	SM2540-G	0.005	0.01	percent wet wt.
Total Organic Carbon	EPA 9060	1,000	2,000	mg/Kg dry wt.
Ammonia Nitrogen	SM 4500-NH3-G	0.2	0.4	mg/Kg dry wt.

The analytical methods and detection limits for the subcontracted conventional chemistry parameters are summarized in the following table. Please note that AmTest reports only a MDL with their data.

Conventionals Methods and Detection Limits (AmTest, Inc.)

Parameter	Method	MDL	Units
Particle Size Distribution	ASTM D422	0.1	percent wet wt.
Total Sulfides	PSEP, p.32	20	mg/Kg dry wt.

11.2 Trace Metals Analytical Methods and Detection Limits

All trace metals analyses will be performed at the King County Environmental Laboratory. The analytical methods and detection limits for the target trace metals are summarized in the following table. Mercury will be analyzed by cold vapor atomic absorption spectroscopy (CVAA) and other metals will be analyzed by inductively coupled plasma optical emission spectroscopy (ICP-OES) with a strong acid digestion.

Trace Metals Target Analytes, Methods, and Detection Limits (mg/Kg dry weight)

Analyte	Method	MDL	RDL
Antimony	EPA 3050A/6010B	3	15
Arsenic	EPA 3050A/6010B	5	25
Cadmium	EPA 3050A/6010B	0.3	1.5
Chromium	EPA 3050A/6010B	0.5	2.5
Copper	EPA 3050A/6010B	0.4	2
Lead	EPA 3050A/6010B	3	15
Mercury	EPA 245.5/7471	0.04	0.4
Nickel	EPA 3050A/6010B	2	10
Silver	EPA 3050A/6010B	0.4	2
Zinc	EPA 3050A/6010B	0.5	2.5

11.3 Organics Analytical Methods and Detection Limits

All organic analyses will be performed at the King County Environmental Laboratory. Organic parameters will include chlorinated pesticides, polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs), and base/neutral/acid extractable semivolatile compounds (BNAs). The analytical methods and detection limits for the target organic compounds are summarized in the following table. Please note that the MDL and RDL values in this section are presented on a dry weight basis. Results for certain non-ionizing organic compounds are normalized to organic carbon for comparison to sediment quality chemical criteria. The ability of the laboratory to attain detection limits which meet organic carbon-normalized chemical criteria will depend upon the TOC content of each sample.

The detection limits for the target chlorinated pesticide/PCB compounds are summarized in the following table. Pesticide/PCB analysis is performed according to EPA methods 3550/8081A/8082 (SW 846), which employs solvent extraction with sonication and analysis by gas chromatography/electron capture detector (GC/ECD) with dual column confirmation.

Chlorinated Pesticide/PCB Target Analytes and Detection Limits (µg/Kg dry weight)

Analyte	MDL	RDL
Aroclor 1016	5.4	11
Aroclor 1221	5.4	11
Aroclor 1232	5.4	11
Aroclor 1242	5.4	11
Aroclor 1248	5.4	11
Aroclor 1254	5.4	11
Aroclor 1260	5.4	11
4,4'-DDD	0.54	1.1
4,4'-DDE	0.54	1.1
4,4'-DDT	0.54	1.1
Aldrin	0.54	1.1
Chlordane	2.7	5.4
Dieldrin	0.54	1.1
Gamma-BHC (Lindane)	0.54	1.1
Heptachlor	0.54	1.1

The detection limits for VOC target analytes are summarized in the following table. VOC analysis is performed according to EPA method 8260, which employs purge and trap 'extraction' methodology with analysis by gas chromatography/mass spectroscopy (GC/MS).

VOC Target Analytes and Detection Limits (µg/Kg dry weight)

Analyte	MDL	RDL
Ethylbenzene	10	20
Tetrachloroethene (PCE)	10	20
Trichloroethene (TCE)	10	20
Total Xylenes	10	20

The detection limits for the target BNA compounds are summarized in the following table. BNA analysis is performed according to EPA methods 3550B/8270A (SW 846), which employs solvent extraction with sonication and analysis by gas chromatography/mass spectroscopy (GC/MS).

BNA Target Analytes and Detection Limits (µg/Kg dry weight))

Analyte	MDL	RDL	Analyte	MDL	RDL
1,2,4-Trichlorobenzene	0.52	1.0	Chrysene	7.9	16
1,2-Dichlorobenzene	0.52	1.0	Coprostanol	28	56
1,3-Dichlorobenzene	0.52	1.0	Dibenzo(a,h)anthracene	14	28
1,4-Dichlorobenzene	0.26	0.52	Dibenzofuran	28	56
2,4-Dimethylphenol	14	28	Diethyl Phthalate	12	24
2-Methylnaphthalene	28	56	Dimethyl Phthalate	22	44
2-Methylphenol	38	76	Di-N-Butyl Phthalate	10	20
4-Methylphenol	32	64	Di-N-Octyl Phthalate	16	32
Acenaphthene	14	28	Fluoranthene	16	32
Acenaphthylene	29	58	Fluorene	26	52
Anthracene	7.9	16	Hexachlorobenzene	1.3	2.6
Benzo(a)anthracene	4.0	8.0	Hexachlorobutadiene	1.5	3.0
Benzo(a)pyrene	6.0	12	Hexachloroethane	29	58
Benzo(b)fluoranthene	6.0	12	Indeno(1,2,3-cd)pyrene	18	36
Benzo(g,h,i)perylene	16	32	Naphthalene	28	56
Benzo(k)fluoranthene	6.0	12	N-Nitrosodiphenylamine	40	80
Benzoic Acid	12	24	Pentachlorophenol	10	20
Benzyl Alcohol	12	24	Phenanthrene	7.9	16
Benzyl Butyl Phthalate	12	24	Phenol	18	36
Bis(2-Ethylhexyl) Phthalate	13	26	Pyrene	7.9	16

11.4 Benthic Community and Biomass Analytical Methods

Contract lab staff will be expected to use standard and accepted techniques to sort all organisms from sediments (PSEP 1987). Small fractions of sample material will be placed in a petri dish under a 10-power dissecting microscope. The petri dish will be scanned systematically and all animals and associated fragments will be removed using forceps. This sorting process will be conducted at least twice to ensure the removal of all animals. These organisms will then be separated out and placed in 70% ethanol according to one of the following major taxonomic groups: Polychaeta, Arthropoda, Mollusca, or miscellaneous taxa (Echinodermata, Nemertea, Sipuncula, etc.).

All organisms will be counted and identified to the lowest practical taxonomic level, which will usually be species. If animal fragments are present, only anterior portions will be counted. Identifications will be performed by regional taxonomic experts using stereo dissecting and high-power compound microscopes. Biomass measurements will also be performed in accordance with standard PSEP procedures.

12 LABORATORY QA/QC

12.1 Chemistry

The quality control (QC) samples to be analyzed in association with the marine sediment chemistry samples are summarized in the following table. The minimum frequency of method blanks, duplicates, triplicates, and matrix spikes is 1 per QC batch (20 samples maximum). The minimum frequency of CRM (certified reference material) analysis is 1 per project (40 samples maximum). Surrogates are added to every organic sample.

Chemistry Quality Control Samples

Analyte	Method Blank	Duplicate	Triplicate	Matrix Spike	CRM	Surrogates
Total Solids	Yes	No	Yes	No	No	No
TVS	Yes	No	Yes	No	No	No
TOC	Yes	No	Yes	No	Yes	No
Ammonia	Yes	No	Yes	Yes	No	No
Total Sulfides	Yes	No	Yes	Yes	No	No
PSD	No	No	Yes	No	No	No
Metals	Yes	Yes	No	Yes	Yes	No
BNA	Yes	Yes	No	Yes	Yes	Yes
VOC	Yes	Yes	No	Yes	No	Yes
Pest./PCB	Yes	Yes	No	Yes	Yes	Yes

The marine sediment chemistry QC limits are shown in the following table.

QC Acceptance Limits for Sediment Chemistry Samples

Analyte	Method Blank	Duplicate	Triplicate	Matrix Spike	CRM	Surrogates
Total Solids	< MDL	N/A	RSD ≤ 20%	N/A	N/A	N/A
TOC	< MDL	N/A	RSD ≤ 20%	N/A	80 - 120%	N/A
Ammonia	< MDL	N/A	RSD ≤ 20%	75 - 125%	N/A	N/A
Total Sulfides	< MDL	N/A	RSD ≤ 20%	65 - 135%	N/A	N/A
PSD	N/A	N/A	RSD ≤ 20%	N/A	N/A	N/A
Metals	< MDL	RPD ≤ 20%	N/A	75 - 125%	≤ 120%	N/A
BNA	< MDL	RPD ≤ 100%	N/A	50 - 150%	80 - 120%	50 - 150%
VOC	< MDL	RPD ≤ 100%	N/A	50 - 150%	N/A	50 - 150%
Pest./PCB	< MDL	RPD ≤ 100%	N/A	50 - 150%	80 - 120%	50 - 150%

< MDL - Method Blank result should be less than the method detection limit.
RPD - Relative Percent Difference
RSD - Relative Standard Deviation
N/A - Not Applicable
QC results for matrix spike, CRM, and surrogates are in *percent recovery of analyte.*

Quality control results that exceed the acceptance limits will be evaluated to determine appropriate corrective actions. Samples will typically be reanalyzed if the unacceptable QC results indicate a systematic problem with the overall analysis. Unacceptable QC results caused by a particular sample or matrix will not require reanalysis unless an allowed method modification would improve the results. Analytical results that are outside of QC control limits will be qualified and flagged according to QA1 data validation guidance (Ecology, 1989).

Data qualifier flags and their associated interpretations are presented in the following table.

Data Qualifier Flags and QC Control Limits

Condition to Qualify	Flag	Organics QC Limits	Metals QC Limits	Conventionals QC Limits
Very low matrix spike recovery	X	< 10 %	< 10 %	< 10 %
Low matrix spike recovery	G	< 50%	< 75%	< 65 - 75%
High matrix spike recovery	L	> 150%	>125%	> 125 - 135%
Low CRM recovery	G	< 80%	N/A	< 80%
High CRM recovery	L	>120%	>120%	>120%
High duplicate RPD	E	>100 %	>20%	N/A
High triplicate RSD	E	N/A	N/A	> 20%
Less than the reporting detection limit	< RDL	RDL	RDL	RDL
Less than the method detection limit	< MDL	MDL	MDL	MDL
Contamination in method blank	B	> MDL	> MDL	> MDL
Very biased data, low surrogate recoveries	X	<10%	N/A	N/A
Biased data, low surrogate recoveries	G	< 50%	N/A	N/A
Biased data, high surrogate recoveries	L	>150%	N/A	N/A
Rejected, unusable for all purposes	R			
A sample handling criterion has been exceeded	H			

Metals data are not qualified based on low CRM recovery since a different digestion method is used from certification of the reference material.
The average fraction surrogate recovery is used for BNA analysis, both surrogate recoveries are used for pesticide/PCB analysis, and the single surrogate recovery is used for chlorobenzene analysis.
Sample handling criteria include: exceedence of hold time, and incorrect preservation, container, or storage conditions.

12.2 Benthic Community Analysis

The subcontractor for taxonomic analysis will follow recommended PSEP guidelines for QC (PSEP, 1987). Benthic taxonomy QC will involve:

- independent verification by a qualified regional expert of 5% of the samples from each major taxonomic group; and
- the resorting of 20% of each processed sample by a different taxonomist to check for sorting efficiency and accuracy. The similarity index between the original and resorted sample results must be within the acceptance limits of the subcontract laboratory.

13 Data Reporting and Record Keeping

All project data will be reported to the following agencies as specified in the Biological Opinion:

- King County Department of Natural Resources, Wastewater Treatment Division
- National Marine Fisheries Service
- United States Fish and Wildlife Service
- United States Environmental Protection Agency
- Washington State Department of Natural Resources
- Washington State Department of Ecology

13.1 Video Surveys

The results of the video survey will be tabulated in two ways: by distance along each transect; and at each synoptic SPI station. Environmental constituents to be tabulated include the following:

- surface features of the physical environment in the study area;
- eel grass and kelp beds; and
- large macroinvertebrates and fish.

A small data report will be prepared discussing the above the survey results.

13.2 Sediment Profile Camera

SPC results will be presented in a series of tables and figures of the following parameters measured using the SPC system:

- prism penetration depth to the nearest centimeter;
- qualitative boundary roughness (high, medium, low);
- sediment grain size up to 4 phi (sand/silt);
- apparent RPD, which estimates the depth to which oxygen diffuses into sediment;
- infaunal successional stage; and
- sedimentary methane.

A small data report will be prepared discussing the above the survey results.

13.3 Chemistry Data

All chemistry data will be reported in QA2 format (Ecology, 1989a). The final QA2 report will contain the following information and deliverables:

- a QA1 narrative (Ecology, 1989b) discussing data quality in relation to project DQOs and data qualification criteria;
- all supporting analytical data needed to validate the data by QA2 guidelines (Ecology, 1989a) including sample preparation records, QC batch summaries, instrument printouts for all sample and QC analyses, and calibration records;
- a comprehensive report containing all analytical chemistry and field data (including data qualifier flags); and
- copies of chain of custody forms and field sheets.

13.4 Benthic Community Data

The mean abundance of each major taxon at the benthic community stations (at three replicates per station) will be reported and compared statistically to results from the two reference stations. A narrative explaining the results, including any anomalies and statistical evaluations, will be included.

13.5 SEDQUAL Files

The chemistry and benthic community data will be reported in SEDQUAL format for eventual delivery to Ecology.

13.6 Record Keeping

All field and sampling records, custody documents, raw lab data, and summaries and narratives will be archived according to King County Environmental Laboratory policy, for a minimum of 10 years from the date samples were collected. Interpretative reports and memoranda, along with all benthic taxonomy data, sediment profile camera images, and video tapes, and their respective data analysis project narratives and reports, will be stored in project files for a minimum of 10 years from the date samples were collected.

14 PROJECT HEALTH AND SAFETY

The following general health and safety guidelines have been provided in lieu of a site-specific Health and Safety Plan. These guidelines will be read and understood by all members of the sampling crew.

- All crew of a research or safety vessel will have received annual vessel safety training which will include proper chain of communication, equipment operation, and safe boating practices.
- Samplers will wear chemical-resistant gloves whenever coming into contact with sediment.
- No eating, drinking, smoking, or tobacco chewing by sampling personnel will be allowed during sampling operations.
- All sampling operations will be conducted during daylight hours.
- All accidents, 'near misses,' and symptoms of possible exposure will be reported to a sampler's supervisor within 24 hours of occurrence.
- All crew members will be aware of the potential hazards associated with any chemicals used during the sampling effort.

Several hazards are inherent to marine sediment sampling. General vessel safety, physical hazards unique to sediment grab sampling and chemical hazards are discussed in sections 14.1 through 14.3.

14.1 General Vessel Safety

To help prevent accidents and ensure adequate preparation for emergencies that may possibly arise, the following safety equipment will be required on the King County research vessel *Liberty*:

- one personal floatation device for each crew member as well as at least one throwable floatation device;
- an accessible, clearly labeled, fully stocked first-aid/CPR kit;
- an accessible and clearly labeled eye wash;
- one (preferably two) VHF marine radio(s) with weather channel;
- a cellular telephone;
- a horn;
- navigation lights;
- an emergency life raft with oars or paddles;
- an anchor and suitable line;

- signal flares; and
- a reach pole or shepherd's hook.

Personal protective equipment will be selected and used that will protect workers involved in sediment sampling from the hazards and potential hazards likely to be encountered. Minimum required personal protective equipment for marine sediment sampling shall include the following:

- hard hat;
- steel-toe rubber boots;
- chemical-resistant gloves (i.e. Nitrile); and
- safety glasses (UV protective).

Recommended additional personal protective equipment will include rain gear and hearing protection when on board the *Liberty*.

14.2 Grab Sampling

Sampler deployment and sediment retrieval present physical hazards due in part to the heavy weight of the grab sampler, its suspension above the vessel deck, and the risk of accidental or premature closure. Prior to each sampling event, all cabling, shackles, pins, housings, and swivels will be inspected to ensure the integrity of all points along the sampling assembly.

The sampler will always be set while it is resting on a stable surface. Once set, a safety pin will be set in place on the triggering mechanism and remain in place until the sampler is swung outboard of the vessel rail. Special care will be exercised when removing the safety pin to ensure personal safety in the event of a gear or winch failure. Fingers will not be placed through the ring of the pin when it is removed and hands will be kept completely clear of the sampler interior after the pin has been removed. If a sampler is retrieved that has not been tripped, it will be lowered to a stable surface before any worker contact.

During grab retrieval, one crew member will watch for the appearance of the grab sampler and alert the winch operator when the sampler is first visible below the water surface. Attempting to bring a swinging grab sampler on board poses a serious risk of being hit or knocked overboard. The winch operator will minimize swinging before the grab sampler is brought on board for the crew to secure. Hard hats and gloves will always be worn when handling the grab sampler.

The winch drum, blocks, capstan, and any area between the grab sampler and railings, the deck, and heavy equipment all represent significant pinching and crushing hazards. Only experienced crew members will operate the winch or capstan during a sampling event. Other crew members will exercise care to avoid these potentially hazardous areas.

14.3 Chemical Hazards

Contact with marine sediment at some sampling stations may present a health hazard from chemical constituents of the sediment. Potential routes of exposure to chemical hazards include **inhalation, skin and eye absorption, ingestion, and injection**. Potentially

hazardous chemical sediment constituents at the Denny Way/Lake Union CSO sampling site may include hydrogen sulfide, mercury, polychlorinated biphenyls, benzyl butyl phthalate, and bis(2-ethylhexyl) phthalate.

Crew members will exercise caution to avoid coming into contact with sediment at all stations during sampling operations. Protective equipment will include chemical-resistant gloves, safety glasses or goggles, and protective clothing (i.e. rain gear). Crew members will exercise good personal hygiene after sampling and prior to eating or drinking.

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APPENDIX A
FIGURES

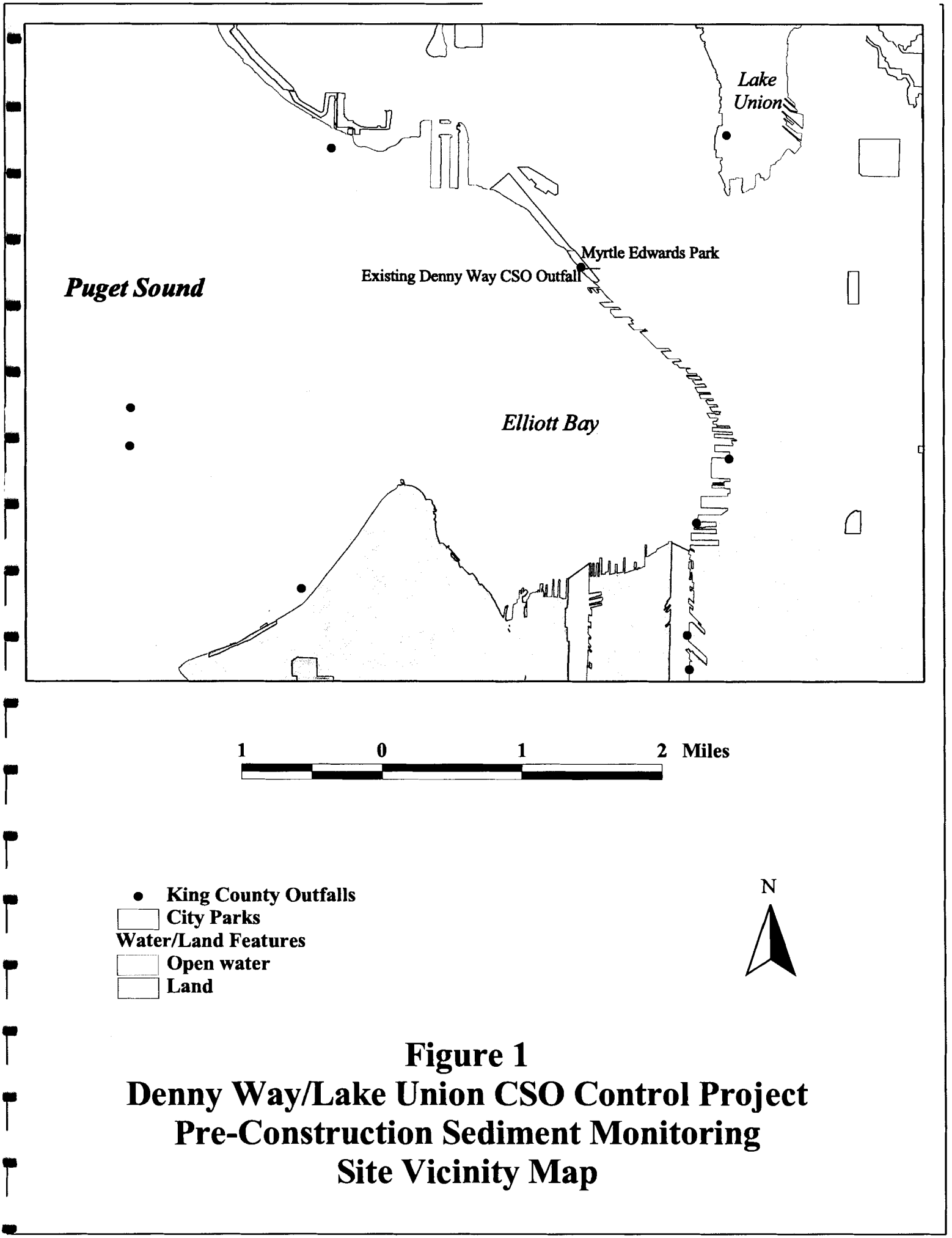
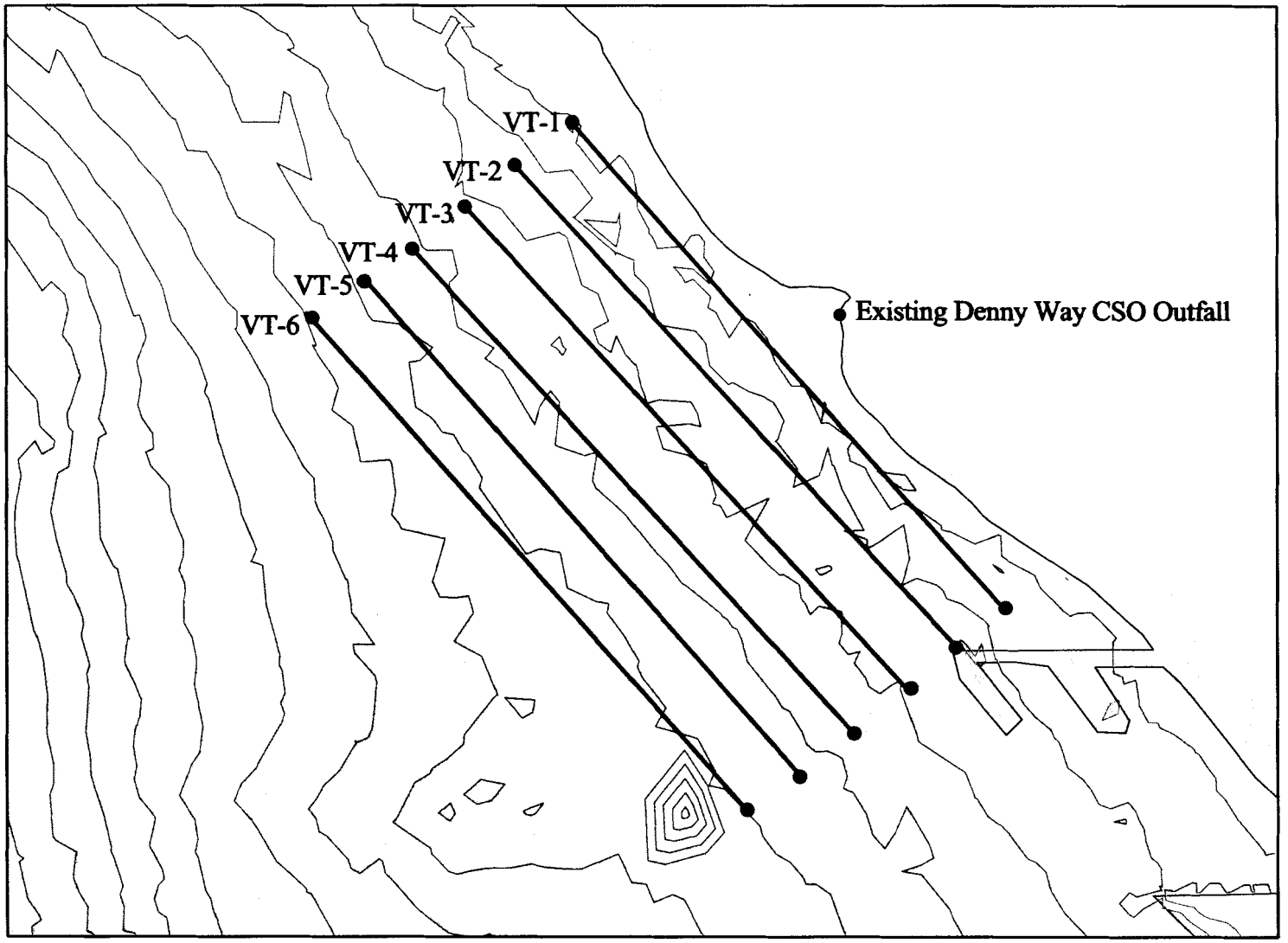


Figure 1
Denny Way/Lake Union CSO Control Project
Pre-Construction Sediment Monitoring
Site Vicinity Map



600 0 600 1200 Feet

N

Underwater Video SurveyTransect Line
King County Outfalls
20 Foot Bathymetry
Water Features
Land Features

Figure 2
Denny Way/Lake Union CSO Control Project
Pre-Construction Sediment Monitoring
Underwater Video Survey

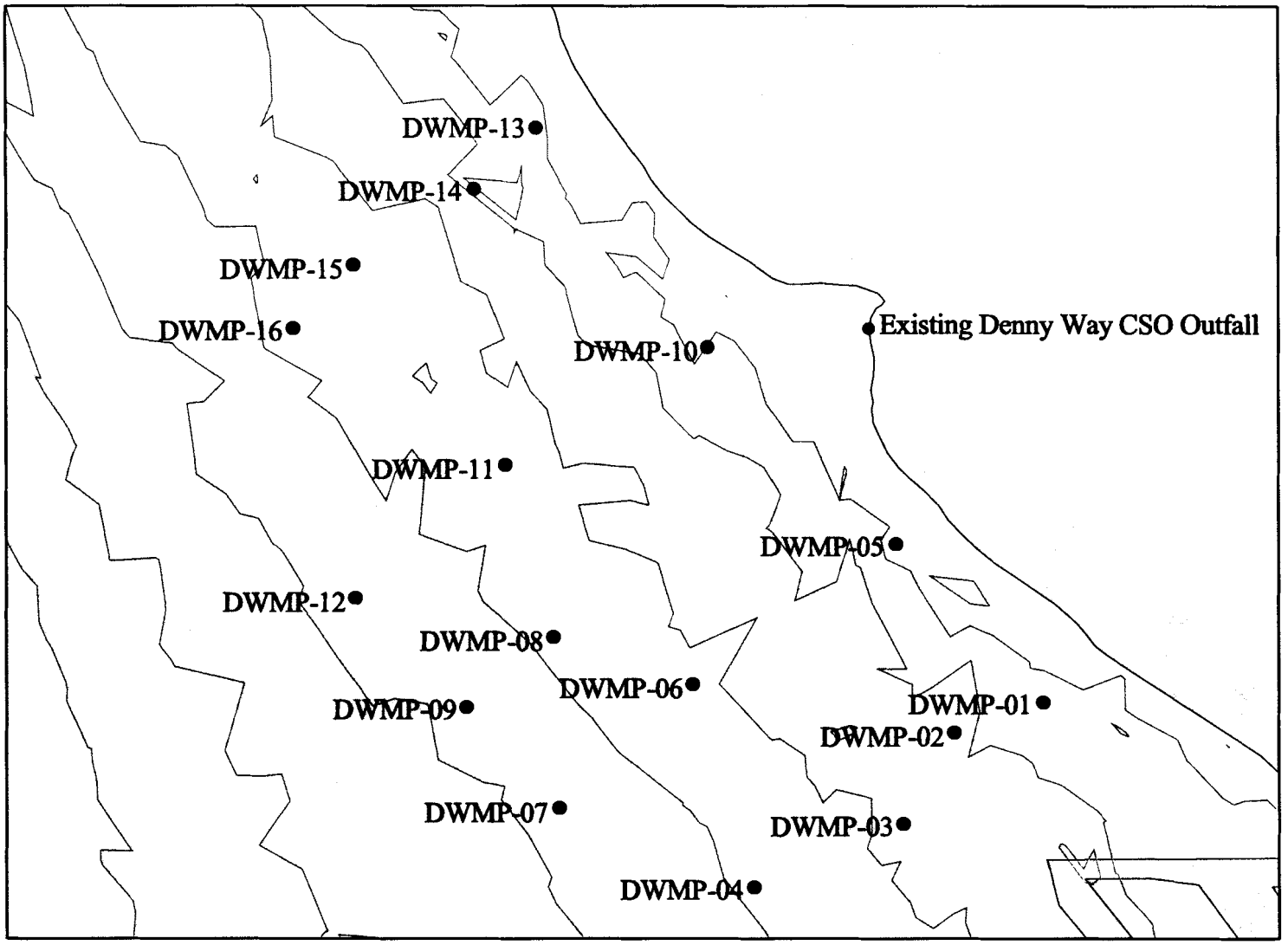


Figure 3
Denny Way/Lake Union CSO Control Project
Pre-Construction Sediment Monitoring
Sediment Chemistry and Benthic Community Stations

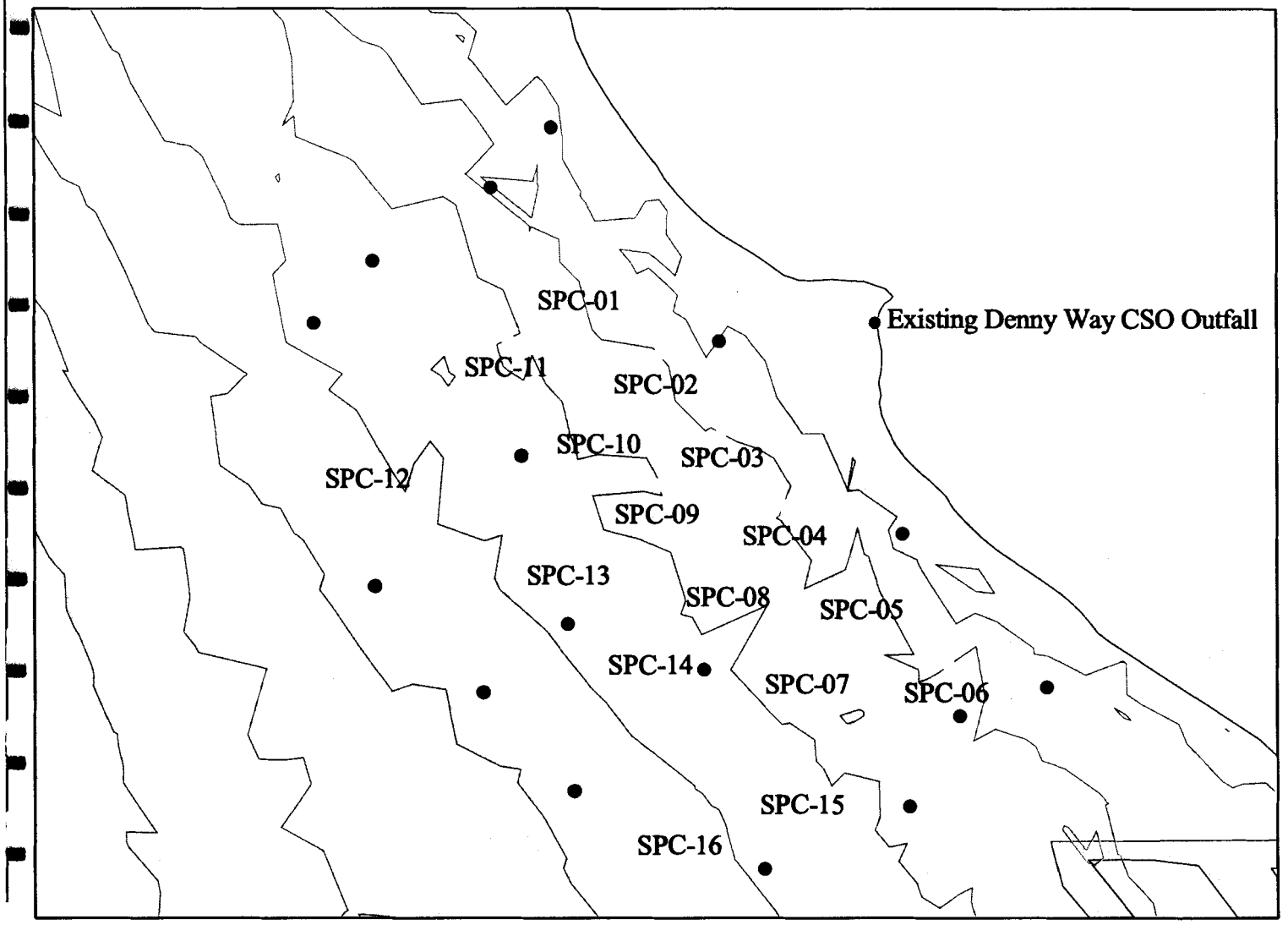


Figure 4
Denny Way/Lake Union CSO Control Project
Pre-Construction Sediment Monitoring
Sediment Profile Camera Stations

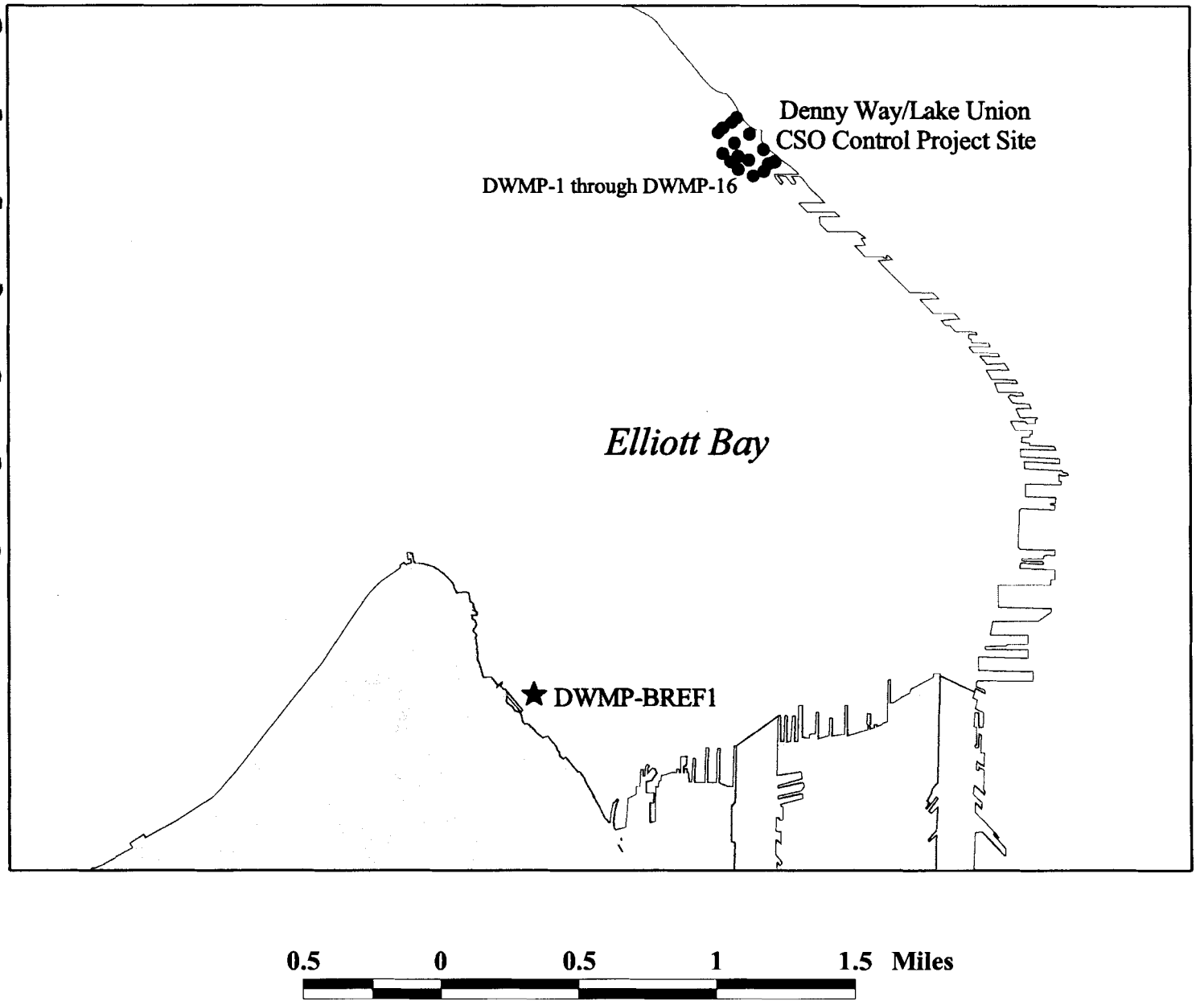


Figure 5
Denny Way/Lake Union CSO Control Project
Pre-Construction Sediment Monitoring
Benthic Community Reference/Evaluation Station

Figure 6
Denny Way/Lake Union CSO Control Project
Pre-Construction Sediment Monitoring
Schematic of Sediment Profile Camera

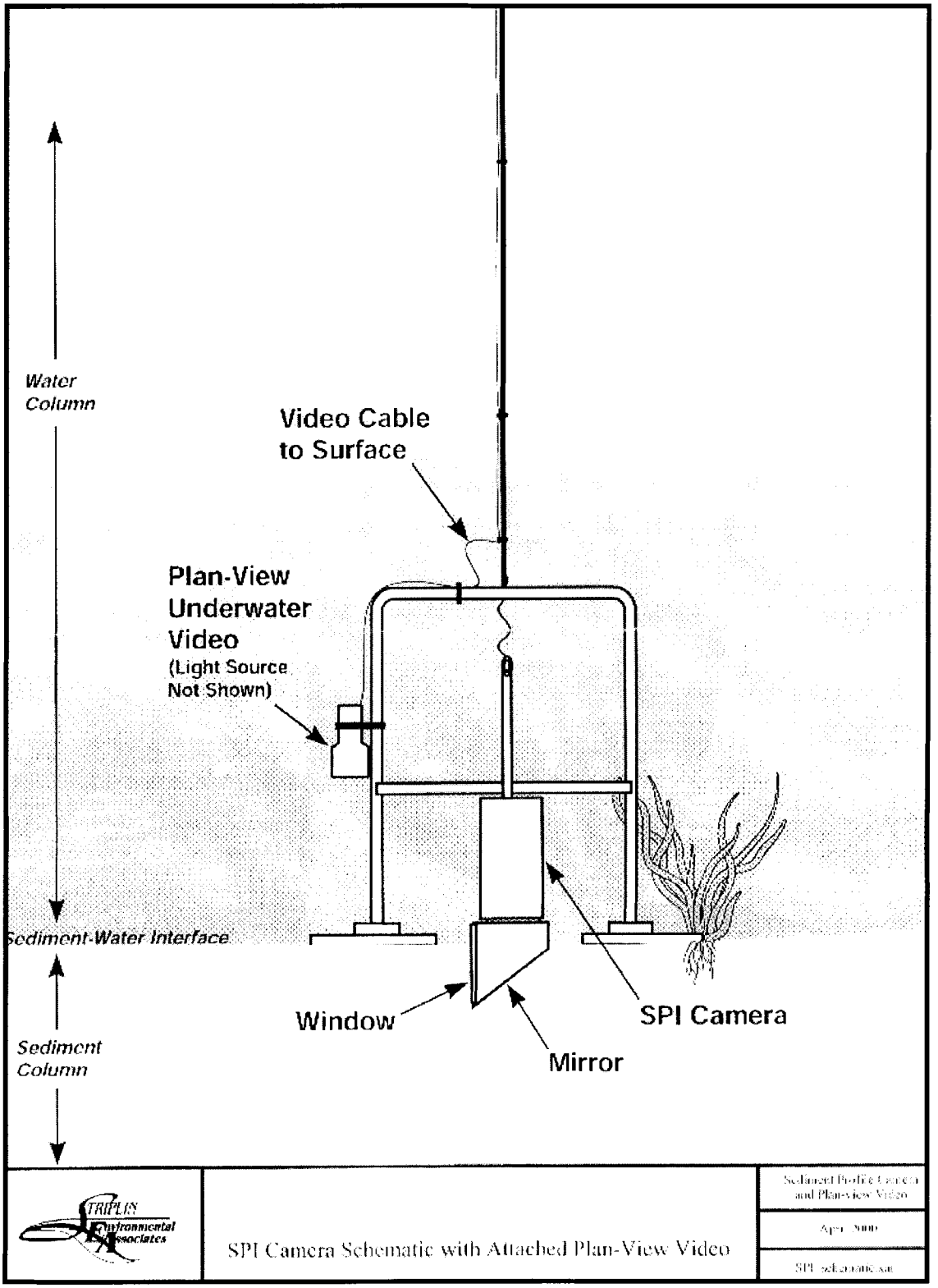


Figure 7
Denny Way/Lake Union CSO Control Project
Pre-Construction Sediment Monitoring
Sample Field Sheet

Fieldsheet ID: 421235_22JUN1999_101133 Page: 1

MAJOR LAKES (wtr col)

Project Number: 421235 Personnel: _____

Sample Number	P15790-1	P15790-2	P15790-3
Locator	0618	0623	0621
Short Loc. Desc.		Rosemnt SD	Sammslough
Locator Desc.		LAKE SAMM/WEST SHORE-ROSEMONT STOR	Lake Sammamish
Site	MAJOR LAKES	MAJOR LAKES	MAJOR LAKES
Sample Depth			
Collect Date			
Comments			
EH, FIELD			
SED DEPTH			
SED SAMP RANGE			
SED TYPE			
TIME			
Dept., Matrix, Prod			
	3 FRSHWTRSED|AVS	3 |FRSHWTRSED|AVS	3 |FRSHWTRSED|AVS
	3 |FRSHWTRSED|NH3	3 |FRSHWTRSED|NH3	3 |FRSHWTRSED|NH3
	3 |FRSHWTRSED|PSD	3 |FRSHWTRSED|PSD	3 |FRSHWTRSED|PSD
	3 |FRSHWTRSED|TOC	3 |FRSHWTRSED|TOC	3 |FRSHWTRSED|TOC
	3 |FRSHWTRSED|TOTP	3 |FRSHWTRSED|TOTP	3 |FRSHWTRSED|TOTP
	3 |FRSHWTRSED|TOTS	3 |FRSHWTRSED|TOTS	3 |FRSHWTRSED|TOTS
	3 |FRSHWTRSED|TOTSULFIDE	3 |FRSHWTRSED|TOTSULFIDE	3 |FRSHWTRSED|TOTSULFIDE
	6 |FRSHWTRSED|HG-CVAA	6 |FRSHWTRSED|HG-CVAA	6 |FRSHWTRSED|HG-CVAA
	6 |FRSHWTRSED|PP ICPMS	6 |FRSHWTRSED|PP ICPMS	6 |FRSHWTRSED|PP ICPMS
	7 |FRSHWTRSED|BNA	7 |FRSHWTRSED|BNA	7 |FRSHWTRSED|BNA
	7 |FRSHWTRSED|CHLOROBENZENES	7 |FRSHWTRSED|CHLOROBENZENES	7 |FRSHWTRSED|CHLOROBENZENES
	7 |FRSHWTRSED|CLPESTPCB	7 |FRSHWTRSED|CLPESTPCB	7 |FRSHWTRSED|CLPESTPCB
	7 |FRSHWTRSED|HERB	7 |FRSHWTRSED|HERB	7 |FRSHWTRSED|HERB
	7 |FRSHWTRSED|OPPEST	7 |FRSHWTRSED|OPPEST	7 |FRSHWTRSED|OPPEST
	7 |FRSHWTRSED|TRIBUTYLTIN	7 |FRSHWTRSED|TRIBUTYLTIN	7 |FRSHWTRSED|TRIBUTYLTIN
	7 |FRSHWTRSED|WTPH-HCID	7 |FRSHWTRSED|WTPH HCID	7 |FRSHWTRSED|WTPH-HCID

End of Fieldsheet.

Figure 8
Denny Way/Lake Union CSO Control Project
Pre-Construction Sediment Monitoring
Sample Chain of Custody Form

LABORATORY WORK ORDER
Chain of Custody

King County Department of Natural Resources
Water and Land Resources Division
Environmental Laboratory
322 West Ewing Street
Seattle, Washington 98119-1507

Project Name:
Project Number:
Laboratory Project Manager:
Telephone Number:

				Analyses															
Sample Number	Locator	Collect Date	Collect Time	BNAS	BUTYLTIN	CHLOROBENZENES	METHYL MERCURY	PCBS	METALS - ICP	MERCURY - CVAA	AMMONIA	OIL & GREASE	PSD	TOC	SOLIDS	SULFIDE		Number of Containers	Comments

Additional Comments: **Total Number of Containers** **Sampled By:**

Relinquished By:		Received By:	
Signature	Date	Signature	Date
Printed Name	Time	Printed Name	Time
Organization		Organization King County Environmental Laboratory	