

Denny Way/Lake Union CSO Control Project
Long-Term Sediment Monitoring Program
Areas A and B Nearshore Sediment Remediation Project
Areas C, D, and E Monitored Natural Recovery

Denny Way CSO and Elliott West CSO Treatment Facility, Post-Operation Sediment Monitoring, Year 3

Denny Way CSO Areas A and B Nearshore Sediment Remediation Project, Post-Construction Sediment Monitoring

Areas C, D, and E Monitored Natural Recovery

Sampling and Analysis Plan

Prepared for the

King County Department of Natural Resources and Parks
Wastewater Treatment Division

by the

King County Department of Natural Resources and Parks
Marine and Sediment Assessment Group

March 2008



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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 the third year of post-operation sediment monitoring for the 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.).

This SAP has also has been prepared to encompass additional sediment monitoring work that will be performed in the vicinity of the Denny Way/Lake Union CSO Control Project sediment monitoring site. The additional sediment monitoring work will include post-construction monitoring of the Denny Way CSO Nearshore Interim Sediment Cleanup Project (Ecology 2007). All of these data will also be used to monitor natural recovery of sediments in the area currently exceeding the Sediment Management Standards chemical criteria.

The SAP includes a description of the project, sampling and analytical methodologies, quality assurance/quality control procedures, and reporting requirements. All figures referenced in this SAP are located at the end of the narrative. The SAP has been prepared in accordance with Washington State Department of Ecology (Ecology) and Army Corps of Engineers (ACOE) SAP preparation guidance documents (Ecology 2003 and ACOE 2000) as well as Chapter 173-204 WAC, the Washington State Sediment Management Standards (Ecology 1995).

2 PROJECT DIRECTIVES

The Denny Way/Lake Union CSO Control Project was a joint effort of King County's Wastewater Treatment Division and Seattle Public Utilities to control City and County CSO discharges into Lake Union, as well as from the Denny Way CSO into Elliott Bay. The project included construction of two outfalls into Elliott Bay. A 490-foot outfall at a depth of -63 feet referenced to mean lower low water (MLLW) discharges treated CSO effluent from the new Elliott West CSO Treatment Facility (TF) during moderately heavy storm events. A 100-foot extension of the former Denny Way CSO outfall to a depth of -20 feet MLLW discharges untreated CSO to Elliott Bay during the once-per-year on average event when flows exceed the TF and system capacity (King County, City of Seattle, and EPA 1998).

Pursuant to the Biological Opinion referenced in Section 1 of this SAP, King County developed a plan to monitor the marine environment surrounding the new 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 operation of the Elliott West CSO TF/Denny Way CSO causes an impact to the biological communities in the marine environment surrounding the outfalls. If operation of the CSO facilities causes increased contamination of marine sediments 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 long-term monitoring program was scheduled to monitor sediment quality over 20 years following construction and operation of the new Elliott West/Denny CSO treatment facility and associated marine outfalls. Subsequently, King County conducted an interim cleanup (Ecology 2007) in the area between the offshore area capped in 1990 and the old outfall location on the shoreline. As part of that Cleanup Action Plan, monitoring was required to address several objectives. The project directives have been amended to encompass the following additional tasks to address the post-construction components of that monitoring plan:

- a one-time monitoring event of sediment quality at seven stations around the perimeter of the area dredged and backfilled during a nearshore interim sediment cleanup project (Areas A and B);
- annual monitoring of one station within the backfilled area to evaluate the potential for recontamination; and
- continued annual monitoring of areas with sediments exceeding the SMS at the Denny Way site (Areas C, D, and E) for evaluation of natural recovery.

The stations to be monitored are shown in Figure 1. The 16 existing stations, which are sampled to monitor sediment quality for compliance with the CSO control project BO are shown on the figure in red (Stations DWMP-01 through DWMP-16). Station DWMP-10 is located within the area remediated during the nearshore interim cleanup project for Areas A and B. Six of the 16 stations are located in natural recovery monitoring Areas C, D, and E. The seven post-construction monitoring stations that will be sampled one time in April 2008, following completion of remediation construction activities, are shown on the figure in yellow. The seven stations sampled once in April 2008 will be submitted for sediment chemical analysis only. Eight of the 16 existing stations will be sampled for sediment chemistry only and eight will be sampled for both sediment chemistry and benthic community assemblages.

3 SITE DESCRIPTION AND PROJECT HISTORY

The Elliott West CSO TF and Denny Way CSO outfalls and the associated sediment monitoring site are located on the northeast side of Elliott Bay, adjacent to Myrtle Edwards Park in Seattle, Washington (Figure 1). The old Denny Way CSO outfall was located in the intertidal zone and discharged directly onto the beach during storm events that occurred during low tides. The shoreline in the monitoring area is heavily armored with rip-rap with the exception of a small cove with some natural beach characteristics. Bathymetry in the area is moderately sloping.

The old Denny Way CSO was the largest in King County's system and large volumes of combined storm water runoff and untreated sewage were discharged at this location. Prior to this location becoming a CSO in 1968, it was a raw sewage outfall. In 1986, The Municipality of Metropolitan Seattle or Metro (later incorporated into King County) 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 beginning at the depth determined to not be subject to wave erosion.

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 old 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 remediation were identified in the vicinity of the old 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. Monitored natural recovery was identified as the preferred alternative for the offshore areas. Sediment monitoring related to site remediation will be addressed in a future project document.

3.1 The Denny Way/Lake Union CSO Control Project

Construction of the new outfalls was completed in March 2002. The shorter, shallow Denny Way CSO outfall is designed to discharge untreated CSO during large storm events, on average of once-per-year in a year of normal rainfall. The longer, deeper Elliott West CSO TF outfall is designed to discharge treated CSO effluent during periods of moderate rainfall when normal system capacity is exceeded. The deeper outfall is covered by a concrete "blanket" to prevent damage from excessive wave action or navigational mishaps. Habitat enhancement following construction included the placement of "habitat mix" (sand, gravel, cobble) in the disturbed areas surrounding the construction zone, along with armoring cobbles and boulders and large woody debris. Destruction of the old Denny Way CSO outfall in August 2002 moved the discharge of untreated CSO effluent offshore to the new Denny Way CSO outfall. Discharge of untreated CSO effluent at the new, shallower outfall continued during periods of rainfall that exceed normal system capacity until the Elliott West CSO TF came online in June 2005. Now online,

the new facility falls under King County’s National Pollutant Discharge Elimination System (NPDES) permit for its West Point Treatment Plant and associated CSO treatment plants.

King County has monitored sediment quality at the project site prior and subsequent to construction of the new outfalls. Monitoring events occurred in: 2001, prior to outfall construction; in 2003, after completion of all construction activities; and in 2006 and 2007, after one and two years of operation. These monitoring events showed consistent exceedances of Washington State Sediment Management Standards (SMS) for mercury, benzyl butyl phthalate, bis(2-ethylhexyl) phthalate, and total PCBs. Tables 3-1 through 3-3 summarize the SMS exceedances of both the Sediment Quality Standards (SQS) and Cleanup Screening Levels (CSL) from Chapter 173-204 WAC (Ecology 1995). The tables provide the numeric SMS chemical criteria, the number of stations that exceeded the SQS and/or CSL criteria, and the concentration ranges detected at those stations. Concentrations of some individual polynuclear aromatic hydrocarbon (PAH) compounds have also exceeded SQS chemical criteria at three stations, although not consistently between the three monitoring events. *Total* HPAH (high molecular weight PAH) concentrations at two stations exceeded the SQS criterion in 2006.

**Table 3-1
Summary of SQS and CSL Exceedances – 2001 Monitoring Event**

Chemical	SQS	Number of Exceedances	Concentration Range	CSL	Number of Exceedances	Concentration Range
Mercury ¹	0.41	5	0.411 – 0.571	0.59	4	0.615 – 0.741
Benzyl Butyl Phthalate ²	4.9	9	4.93 – 34.8	64	0	--
Bis (2-ethylhexyl) Phthalate ²	47	4	54.0 – 71.9	78	3	83.6 – 304
Total PCBs ²	12	10	13.0 – 35.1	65	0	--

¹SQS, CSL, and Concentration Range in milligrams per kilogram normalized to dry weight (mg/Kg DW).

²SQS, CSL, and Concentration Range in milligrams per kilogram normalized to organic carbon (mg/Kg OC).

**Table 3-2
Summary of SQS and CSL Exceedances – 2003 Monitoring Event**

Chemical	SQS	Number of Exceedances	Concentration Range	CSL	Number of Exceedances	Concentration Range
Mercury ¹	0.41	4	0.419 – 0.563	0.59	4	0.610 – 0.751
Benzyl Butyl Phthalate ²	4.9	2	14.2 – 31.9*	64	0	--
Bis (2-ethylhexyl) Phthalate ²	47	3	48.4 – 59.5	78	1	155
Total PCBs ²	12	10	14.1 – 29.3	65	0	--

¹SQS, CSL, and Concentration Range in milligrams per kilogram normalized to dry weight (mg/Kg DW).

²SQS, CSL, and Concentration Range in milligrams per kilogram normalized to organic carbon (mg/Kg OC).

*Results impacted by laboratory contamination.

**Table 3-3
Summary of SQS and CSL Exceedances – 2006 Monitoring Event**

Chemical	SQS	Number of Exceedances	Concentration Range	CSL	Number of Exceedances	Concentration Range
Mercury ¹	0.41	5	0.411 – 0.568	0.59	3	0.602 – 0.922
Benzyl Butyl Phthalate ²	4.9	11	5.07 – 58.4	64	0	--
Bis (2-ethylhexyl) Phthalate ²	47	6	47.1 – 70.3*	78	2	98.4 – 166
Total HPAHs ²	960	2	993 – 1,050	5,300	0	--
Total PCBs ²	12	10	12.9 – 29.8	65	0	--

¹SQS, CSL, and Concentration Range in milligrams per kilogram normalized to dry weight (mg/Kg DW).

²SQS, CSL, and Concentration Range in milligrams per kilogram normalized to organic carbon (mg/Kg OC).

*Results impacted by laboratory contamination.

Analysis of the benthic taxonomy data indicates a generally healthy benthic community over most of the site. The data also indicate, however, that the benthic community assemblage in the area around the former Denny Way CSO outfall has most likely been impacted by historic discharges and, possibly, other sources. Some other locations in the shallow, nearshore environment also show possible environmental stress based on the presence of dominant, pollution-tolerant species. Benthic data from the 2006 and 2007 monitoring events indicate that some opportunistic, pollution-tolerant polychaetes have colonized the area near the new Elliott West CSO TF outfall.

Data from these four monitoring events indicate no major changes in sediment quality at the site as a result of outfall construction activities or operation. The 2008 monitoring event, described in this SAP, will evaluate sediment quality approximately three years after the Elliott West CSO TF became operational.

3.2 Sediment Remediation at the Denny Way Site

In 1997, King County characterized the nature and extent of surface and subsurface sediment contamination in the area of the old Denny Way outfall, as well as areas inshore and offshore of the existing Denny Way sediment cap (SEA 1997). Follow-up sediment sampling conducted by King County in 2005 demonstrated that chemical concentrations in the offshore areas declined over time due to a combination of natural processes, including biodegradation of chemicals, accumulation and mixing of clean sediment, and reduction of contaminant sources (King County 2005). Thus, monitored natural recovery is a prospective cleanup remedy for the offshore areas (Areas C, D, and E). These areas will continue to be evaluated by the Ecology and the County to determine if a more active cleanup remedy is required. Areas C, D, and E are shown in Figure 1.

Unlike offshore areas of the site, natural recovery rates in the inshore sediment areas appeared to be progressing relatively slowly. In order to accelerate cleanup of the site and minimize the risk of future recontamination to other site areas due to resuspension of inshore sediments, including the offshore cap, an interim sediment cleanup action plan for the site was developed by King County and Ecology in 2007, including dredging to the extent practicable to remove sediments exceeding the SMS, and backfilling to restore the grade to close to pre-project conditions. The Denny Way CSO interim action remediated contaminated sediment present in the two nearshore areas in the immediate vicinity of the former Denny Way CSO outfall (Areas A and B). A combination of dredging, backfilling, and armoring was employed to remediate the nearshore areas. The dredging boundary for the Areas A and B cleanup is shown in Figure 1.

Approximately 13,700 cubic yards (cy) of contaminated sediments were dredged from approximately +10 feet MLLW to approximately -35 feet MLLW within the 1.2-acre interim action area. The material within the dredge footprint was mechanically dredged using a clamshell bucket deployed from a derrick barge. The dredged area was backfilled and armored with an average thickness of more than 10 feet of material. Approximately 14,500 cy of well-graded clean sand was armored with approximately 4,000 cy of sandy-gravel habitat mix as well as large cobbles and boulders. An additional 1,500 cy of well-graded clean sand was placed in an approximately 6-in thin layer around the perimeter of the dredge prism to address any residuals that may have resulted from the dredging. Prior to commencement of construction activities, sediment grab samples were collected adjacent to and beyond the dredge boundary to document baseline pre-dredge sediment quality conditions near the project area.

3.3 Amended Sediment Monitoring Scope of Work

The original Denny Way sediment monitoring scope of work was designed as part of a long-term sediment monitoring program to meet requirements of the CSO control project BO. The long-term monitoring program was scheduled to monitor sediment quality over a 20-year period, following construction and operation of the new Elliott West CSO TF and Denny Way CSO. The amended sediment monitoring scope of work will encompass the tasks listed below.

- A one-time monitoring event of sediment quality at seven stations around the perimeter of Areas A and B will evaluate whether dispersal of contaminated sediments during remedial activities has occurred. This monitoring event will occur in April 2008, following completion of all remedial construction activities. Surface sediment samples will be collected from Stations DW-01, DW-03, DW-13, DW-19, DW033, DW-34, and LTBC20(J), which are shown in yellow in Figure 1. Baseline sediment data was collected from these seven stations in November 2007.
- Annual monitoring of one station within Areas A and B will evaluate the potential for recontamination. Surface sediment samples will be collected from Station DWMP-10 annually in April, from 2008 through 2012.
- Continued annual monitoring of additional impacted sediments at the Denny Way site (Areas C, D, and E) will evaluate natural recovery at the site. Surface sediment samples will be collected annually in April, from 2008 through 2012 from Stations DWMP-14 and DWMP-15 (Area C), Station DWMP-08 (Area D), and Stations DWMP-01, DWMP-02, and DWMP-03 (Area E).

Figure 1 summarizes all of the stations that will be sampled under the amended scope of work for the Denny Way sediment monitoring program. The 16 existing stations, which are sampled to monitor sediment quality for compliance with the project BO, are shown on the figure in red (Stations DWMP-01 through DWMP-16). As stated above, seven of these stations will also monitor the effectiveness of the nearshore interim sediment remediation (DWMP-10) and natural recovery (DWMP-01, DWMP-02, DWMP-03, DWMP-08, DWMP-14, and DWMP-15). The seven monitoring stations that will be sampled one time in April 2008, following completion of remediation construction activities are shown on the figure in yellow.

The seven stations sampled once in April 2008 (DW-01, DW-03, DW-13, DW-19, DW-33, DW-34, and LTBC20(J)) will be submitted for sediment chemical analysis only. The 16 existing stations (DWMP-01 through DWMP-16) will be sampled for analysis of sediment chemistry and benthic community assemblages will be analyzed on eight of those 16 sediment chemistry samples.

4 SAMPLING DESIGN

The goal of the third year, post-operation sediment monitoring event is to continue evaluating sediment quality in the vicinity of the new Elliott West CSO TF outfall and the new, deeper Denny Way CSO outfall. Another goal is to monitor the areas around the perimeter of the nearshore sediment remediation area (Areas A and B) to see whether construction activities may have dispersed contaminated sediment outside the dredge prism or otherwise negatively impacted the area. The final goal is to continue monitoring sediment quality and natural recovery in Areas C, D, and E.

4.1 Data Quality Objectives

The data quality objectives (DQOs) of the third year, post-operation sediment monitoring event are to collect data of sufficient quantity and quality to be able to meet the following monitoring objectives:

- evaluate the areal extent and spatial variations of sediment chemical concentrations in the vicinity of the former Denny Way CSO and the new Elliott West CSO TF and Denny Way CSO outfalls;
- evaluate sediment chemical concentrations in the study area relative to the current marine sediment quality standards of Chapter 173-204 WAC (Ecology 1995);
- evaluate the benthic community assemblages at eight of the 16 stations from which sediment chemistry data have been collected; and
- evaluate spatial differences in benthic community assemblages over the site as well as comparing the benthic community assemblages at the study site to regional Puget Sound benthic community data.
- evaluate sediment chemical concentrations at seven stations proximal and distal to the perimeter of remedial areas A and B, which were sampled prior to commencement of remedial construction activities; and
- evaluate sediment chemical concentrations over time with the three natural recovery areas, Areas C, D, and E.

The *quantity* of sediment chemistry data to be collected is based on specifications in the project Biological Opinion (NMFS 2000). One sediment chemistry sample will be collected from each of 16 stations and will consist of sediment composited from three separate deployments of a grab sampler. Concurrent benthic taxonomy samples will be collected in triplicate from eight of the stations. Benthic taxonomy data has previously been collected from all 16 of the sediment chemistry stations. A review of all benthic taxonomy data collected to date has indicated that the benthos falls into two major communities, based on depth and grain size. These two groups can be successfully monitored through the collection of samples from just eight stations, rather than 16 as previously done.

Validation of project data will assess whether the data collected are of sufficient *quality* to meet the study goals. The data quality issues of precision, accuracy, bias, representativeness, completeness, comparability, and sensitivity are described in the following sections.

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 sediment chemistry and benthic taxonomy may be measured by one or more of the following quality control (QC) procedures:

- analysis of various laboratory QC samples such as method blanks, matrix spikes, certified reference materials, and laboratory duplicates or triplicates for sediment chemistry;
- collection of sediment chemistry samples composited from three separate grab deployments;
- analysis of triplicate benthic community samples from each station; and
- confirmation of species identification by secondary taxonomists during benthic community analysis.

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. Sediment chemistry and benthic taxonomy samples will be collected from stations with pre-selected coordinates to represent specific site locations. Sediment chemistry samples will be homogenized to minimize variations in the chemical and physical composition of the sediments. Benthic taxonomy samples will be collected in triplicate at each station. Concurrent sediment chemistry samples will be collected along with each of the three benthic taxonomy samples and then composited into a single sample. Following the guidelines described for sampler decontamination, sample acceptability criteria, and sample processing (Section 6) will also help ensure that samples are representative.

4.1.3 Completeness

Completeness is defined as the total number of samples for which acceptable analytical data are generated, compared to the total number of samples submitted for analysis. Adhering to standardized sampling and testing protocols will aid in providing a complete set of data for this study. The goal for completeness is 100%. If 100% completeness is not achieved, the study team will evaluate whether the DQOs can still be achieved 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.

4.1.5 Sensitivity

Sensitivity is a measure of the capability of analytical methods to meet study goals. The analytical method detection limits presented in Section 9 are sensitive enough to allow comparison of sediment chemistry data to current Ecology and PSDDA sediment quality criteria, both normalized to dry weight and to organic carbon, as appropriate.

4.2 Sampling Strategy

Sediment chemistry samples will be collected from each of the 16 stations at the monitoring site that have been sampled since 2001, as well as from the seven perimeter stations that were

previously sampled in November 2007, prior to commencement of remedial construction activities. Dual van Veen grab samplers will be deployed in tandem at each station. For the 16 stations sampled as part of the long-term sediment monitoring program, sediment chemistry samples were previously collected from the top 2 centimeters (cm) of sediment retrieved in each of three separate deployments of the grab samplers, and then composited into a single sample. Samples at 10 of those stations will now be comprised of sediments collected from the top 10 cm. Collection of the top 10 cm will allow an assessment of sediment quality over the entire biologically active zone and allow King County to meet requirements of the post-construction sediment monitoring requirement at cleanup Areas A and B, as well as monitored natural recovery Areas C, D, and E.

Samples at the six stations proximal to the Elliott West CSO TF outfall will continue with the 0- to 2-cm sampling regime to meet NPDES monitoring protocols. One station proximal to the outfall, DWMP-08 will have samples collected both from the 0- to 2-cm and 0- to 10-cm depth strata to meet NPDES protocols and monitoring requirements for monitored natural recovery Area D. Table 4-1 summarizes the sampling depth strata for the 16 long-term sediment monitoring stations. Sediment chemistry samples will be collected from the top 2 or 10 cm of sediment in one of the dual grab samplers during each deployment, while the benthic taxonomy replicate will be collected from the entire contents of the other tandem grab sampler at the eight stations from which benthic taxonomy data will be collected. For each of the seven perimeter stations, sediment will be collected from the top 10 cm of sediment, with the same number of grab deployments and compositing regime.

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 Sampling Stations

Figure 2 shows the locations of the 16 stations from which samples will be collected for analysis of sediment chemistry. Benthic taxonomy samples will be collected from eight of those stations. 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 terminus of the new 490-foot outfall for the Elliott West CSO Storage and Treatment Facility. Fourteen of the 16 sampling locations are positioned at stations from which previous sediment samples were collected as part of the Denny Way Sediment Characterization (SEA 1998). Samples were collected from all 16 stations in 2001, 2003, 2006, and 2007.

The seven perimeter stations that will be sampled once in 2008 for sediment chemistry as part of the nearshore sediment remediation monitoring are also shown on figure 2. Table 4-1 summarizes the stations, their coordinates, depth strata, and the analyses that will be performed at each station.

Table 4-1
Sediment Sampling Stations – Coordinates, Depth Strata and Analyses

Station	Northing	Easting	Depth Stratum (cm)	Ammonia Nitrogen	Particle Size Distribution	Total Organic Carbon	Total Solids	Total Sulfide	Volatile Solids	Total Metals ¹	BNAs ²	Chlorinated Pesticides	PCB Aroclors ³	Volatile Organics ⁴	Benthic Taxonomy (3 reps)
DWMP-01	228813	1264047	10	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DWMP-02	228770	1263919	10	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
DWMP-03	228638	1263846	10	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DWMP-04	228546	1263631	10	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
DWMP-05	229041	1263836	10	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DWMP-06	228839	1263542	2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
DWMP-07	228660	1263350	2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
DWMP-08	228907	1263341	2/10	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DWMP-09	228806	1263215	2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DWMP-10	229326	1263565	10	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DWMP-11	229156	1263272	2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
DWMP-12	228963	1263055	2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
DWMP-13	229640	1263317	10	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
DWMP-14	229553	1263228	10	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DWMP-15	229444	1263053	10	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DWMP-16	229353	1262966	10	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
DW-01	229703	1263143	10		✓	✓	✓			✓	✓		✓		
DW-03	229529	1263359	10		✓	✓	✓			✓	✓		✓		
DW-13	229363	1263343	10		✓	✓	✓			✓	✓		✓		
DW-19	229150	1263268	10		✓	✓	✓			✓	✓		✓		
DW-33	229130	1263747	10		✓	✓	✓			✓	✓		✓		
DW-34	228952	1263903	10		✓	✓	✓			✓	✓		✓		
LTBC20	229241	1263454	10		✓	✓	✓			✓	✓		✓		

4.4 Sample Acquisition and Analytical Parameters

Chemistry samples will be collected from either the top 2 cm or top 10 cm of sediment recovered from three deployments of a van Veen grab sampler. Samples will be composited, 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 ACOE recommendations for conducting baseline sediment quality studies (Ecology 1995; ACOE 2000). Analytical parameters for sediment chemistry will include:

- conventionals - percent solids, percent volatile solids, particle size distribution (PSD), total organic carbon (TOC), ammonia, and total sulfide;

- metals - arsenic, antimony, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc; and
- organics - volatile organic compounds (VOCs), base/neutral/acid extractable semivolatile organic compounds (BNAs), chlorinated pesticides, and PCBs (the complete list of organic parameters is shown in Section 9.3).

Note that the parameters above are those for which the 16 samples collected as part of the long-term monitoring program will be analyzed. The seven samples collected in association with the nearshore sediment remediation monitoring will be analyzed for a subset of those parameters (see Table 4-1). Benthic taxonomy samples will be collected concurrently with chemistry samples from the eight of the 16 study area stations. 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 taxonomy 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 taxonomy samples.

4.5 Data Analysis

Sediment chemistry data will be evaluated by comparison to sediment chemical criteria from the SMS Tables I and III (Ecology 1995) as well as Table 5-1 in the PSDDA users manual (ACOE 2000). Data from this sampling event will be compared to results from previous studies including the Denny Way Sediment Characterization (SEA 1998) and the Denny Way Pre- and Post-Construction Sediment Characterization Studies (King County 2001, 2005), as well as the 2006 and 2007 years one and two, post-operation monitoring events.

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 taxonomy results from the eight sampling stations will be compared to Puget Sound regional benthic data from areas of similar physical characteristics such as depth, grain size distribution, organic carbon content, and ambient water quality. These data will also be used to calculate diversity indices, species abundance (total abundance as well as abundance in each major taxa group), and biomass.

5 PROJECT ORGANIZATION AND SCHEDULE

The tasks involved in conducting the third year, post-operation sediment monitoring event at the Denny Way/Lake Union CSO Control Project site, along with the post-construction monitoring for the Denny Way CSO Nearshore Interim Sediment Cleanup Project, and the King County and contracted personnel who will assume responsibility for those tasks are listed below.

- **Scott Mickelson** King County Marine and Sediment Assessment Group – (206) 296-8247 scott.mickelson@kingcounty.gov Project management, study design, preparation of SAP, data validation and analysis, and preparation of final study report.
- **John Blaine** King County Environmental Laboratory – (206) 684-2384 john.blaine@kingcounty.gov Coordination of field activities for sediment chemistry and benthic taxonomy sampling and field oversight of contract personnel.
- **Fritz Grothkopp** King County Environmental Laboratory – (206) 684-2327 fritz.grothkopp@kingcounty.gov Coordination of all King County Environmental Laboratory activities, data validation, and data reporting.
- **Allan Fukuyama** University of Washington – (425) 745-3349 allanf@u.washington.edu Coordination of sampling and analytical activities for benthic taxonomy analysis.
- **John Phillips** King County Wastewater Treatment Division – (206) 263-6543 john.phillips@kingcounty.gov Review of SAP and final study report; coordination of nearshore interim sediment cleanup project.
- **Jeff Stern** King County Wastewater Treatment Division – (206) 263-6447 jeff.stern@kingcounty.gov Review of SAP and final study report; coordination of King County's long-term sediment management plan.

Field work for the 2008 monitoring event is anticipated to require up to one week of field time and will occur in April 2008. Sediment chemistry results will be available by August 2008. Validated chemistry data packages and electronic data files will be ready for release by September 2008. Benthic taxonomy results will be available by November 2008. The final report for this monitoring event will be ready for release in January 2009.

6 SAMPLING PROCEDURES

All sampling will be performed according to guidelines recommended by the Puget Sound Estuary Program's (PSEP) Puget Sound Protocols (PSEP 1987,1997a, 1998). Sediment samples will be collected using dual, tandem 0.1 m² modified, stainless steel van Veen grab samplers deployed via hydrowire and hydraulic winch from the King County research vessel *Liberty*.

Chemistry samples will be collected from the top 2 or 10 cm of sediment. Sediment will be collected from the contents of three deployments of the dual grab samplers. Sediment chemistry 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.

6.1 Station Positioning

Station positioning will employ a Trimble[®] Differential Global Positioning System (DGPS). Prior to the monitoring event, the prescribed station coordinates will be entered into the shipboard DGPS laptop computer. During sampling, 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 ± 2 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 the grab deployment is outside of this limit. If conditions such as a steep slope or rocky substrate preclude sample collection at a particular station, the station may be relocated after consultation with the study coordinator and if relocation will not compromise the project goals. Any station relocation will be documented and reported.

6.2 Sampler Deployment and Retrieval

Two 0.1 m², modified, stainless-steel van Veen grab samplers will be deployed in tandem at each sampling station. The grab samplers will be lowered at a controlled speed of approximately 4 feet per second until it is near the bottom, at which time the speed will be decreased to approximately 1 foot per second to minimize potential bow-wake activity and subsequent bottom disturbance.

After the grabs have tripped upon reaching the bottom, they will be raised slowly to allow gentle and complete closure of the sampler jaws, thus avoiding sample disturbance and loss. Once clear of the bottom, the ascent speed will be increased to approximately 4 feet per second. Care will

be taken to ensure that minimal sample disturbance occurs when swinging the grabs on board. Collection of undisturbed sediment requires that the grab samplers:

- create a minimal bow wake when descending;
- form a leak-proof seal upon closure of the jaws;
- are carefully retrieved to prevent excessive sample disturbance; and
- allow easy access to the sediment within the grab.

6.3 Sample Acceptability Criteria

When the grab samplers have been secured on board, the hinged top flaps will be opened and the samples examined for acceptability. Acceptability criteria will include that:

- 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 at least 4 cm has been achieved.

Samples collected from the top 2 cm of sediment will require a minimum grab penetration depth of 4 cm. Samples collected from the top 10 cm of sediment will require a minimum grab penetration depth of 11 cm. Care will be taken to extract sediment from the most undisturbed center portion of each grab without collecting sediment that has touched the sides or bottom of the grab. Penetration depth will be determined by measuring the depth of sediment within each grab by sliding a ruler vertically along the inside of the grab's side wall after each successful cast. Penetration depth can also be calculated by measuring the space between the sediment's surface within the grab and the top of the grab, then subtracting this vertical distance from 17 cm, the total inside height of the grab at the center point. Overlying water within the grab will be carefully siphoned off of the sediment surface for all acceptable samples.

6.4 Sample Processing – Sediment Chemistry

Prior to any subsampling, sediment aliquots will be collected for analysis of volatile organic compounds and total sulfide. The volatile organic compound and total sulfide sample aliquots will always be collected from the top 2 cm of sediment in the first grab using a stainless steel spoon and then placed directly in the appropriate sample containers without homogenization. The remaining top 2 cm of undisturbed sediment will be collected from the first grab, as well as the subsequent two grabs, with a stainless steel "cookie cutter" and spatula. The sediment will then be 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 since multiple grab deployments are required.

Head space will be left in all lab containers, with the exception of total sulfide 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. Total sulfide samples also require the use of a preservative. After the 4-ounce total sulfide 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. All sample containers, storage conditions, and hold times are summarized in Table 6-1.

Table 6-1
Sediment Chemistry – Sample Containers, Storage Conditions, and Hold Times

Analyte	Container	Preferred Storage Conditions	Hold Time	Acceptable Storage Conditions	Hold Time
Ammonia	4-oz. PP ^{2,3}	refrigerate at 4°C	7 days to analyze	freeze at -18°C	6 months to analyze
PSD	16-oz. PP ^{1,3}	refrigerate at 4°C	6 months to analyze	N/A	N/A
TOC	4-oz. PP ³	freeze at -18°C	6 months to analyze	refrigerate at 4°C	14 days to analyze
Percent Solids (collect w/ TOC)	4-oz. PP ³	freeze at -18°C	6 months to analyze	refrigerate at 4°C	14 days to analyze
Total Sulfide	4-oz. PP ³ no headspace	refrigerate at 4°C w/ 2N Zn acetate	7 days to analyze	N/A	N/A
Volatile Solids (collect w/ TOC)	4-oz. PP ³	freeze at -18°C	6 months to analyze	refrigerate at 4°C	14 days to analyze
Mercury	250-ml PP ²	freeze at -18°C	28 days to analyze	N/A	N/A
Other Metals	250-ml PP	freeze at -18°C	2 years to analyze	refrigerate at 4°C	6 months to analyze
BNAs	16-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
Chl. Pest./PCBs (collect w/ BNAs)	16-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
VOCs	4-oz. glass no headspace	refrigerate at 4°C	14 days to analyze	N/A	N/A

¹One additional 16-oz. PP container should be collected every 10 samples to be used for quality control purposes.

²PP – polypropylene.

³PP container is preferred but glass container is also acceptable.

6.5 Sample Processing – Benthic Taxonomy

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 PSEP protocols (PSEP 1987).

6.6 Sampling Equipment Decontamination

The grab samplers 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 in the field.

6.7 Sample Storage and Delivery

All sample containers will be stored in an insulated cooler containing ice immediately after collection to maintain the samples at a temperature of approximately 4° Celsius 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 and the benthic taxonomy laboratory.

6.8 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 field staff or the benthic taxonomy contractor. 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. 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, original COC forms will be archived in the project file. Samples delivered after regular business hours will be stored in a secure chain of custody refrigerator until the next day. An example of the King County Environmental Laboratory’s COC form is included as Figure 3.

7 SAMPLE DOCUMENTATION

Sampling information and sample metadata will be documented using the methods noted below.

- Field sheets generated by King County's Laboratory Information Management System (LIMS) that will include information such as:
 1. sample identification number
 2. station name
 3. station bottom depth
 4. sediment depth (i.e., sampler penetration depth) for each successful grab deployment
 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 *Liberty'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 *Liberty'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 acceptable grab deployment, using both latitude/longitude and NAD 83 State Plane formats.
- COC documentation will consist of the King County Environmental Laboratory's standard COC form, which is used to track release and receipt of each sample from collection to arrival at the lab.

A sample of a typical field sheet used by the King County Environmental Laboratory is included as Figure 4.

8 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 Stations DWMP-01 through DWMP-16 and 0 to 10 cm for Stations DW-01, DW-03, DW-13, DW-19, DW-33, DW-34, and LTBC20);
- sediment type (a mnemonic code indicating color, gross grain size, odor, and debris);
- tide condition and height; and
- collect date, collect time, and sampling personnel.

9 SEDIMENT CHEMISTRY ANALYTICAL METHODS

Analytical methods for sediment chemistry samples are presented in the following subsections. Sediment chemistry analytical parameters were selected based on guidance for conducting sediment characterizations (ACOE 2000; Ecology 2003) and will allow comparison of analytical results with published sediment quality guidelines/criteria (ACOE 2000; Ecology 1995). All analyses will be performed at the King County Environmental Laboratory and will follow guidelines recommended in the most recent editions of the Puget Sound Protocols (PSEP 1986, 1997b, 1997c at this time).

The terms MDL and RDL, used in the following sediment chemistry analysis subsections, 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*.

9.1 Conventional – Analytical Methods and Detection Limits

Conventional sediment parameters will include ammonia, particle size distribution (PSD), total organic carbon (TOC), total and volatile solids, and total sulfide. The analytical methods and detection limits for conventional parameters are summarized in Table 9-1.

Table 9-1
Conventional Methods and Detection Limits

Parameter	Method	MDL	RDL	Units ¹
Ammonia	SM 4500-NH3-G	0.2	0.4	mg/Kg dry wt.
PSD (gravel and sand)	ASTM D422	0.1	1.0	percent dry wt.
PSD (silt and clay)	ASTM D422	0.5	1.0	percent dry wt.
Total Organic Carbon	EPA 9060, PSEP 1996	1,000	2,000	mg/Kg dry wt. ²
Total Solids	SM 2540-G	0.005	0.01	percent wet wt.
Total Sulfide	EPA 9030B/SM 4500-S2-D	1.0	4.0	mg/Kg dry wt.
Volatile Solids	SM 2540-G	0.005	0.01	percent wet wt. ³

¹Dry-weight MDLs for ammonia, TOC, and sulfide are based on an assumed 50% solids content.

²Stored on King County's LIMS data base in units of mg/Kg but will be reported to SEDQUAL in units of %.

³Stored on King County's LIMS data base in units of percent but will be reported to SEQUAL in units of mg/Kg.

Total solids will be analyzed on all samples to allow normalization of all other sediment chemistry data except PSD to dry weight. Volatile solids will be analyzed to provide an estimate of the organic content of the sediment. Total and volatile solids analyses will be performed according to the latest edition of Standard Method (SM)2540-G (APHA 1998), which is a gravimetric determination. Results for solids analyses are presented in units of percent on a wet weight basis.

TOC analysis will be performed on all samples to allow normalization of some organic parameters to organic carbon. TOC analysis will be performed according to EPA Method 9060/SW-846 (EPA 1995), high-temperature combustion with infrared spectroscopy. Results for TOC analysis are presented in units of mg/Kg on a dry weight basis.

PSD analysis will be performed according to ASTM Method D422 (ASTM 2002), which is a combination of sieve and hydrometer analyses. Results for PSD analysis are presented in units of percent on a dry weight basis, both for phi sizes and for the four broad classifications of clay,

silt, sand, and gravel. Results for the clay and silt fractions are also summed to provide a result for “percent fines.”

Ammonia and total sulfide, which are indicators of potential sediment toxicity, will be analyzed by SM 4500-NH3-G and SM 4500-S2-D (EPA 9030B), respectively. Ammonia analysis will involve a potassium chloride extraction followed by spectrometric analysis of the extract. Total sulfide will be analyzed by distillation following acidification and colorimetric analysis of the distillate.

9.2 Trace Metals – Analytical Methods and Detection Limits

The analytical methods and detection limits for the target trace metals are summarized in Table 9-2. These MDLs and RDLs are presented on a wet-weight basis and are based on an initial sample weight of 1±0.05 grams (g) and a final volume of 50 ml for ICP metals and 100 ml for mercury. 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.

**Table 9-2
Trace Metals Target Analytes, Methods,
and Detection Limits (mg/Kg wet weight)**

Analyte	Method	MDL	RDL
Antimony	EPA 3050B/6010B	1.5	7.5
Arsenic	EPA 3050B/6010B	1.25	6.25
Cadmium	EPA 3050B/6010B	0.10	0.50
Chromium	EPA 3050B/6010B	0.125	.625
Copper	EPA 3050B/6010B	0.20	1.0
Lead	EPA 3050B/6010B	.75	3.75
Mercury	EPA 7471A	0.005	0.05
Nickel	EPA 3050B/6010B	.25	1.25
Silver	EPA 3050B/6010B	0.20	1.0
Zinc	EPA 3050B/6010B	0.25	1.25

Trace metal MDLs, normalized to dry weight over a range of percent solids concentrations, are shown in Appendix A. This information is provided to demonstrate whether dry-weight normalized trace metal MDLs will meet Ecology’s recommended Practical Quantitation Limits (PQLs) from the Sampling and Analysis Plan Appendix (SAPA) (Ecology 2003). The information in Appendix A shows that all dry-weight normalized MDLs for trace metals meet the SAPA-recommended PQLs at the range of percent solids from 25 to 75%.

9.3 Trace Organics – Analytical Methods and Detection Limits

Trace organic parameters will include base/neutral/acid extractable semivolatile compounds (BNAs), chlorinated pesticides, PCBs, and volatile organic compounds (VOCs). The analytical methods and detection limits for the target trace organic compounds are summarized in Tables 9-3 through 9-6 on a wet-weight basis.

Results for certain non-ionizing organic compounds are generally normalized to organic carbon for comparison to SMS chemical criteria. The King County Environmental Laboratory has attempted to optimize its procedures to produce the lowest cost-effective MDLs that are routinely achievable in a standard sediment sample. These MDLs should meet the required SMS chemical criteria for each parameter in most cases. The ability of the laboratory to attain

detection limits which meet organic-carbon normalized chemical criteria, however, will depend upon the TOC content of each sample.

Organic-carbon normalized detection limits are shown in Table 9-7. These values are based on the wet weight detection limits shown in Tables 9-3 and 9-5 and converted using a conservatively-low percent solids concentration of 35% and the minimum TOC content that would be applicable for organic-carbon normalization (0.5% by dry weight).

9.3.1 BNA Target Analytes and Detection Limits

The detection limits for the target BNA compounds are summarized in Table 9-3. These MDLs and RDLs are presented on a wet-weight basis and are based on a 40 g extraction with gel permeation cleanup and concentration to a final volume of 0.5 ml for analysis. Note that the detection limits can vary if limited sample is available for extraction (less than 30 g) or if dilution is required due to elevated analyte concentration(s). BNA analysis will be performed according to EPA methods 3550B/8270C (SW 846), which employ solvent extraction with sonication and analysis by gas chromatography/mass spectroscopy (GC/MS).

Table 9-3
BNA Target Analytes and Detection Limits (µg/Kg wet weight)

Analyte	MDL	RDL	Analyte	MDL	RDL
1,2,4-Trichlorobenzene	0.27	0.53	Chrysene	2.7	5.3
1,2-Dichlorobenzene	0.27	0.53	Coprostanol	53	106
1,3-Dichlorobenzene	0.27	0.53	Dibenzo(a,h)anthracene	2.7	5.3
1,4-Dichlorobenzene	0.27	0.53	Dibenzofuran	2.7	5.3
2,4-Dimethylphenol	2.7	5.3	Diethyl Phthalate	5.3	10.6
2-Methylnaphthalene	2.7	5.3	Dimethyl Phthalate	5.3	10.6
2-Methylphenol	5.3	10.6	Di-N-Butyl Phthalate	5.3	10.6
4-Methylphenol	5.3	10.6	Di-N-Octyl Phthalate	5.3	10.6
Acenaphthene	2.7	5.3	Fluoranthene	2.7	5.3
Acenaphthylene	2.7	5.3	Fluorene	2.7	5.3
Anthracene	2.7	5.3	Hexachlorobenzene	0.53	1.1
Benzo(a)anthracene	2.7	5.3	Hexachlorobutadiene	1.3	2.6
Benzo(a)pyrene	2.7	5.3	Hexachloroethane	2.7	5.3
Benzo(b)fluoranthene	2.7	5.3	Indeno(1,2,3-cd)pyrene	2.7	5.3
Benzo(g,h,i)perylene	2.7	5.3	Naphthalene	2.7	5.3
Benzo(k)fluoranthene	2.7	5.3	N-Nitrosodiphenylamine	5.3	10.6
Benzoic Acid	13	26	Pentachlorophenol	13.3	26.7
Benzyl Alcohol	5.3	10.6	Phenanthrene	2.7	5.3
Benzyl Butyl Phthalate	5.3	10.6	Phenol	5.3	10.6
Bis(2-Ethylhexyl) Phthalate	5.3	10.6	Pyrene	5.3	10.6
Caffeine	4.0	8.0	Total 4-Nonylphenol	5.0	10.0
Carbazole	2.0	4.0			

MDLs for BNA compounds, normalized to dry weight over a range of percent solids concentrations, are shown in Appendix A. This information is provided to demonstrate whether dry-weight normalized MDLs for BNAs will meet Ecology's recommended PQLs. The information in Appendix A shows that all dry-weight normalized MDLs for BNA compounds meet the SAPA-recommended PQLs at the range of percent solids from 25 to 75%.

9.3.2 Chlorinated Pesticide and PCB Target Analytes and Detection Limits

The detection limits for the target chlorinated pesticides and PCB Aroclors[®] are summarized in Tables 9-4 and 9-5. These MDLs and RDLs are presented on a wet-weight basis and are based on a 20 g extraction with gel permeation cleanup and concentration to a final volume of 0.5 ml for PCB analysis and 2.5 ml for pesticides. Note that the detection limits can vary if limited sample is available for extraction (less than 30 g) or if dilution is required due to elevated analyte concentration(s). Chlorinated pesticide/PCB analysis will be performed according to EPA methods 3550B/8081A/8082 (SW 846), which employ solvent extraction with sonication and analysis by gas chromatography with electron capture detector (GC/ECD) and dual column confirmation.

Table 9-4
Chlorinated Pesticide Target Analytes and Detection Limits (µg/Kg wet weight)

Analyte	MDL	RDL	Analyte	MDL	RDL
4,4'-DDD	1.0	2.0	Endosulfan II	1.0	2.0
4,4'-DDE	1.0	2.0	Endosulfan Sulfate	1.0	2.0
4,4'-DDT	1.0	2.0	Endrin	1.0	2.0
Aldrin	1.0	2.0	Endrin Aldehyde	2.0	4.0
Alpha-BHC	0.5	1.0	Gamma-BHC (Lindane)	0.5	1.0
Alpha-Chlordane	0.5	1.0	Gamma-Chlordane	0.5	1.0
Beta-BHC	0.5	1.0	Heptachlor	0.5	1.0
Delta-BHC	0.5	1.0	Heptachlor Epoxide	0.5	1.0
Dieldrin	1.0	2.0	Methoxychlor	5.0	10
Endosulfan I	1.0	2.0	Toxaphene	10	20

Table 9-5
PCB Target Analytes and Detection Limits (µg/Kg wet weight)

Analyte	MDL	RDL	Analyte	MDL	RDL
Aroclor 1016	1.3	2.6	Aroclor 1248	1.3	2.6
Aroclor 1221	3.3	6.6	Aroclor 1254	1.3	2.6
Aroclor 1232	3.3	6.6	Aroclor 1260	1.3	2.6
Aroclor 1242	1.3	2.6			

MDLs for chlorinated pesticides and PCBs, normalized to dry weight over a range of percent solids concentrations, are shown in Appendix A. This information is provided to demonstrate whether dry-weight normalized MDLs for chlorinated pesticides and PCBs will meet Ecology's recommended PQLs. The information in Appendix A shows that dry-weight normalized MDLs for chlorinated pesticides and PCB Aroclors meet the SAPA-recommended PQLs at the range of percent solids from 25 to 75% with two exceptions. The dry-weight normalized MDLs for Aroclors 1221 and 1232 at 25% and 50% solids exceed the SAPA-recommended PQL of 6 µg/Kg DW. This should not prove problematic, however, since the highest dry-weight normalized MDL of 13 µg/Kg DW is still a factor of 10 lower than the LAET of 130 µg/Kg DW.

9.3.3 VOC Target Analytes and Detection Limits

The detection limits for VOC target analytes are summarized in Table 9-6. These MDLs and RDLs are presented on a wet-weight basis and are based on a 5 g purge onto the VOA trap and desorbed onto the GC/MS. Note that the detection limits can vary if limited sample is available for purging (less than 5 g) or if dilution is required due to elevated analyte concentration(s).

VOC analysis will be performed according to EPA method 8260, which employs a methanol extraction diluted in reagent water and introduced via purge and trap to analysis by GC/MS.

Table 9-6
VOC Target Analytes and
Detection Limits (µg/Kg wet weight)

Analyte	MDL	RDL
Ethylbenzene	1.0	2.0
Tetrachloroethene (PCE)	1.0	2.0
Trichloroethene (TCE)	1.0	2.0
Total Xylenes	1.0	2.0

MDLs for VOCs, normalized to dry weight over a range of percent solids concentrations, are shown in Appendix A. This information is provided to demonstrate whether dry-weight normalized MDLs for VOCs will meet Ecology’s recommended PQLs. The information in Appendix A shows that dry-weight normalized MDLs for VOCs meet the SAPA-recommended PQLs at the range of percent solids from 25 to 75% with four exceptions. The dry-weight normalized MDLs for ethylbenzene, PCE, TCE, and total xylenes at 25% solids exceed the SAPA-recommended PQL of 3.2 µg/Kg DW. This should not prove problematic, however, since the lowest percent solids detected in samples collected previously at Denny Way has been 35%, which provides a dry-weight normalized MDL of 2.9 µg/Kg.

9.3.4 Organic-Carbon Normalized Detection Limits

Table 9-7 shows the organic-carbon normalized detection limits for the non-ionizable organic compounds regulated under the SMS, based on a percent solids concentration of 35% and a TOC content of 0.5%.

Table 9-7
Non-Ionizable Organic Compound Detection Limits (mg/Kg OC)

Analyte	MDL	RDL	Analyte	MDL	RDL
2-Methylnaphthalene	1.5	3.0	Pyrene	3.0	6.1
Acenaphthene	1.5	3.0	1,2,4-Trichlorobenzene	0.15	0.30
Acenaphthylene	1.5	3.0	1,2-Dichlorobenzene	0.15	0.30
Anthracene	1.5	3.0	1,4-Dichlorobenzene	0.15	0.30
Benzo(a)anthracene	1.5	3.0	Hexachlorobenzene	0.30	0.63
Benzo(a)pyrene	1.5	3.0	Benzyl Butyl Phthalate	3.0	6.1
Benzo(b)fluoranthene	1.5	3.0	Diethyl Phthalate	3.0	6.1
Benzo(g,h,i)perylene	1.5	3.0	Dimethyl Phthalate	3.0	6.1
Benzo(k)fluoranthene	1.5	3.0	Di-N-Butyl Phthalate	3.0	6.1
Chrysene	1.5	3.0	Bis(2-Ethylhexyl) Phthalate	3.0	6.1
Dibenzo(a,h)anthracene	1.5	3.0	Di-N-Octyl Phthalate	3.0	6.1
Fluoranthene	1.5	3.0	Dibenzofuran	1.5	3.0
Fluorene	1.5	3.0	Hexachlorobutadiene	0.74	1.5
Indeno(1,2,3-cd)pyrene	1.5	3.0	N-Nitrosodiphenylamine	3.0	6.1
Naphthalene	1.5	3.0	PCBs (1016, 1242, 1248, 1254, 1260)	0.74	1.5
Phenanthrene	1.5	3.0	PCBs (1221, 1232)	1.9	3.8

All of the organic carbon normalized MDLs shown in Table 9-7 are below their respective SQS chemical criteria from Table I of Chapter 173-204 WAC (Ecology 1995).

10 BENTHIC TAXONOMY ANALYTICAL METHODS

Contract laboratory 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 10X 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: Annelida, Crustacea, Mollusca, and 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.

11 LABORATORY QUALITY ASSURANCE/QUALITY CONTROL

This section presents laboratory quality assurance/quality control (QA/QC) measures that will be employed to ensure data are of sufficient quality to meet the project DQOs.

11.1 Sediment Chemistry QA/QC

The quality control (QC) samples that will be analyzed in association with sediment chemistry samples are summarized in Table 11-1. The frequency of method blanks, duplicates, triplicates, and matrix spikes is one per QC batch (20 samples maximum). The frequency of SRM (standard reference material) or LCS (laboratory control sample) analysis is one per project (40 samples maximum). LCS analysis is used in lieu of SRM analysis for selected analytes when an SRM may not be readily available. Surrogates are analyzed with every organic sample.

Table 11-1
Marine Sediment Chemistry Quality Control Samples

Analyte	Method Blank	Duplicate	Triplicate	Matrix Spike (MS)	MS Duplicate	SRM/LCS	Surrogates
Ammonia	Yes	No	Yes	Yes	No	No	No
PSD	No	No	Yes	No	No	No	No
TOC	Yes	No	Yes	Yes	No	Yes	No
Total Solids	Yes	No	Yes	No	No	No	No
Total Sulfide	Yes	No	Yes	Yes	No	No	No
Volatile Solids	Yes	No	Yes	No	No	No	No
Mercury	Yes	Yes	No	Yes	Yes	Yes	No
Other Metals	Yes	Yes	No	Yes	No	Yes	No
BNAs	Yes	Yes	No	Yes	Yes	Yes	Yes
Chl. Pesticides	Yes	Yes	No	Yes	Yes	Yes	Yes
PCBs	Yes	Yes	No	Yes	Yes	Yes	Yes
Vol. Organics	Yes	Yes	No	Yes	Yes	No	Yes

Quality assurance (QA1) marine sediment chemistry acceptance criteria (Ecology 1989) are shown in Table 11-2.

Table 11-2
QA1 Acceptance Criteria for Marine Sediment Chemistry Samples

Analyte	Method Blank	Duplicate	Triplicate	Matrix Spike	SRM/LCS	Surrogates
Ammonia	< MDL	N/A	RSD ≤ 20%	75 - 125%	N/A	N/A
PSD	N/A	N/A	RSD ≤ 20%	N/A	N/A	N/A
TOC	< MDL	N/A	RSD ≤ 20%	75 - 125%	80 - 120%	N/A
Total Solids	< MDL	N/A	RSD ≤ 20%	N/A	N/A	N/A
Total Sulfide	< MDL	N/A	RSD ≤ 20%	65 - 135%	N/A	N/A
Volatile Solids	< MDL	N/A	RSD ≤ 20%	N/A	N/A	N/A
Metals	< MDL	RPD ≤ 20%	N/A	75 - 125%	Appendix B	N/A
BNAs	< MDL	RPD ≤ 35%	N/A	Appendix B	Appendix B	Appendix B
Chl. Pesticides	< MDL	RPD ≤ 35%	N/A	Appendix B	Appendix B	Appendix B
PCBs	< MDL	RPD ≤ 35%	N/A	Appendix B	Appendix B	Appendix B
Vol. Organics	<MDL	RPD ≤ 35%	N/A	Appendix B	N/A	Appendix B

< MDL - Method Blank result should be less than the *method detection limit*.

RPD – Relative Percent Difference, RSD – Relative Standard Deviation

QC results for matrix spike, SRM/LCS, and surrogates are in *percent recovery of analyte*.

Some trace metal and organic analyses have empirically-derived laboratory limits for various QC samples. Specific laboratory-derived acceptance limits for trace metal and organic analyses are included as Appendix B. QC 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 do not meet QA1 acceptance criteria will be qualified and flagged according to QA1 data validation guidance (Ecology 1989). Data qualifier flags and their interpretations are presented in Table 11-3.

**Table 11-3
Data Qualifier Flags and QA1 Acceptance Criteria**

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	Appendix B	< 75%	<65 - 75%
High matrix spike recovery	L	Appendix B	>125%	>125 - 135%
Low SRM/LCS recovery	G	Appendix B	Appendix B	<80%
High SRM/LCS recovery	L	Appendix B	Appendix B	>120%
High duplicate RPD	E	>35 %	>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	Appendix B	N/A	N/A
Biased data, high surrogate recoveries	L	Appendix B	N/A	N/A
Rejected, unusable for all purposes	R			
A sample handling criterion has been exceeded	H			

The individual surrogate recovery is used for all organic analyses with the following exception – for BNA analysis, one surrogate recovery per fraction is allowed to be outside acceptance limits without causing the associated sample data to be flagged. Sample handling criteria include an exceedance of hold time and incorrect preservation, container, or storage conditions.

11.2 Benthic Taxonomy QA/QC

The contractor for benthic taxonomic analysis will follow recommended PSEP guidelines for QA/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 contract laboratory.

12 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

12.1 Sediment Chemistry Data

All sediment chemistry data will be reported in QA1 format (Ecology 1989). The final QA1 report will contain the following information and deliverables:

- a QA1 narrative discussing data quality in relation to study objectives and data criteria;
- all associated QC data (LIMS QC reports and worklists);
- copies of field sheets and COC forms; and
- a comprehensive report containing all analytical and field data (including data qualifier flags).

12.2 Benthic Taxonomy Data

The mean abundance and richness of each major taxon at the benthic taxonomy stations (at three replicates per station) will be reported. Various diversity indices will also be calculated for each station. Data will be compared to regional Puget Sound benthic data. A narrative explaining the results, including any anomalies and statistical evaluations, will be included.

12.3 Final Report and SEDQUAL Files

A final monitoring report will be prepared that will include a presentation and interpretation of the sediment chemistry and benthic taxonomy results. The report will compare sediment chemistry results to published sediment quality chemical criteria (ACOE 2000; Ecology 1995) as well as regional Puget Sound values in order to provide an evaluation of year one, post-construction sediment quality around the new CSO outfalls. Benthic taxonomy data will be compared to regional Puget Sound benthic data. The report narrative will include summary tables of sediment chemistry and benthic taxonomy results. Complete data packages and the QA1 review will be included as report appendices. The chemistry data will be also reported in SEDQUAL format (latest version) for delivery to Ecology.

12.4 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 chemistry data, benthic taxonomy data, 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. Appendix C includes LIMS “product names” and “list types” under which analytical data will be stored.

13 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 the research 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 when coming into contact with sediment.
- No eating or drinking 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 crew member’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 13.1 through 13.3.

13.1 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 *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-toed rubber boots;
- chemical-resistant gloves (i.e. Nitrile); and
- safety glasses (safety glasses will be available for use if sediment characteristics indicate the possible presence of hazardous chemicals; i.e., sheen or petroleum/solvent odor).

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

13.2 Grab Sampling

Sampler deployment and 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.

13.3 Chemical Hazards

Contact with marine sediment at some sampling stations near the Elliott West CSO Storage and Treatment Facility and Denny Way CSO outfalls may present a health hazard from chemical constituents of the sediment, such as PAHs, PCBs, and mercury. Potential routes of exposure to chemical hazards include **inhalation, skin and eye absorption, ingestion, and injection**. 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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FIGURES

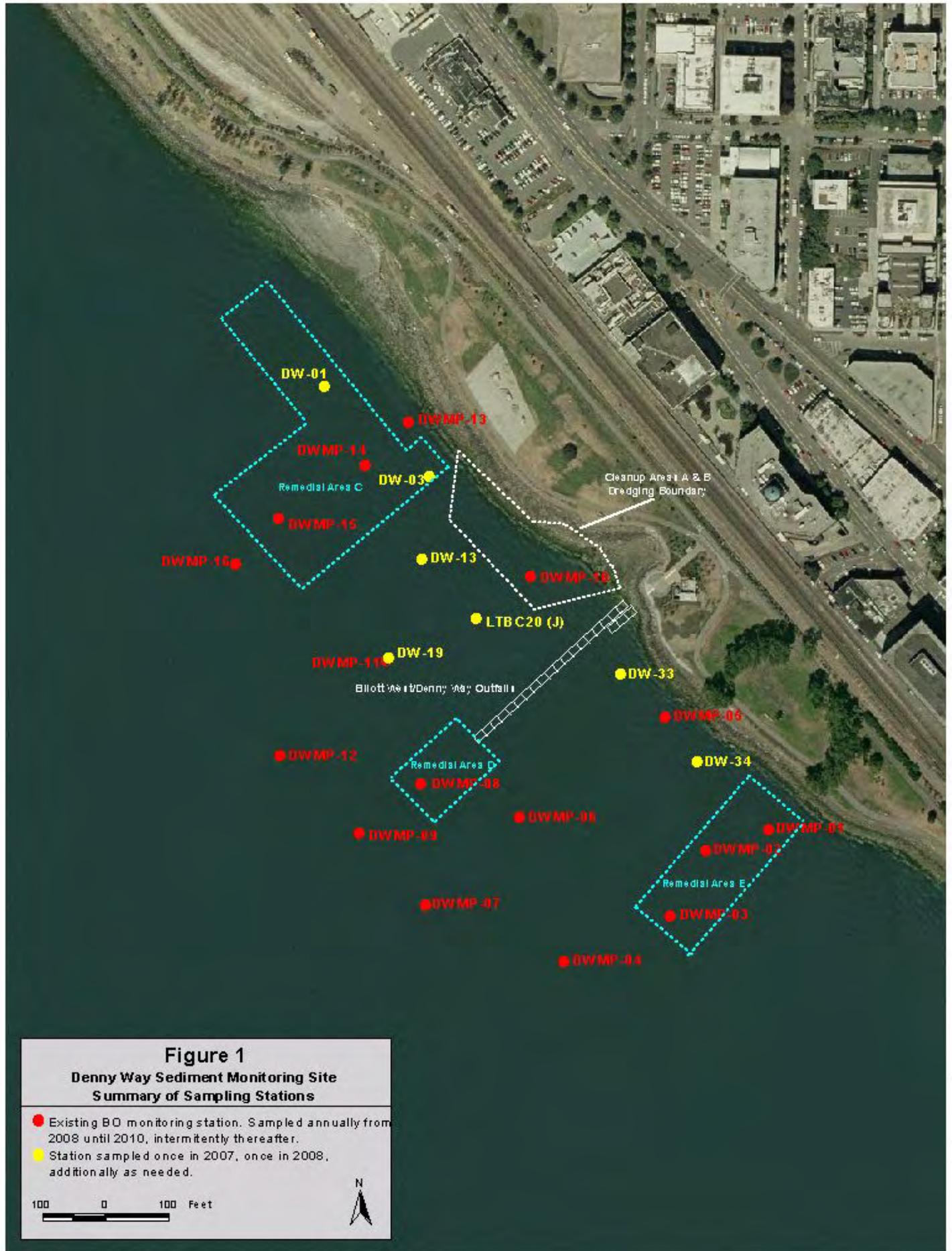




Figure 2

2008 Elliott West TF/Denny Way CSO
Sediment Monitoring Event Sampling Stations

-  Elliott West/Denny Way Outfalls
-  Chemistry and Benthic Taxonomy Station
-  Chemistry Station

100 0 100 200 Feet



FIGURE 3

KING COUNTY ENVIRONMENTAL LABORATORY CHAIN OF CUSTODY FORM

LABORATORY WORK ORDER

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

Chain of Custody

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

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

FIGURE 4

KING COUNTY ENVIRONMENTAL LABORATORY STANDARD 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	0625
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.

APPENDIX A
TRACE METAL AND TRACE ORGANIC DRY-WEIGHT NORMALIZED
METHOD DETECTION LIMITS (MDLS) COMPARED TO
RECOMMENDED PRACTICAL QUANTITATION LIMITS (PQLs)
TABLES A-1 THROUGH A-5

Table A-1
Dry-Weight Normalized MDLs for Trace Metals
Compared to SAPA PQLs (all values in mg/Kg)

Trace Metal	WW MDL	DW MDL 25%	DW MDL 50%	DW MDL 75%	DW SAPA PQL
Antimony	1.5	6.0	3.0	2.0	50
Arsenic	1.25	5	2.5	1.7	19
Cadmium	0.10	0.40	0.20	0.13	1.7
Chromium	0.125	0.50	0.25	.17	87
Copper	0.20	0.80	0.40	0.27	130
Lead	0.75	3.0	1.5	1.0	150
Mercury	0.005	0.020	0.010	0.0067	0.14
Nickel	0.25	1.0	0.50	0.33	47
Silver	0.20	0.80	0.40	0.27	2
Zinc	0.25	1.0	0.50	0.33	137

WW MDL – Nominal wet weight method detection limit from Table 9-2.

DW MDL – Dry-weight normalized method detection limit based on percent solids content of 25, 50, and 75%.

DW SAPA PQL – Recommended practical quantitation limit from Sampling and Analysis Plan Appendix (Ecology 2003).

All dry-weight normalized MDLs for trace metals meet the SAPA-recommended PQLs at the range of percent solids from 25 to 75%.

Table A-2
Dry-Weight Normalized MDLs for BNAs
Compared to SAPA PQLs (all values in µg/Kg)

BNA	WW MDL	DW MDL 25%	DW MDL 50%	DW MDL 75%	DW SAPA PQL
1,2,4-Trichlorobenzene	0.27	1.1	0.54	0.36	31
1,2-Dichlorobenzene	0.27	1.1	0.54	0.36	35
1,3-Dichlorobenzene	0.27	1.1	0.54	0.36	37
1,4-Dichlorobenzene	0.27	1.1	0.54	0.36	37
2,4-Dimethylphenol	2.7	11	5.4	3.6	29
2-Methylnaphthalene	2.7	11	5.4	3.6	223
2-Methylphenol	5.3	21	11	7.1	63
4-Methylphenol	5.3	21	11	7.1	223
Acenaphthene	2.7	11	5.4	3.6	167
Acenaphthylene	2.7	11	5.4	3.6	433
Anthracene	2.7	11	5.4	3.6	320
Benzo(a)anthracene	2.7	11	5.4	3.6	433
Benzo(a)pyrene	2.7	11	5.4	3.6	533
Benzo(b)fluoranthene	2.7	11	5.4	3.6	1,067
Benzo(g,h,i)perylene	2.7	11	5.4	3.6	223
Benzo(k)fluoranthene	2.7	11	5.4	3.6	1,067
Benzoic Acid	13	52	26	17	217
Benzyl Alcohol	5.3	21	11	7.1	57
Benzyl Butyl Phthalate	5.3	21	11	7.1	21
Bis(2-Ethylhexyl) Phthalate	5.3	21	11	7.1	433
Caffeine	4.0	16	8	5.2	--
Carbazole	2.0	8.0	4.0	2.6	--
Chrysene	2.7	11	5.4	3.6	467
Coprostanol	53	210	110	71	--
Dibenzo(a,h)anthracene	2.7	11	5.4	3.6	77
Dibenzofuran	2.7	11	5.4	3.6	180
Diethyl Phthalate	5.3	21	11	7.1	67
Dimethyl Phthalate	5.3	21	11	7.1	24
Di-N-Butyl Phthalate	5.3	21	11	7.1	467
Di-N-Octyl Phthalate	5.3	21	11	7.1	2,067
Fluoranthene	2.7	11	5.4	3.6	567
Fluorene	2.7	11	5.4	3.6	180
Hexachlorobenzene	0.53	2.1	1.1	0.71	22
Hexachlorobutadiene	1.3	5.2	2.6	1.7	11
Hexachloroethane	2.7	11	5.4	3.6	47
Indeno(1,2,3-cd)pyrene	2.7	11	5.4	3.6	200
Naphthalene	2.7	11	5.4	3.6	700
N-Nitrosodiphenylamine	5.3	21	11	7.1	28
Pentachlorophenol	13	52	26	17	120
Phenanthrene	2.7	11	5.4	3.6	500
Phenol	5.3	21	11	7.1	140
Pyrene	5.3	21	11	7.1	867
Total 4-Nonylphenol	5.0	20	10	6.7	--

WW MDL – Nominal wet weight method detection limit from Table 9-3.

DW MDL – Dry-weight normalized method detection limit based on percent solids content of 25, 50, and 75%.

DW SAPA PQL – Recommended practical quantitation limit from Sampling and Analysis Plan Appendix (Ecology 2003a).

All dry-weight normalized MDLs for BNA compounds meet the SAPA-recommended PQLs at the range of percent solids from 25 to 75%.

Table A-3
Dry-Weight Normalized MDLs for Chlorinated Pesticides
Compared to SAPA PQLs (all values in µg/Kg)

Pesticide	WW MDL	DW MDL	DW MDL	DW MDL	DW SAPA PQL
		25%	50%	75%	
4,4'-DDD	1.0	4	2	1.3	3.3
4,4'-DDE	1.0	4	2	1.3	2.3
4,4'-DDT	1.0	4	2	1.3	6.7
Aldrin	1.0	4	2	1.3	1.7
Alpha-BHC	0.5	2	1	0.7	--
Alpha-Chlordane	0.5	2	1	0.7	1.7
Beta-BHC	0.5	2	1	0.7	--
Delta-BHC	0.5	2	1	0.7	--
Dieldrin	1.0	4	2	1.3	2.3
Endosulfan I	1.0	4	2	1.3	--
Endosulfan II	1.0	4	2	1.3	--
Endosulfan Sulfate	1.0	4	2	1.3	--
Endrin	1.0	4	2	1.3	--
Endrin Aldehyde	2.0	8	4	2.7	--
Gamma-BHC (Lindane)	0.5	2	1	0.7	1.7
Gamma-Chlordane	0.5	2	1	0.7	1.7
Heptachlor	0.5	2	1	0.7	1.7
Heptachlor Epoxide	0.5	2	1	0.7	--
Methoxychlor	5.0	20	10	6.7	--
Toxaphene	10	40	20	13	--

WW MDL – Nominal wet weight method detection limit from Table 9-4.

DW MDL – Dry-weight normalized method detection limit based on percent solids content of 25, 50, and 75%.

DW SAPA PQL – Recommended practical quantitation limit from Sampling and Analysis Plan Appendix (Ecology 2003).

All dry-weight normalized MDLs for chlorinated pesticides meet the SAPA-recommended PQLs at the range of percent solids from 50 to 75%. Except for DDT, all dry-weight normalized MDLs are above the SAPA-recommended PQL at 25% total solids.

Table A-4
Dry-Weight Normalized MDLs for PCBs
Compared to SAPA PQLs (all values in µg/Kg)

PCB	WW MDL	DW MDL	DW MDL	DW MDL	DW SAPA PQL
		25%	50%	75%	
Aroclor 1016	1.3	5.2	2.6	1.7	6
Aroclor 1221	3.3	13	6.6	4.4	6
Aroclor 1232	3.3	13	6.6	4.4	6
Aroclor 1242	1.3	5.2	2.6	1.6	6
Aroclor 1248	1.3	5.2	2.6	1.7	6
Aroclor 1254	1.3	5.2	2.6	1.7	6
Aroclor 1260	1.3	5.2	2.6	1.7	6

WW MDL – Nominal wet weight method detection limit from Table 9-5.

DW MDL – Dry-weight normalized method detection limit based on percent solids content of 25, 50, and 75%.

DW SAPA PQL – Recommended practical quantitation limit from Sampling and Analysis Plan Appendix (Ecology 2003).

Dry-weight normalized MDLs for PCB Aroclors meet the SAPA-recommended PQLs at the range of percent solids from 25 to 75% with two exceptions. The dry-weight normalized MDLs for Aroclors 1221 and 1232 at 25% and 50% solids exceed the SAPA-recommended PQL of 6 µg/Kg DW.

Table A-5
Dry-Weight Normalized MDLs for VOCs
Compared to SAPA PQLs (all values in µg/Kg)

VOC	WW MDL	DW MDL 25%	DW MDL 50%	DW MDL 75%	DW SAPA PQL
Ethylbenzene	1.0	4.0	2.0	1.3	3.2
Tetrachloroethene (PCE)	1.0	4.0	2.0	1.3	3.2
Trichloroethene (TCE)	1.0	4.0	2.0	1.3	3.2
Total Xylenes	1.0	4.0	2.0	1.3	3.2

WW MDL – Nominal wet weight method detection limit from Table 9-6.

DW MDL – Dry-weight normalized method detection limit based on percent solids content of 25, 50, and 75%.

DW SAPA PQL – Recommended practical quantitation limit from Sampling and Analysis Plan Appendix (Ecology 2003).

Dry-weight normalized MDLs for VOCs meet the SAPA-recommended PQLs at the range of percent solids from 25 to 75% with four exceptions. The dry-weight normalized MDLs for ethylbenzene, PCE, TCE, and total xylenes at 25% solids exceed the SAPA-recommended PQL of 3.2 µg/Kg DW.

APPENDIX B
TRACE METAL AND TRACE ORGANIC QC LIMITS
TABLES B1 – B10

Table B-1a
Laboratory QC Limits for Sediment Metals – SRM Recoveries (PACS-2)

Parameter	Lower Limit (%)	Upper Limit (%)
Chromium	30	70
Copper	78	118
Lead	74	114
Mercury	80	120
Nickel	51	91
Zinc	73	113

Table B-1b
Laboratory QC Limits for Sediment Metals – LCS Recoveries (ERA Soil)

Parameter	Lower Limit (%)	Upper Limit (%)
Antimony	10	211
Arsenic	80	120
Cadmium	80	120
Chromium	79	121
Copper	80	120
Lead	80	120
Nickel	80	120
Silver	66	134
Zinc	79	121

No QA1 flagging occurs as a result of LCS recoveries being outside of control limits.

Table B-2
Laboratory QC Limits for Sediment BNAs, Matrix Spike Recoveries

Parameter	Lower Limit (%)	Upper Limit (%)	Parameter	Lower Limit (%)	Upper Limit (%)
1,2,4-Trichlorobenzene	10	115	Chrysene	14	184
1,2-Dichlorobenzene	10	105	Coprostanol	10	183
1,3-Dichlorobenzene	10	103	Di-N-Butyl Phthalate	10	194
1,4-Dichlorobenzene	10	104	Di-N-Octyl Phthalate	52	151
2,4-Dimethylphenol	10	150	Dibenzo(a,h)anthracene	10	166
2-Methylnaphthalene	22	112	Dibenzofuran	21	134
2-Methylphenol	10	142	Diethyl Phthalate	31	150
4-Methylphenol	10	163	Dimethyl Phthalate	13	162
Acenaphthene	25	130	Fluoranthene	12	188
Acenaphthylene	27	132	Fluorene	22	147
Anthracene	10	181	Hexachlorobenzene	18	151
Benzo(a)anthracene	32	168	Hexachlorobutadiene	10	97
Benzo(a)pyrene	10	200	Hexachloroethane	10	89
Benzo(b)fluoranthene	10	199	Indeno(1,2,3-Cd)Pyrene	10	177
Benzo(g,h,i)perylene	10	173	N-Nitrosodiphenylamine	10	169
Benzo(k)fluoranthene	10	192	Naphthalene	12	97
Benzoic Acid	10	158	Pentachlorophenol	17	170
Benzyl Alcohol	10	138	Phenanthrene	10	200
Benzyl Butyl Phthalate	41	145	Phenol	10	127
Bis(2-Ethylhexyl)Phthalate	10	189	Pyrene	20	174

Table B-3
Laboratory QC Limits for Sediment BNAs, Blank Spike Recoveries

Parameter	Lower Limit (%)	Upper Limit (%)	Parameter	Lower Limit (%)	Upper Limit (%)
1,2,4-Trichlorobenzene	13	110	Chrysene	69	111
1,2-Dichlorobenzene	10	116	Coprostanol	10	159
1,3-Dichlorobenzene	18	95	Di-N-Butyl Phthalate	17	180
1,4-Dichlorobenzene	21	99	Di-N-Octyl Phthalate	10	200
2,4-Dimethylphenol	10	81	Dibenzo(a,h)anthracene	53	129
2-Methylnaphthalene	22	99	Dibenzofuran	37	97
2-Methylphenol	16	91	Diethyl Phthalate	51	118
4-Methylphenol	10	125	Dimethyl Phthalate	38	114
Acenaphthene	29	102	Fluoranthene	55	132
Acenaphthylene	31	101	Fluorene	39	106
Anthracene	45	114	Hexachlorobenzene	40	111
Benzo(a)anthracene	69	117	Hexachlorobutadiene	10	97
Benzo(a)pyrene	15	137	Hexachloroethane	17	92
Benzo(b)fluoranthene	50	121	Indeno(1,2,3-Cd)Pyrene	51	132
Benzo(g,h,i)perylene	46	126	N-Nitrosodiphenylamine	11	148
Benzo(k)fluoranthene	58	128	Naphthalene	17	94
Benzoic Acid	10	170	Pentachlorophenol	38	124
Benzyl Alcohol	10	119	Phenanthrene	57	104
Benzyl Butyl Phthalate	15	183	Phenol	10	107
Bis(2-Ethylhexyl)Phthalate	10	182	Pyrene	48	132

Table B-4
Laboratory QC Limits for Sediment BNAs, Surrogate Recoveries

Parameter	Lower Limit (%)	Upper Limit (%)
2,4,6-Tribromophenol	29	112
2-Fluorophenol	10	112
d5-Phenol	10	106
d5-Nitrobenzene	28	94
d4-2-Chlorophenol	11	105
d4-1,2-Dichlorobenzene	24	91
2-Fluorobiphenyl	31	101
d14-Terphenyl	51	130

Table B-5
Laboratory QC Limits for Sediment BNAs, SRM Recoveries

Parameter	Lower Limit (%)	Upper Limit (%)
Anthracene	28	98
Benzo(a)anthracene	66	124
Benzo(a)pyrene	60	116
Benzo(b)fluoranthene	52	190
Benzo(g,h,i)perylene	15	121
Benzo(k)fluoranthene	60	146
Chrysene	77	136
Dibenzo(a,h)anthracene	10	200
Fluoranthene	45	126
Indeno(1,2,3-Cd)Pyrene	33	121
Naphthalene	10	29
Phenanthrene	51	106
Pyrene	36	135

Table B-6
Laboratory QC Limits for Sediment Pesticides and PCBs
Matrix Spike Recoveries

Parameter	Lower Limit (%)	Upper Limit (%)
4,4'-DDD	41	157
4,4'-DDE	59	125
4,4'-DDT	50	144
Aldrin	61	119
Alpha-BHC	59	111
Aroclor 1016	43	176
Aroclor 1260	13	198
Beta-BHC	60	119
Delta-BHC	54	126
Dieldrin	60	139
Endosulfan I	64	113
Endosulfan II	36	146
Endosulfan Sulfate	46	113
Endrin	62	166
Endrin Aldehyde	10	66
Gamma-BHC (Lindane)	61	135
Heptachlor	52	157
Heptachlor Epoxide	61	118
Methoxychlor	53	129

Table B-7
Laboratory QC Limits for Sediment Pesticides and PCBs
Blank Spike Recoveries

Parameter	Lower Limit (%)	Upper Limit (%)
4,4'-DDD	78	121
4,4'-DDE	75	111
4,4'-DDT	57	145
Aldrin	28	113
Alpha-BHC	20	99
Aroclor 1016	35	111
Aroclor 1260	47	146
Beta-BHC	66	102
Delta-BHC	63	108
Dieldrin	58	139
Endosulfan I	62	104
Endosulfan II	72	109
Endosulfan Sulfate	61	104
Endrin	60	160
Endrin Aldehyde	0	77
Gamma-BHC (Lindane)	27	130
Heptachlor	20	137
Heptachlor Epoxide	59	107
Methoxychlor	72	131

Table B-8
Laboratory QC Limits for Sediment Pesticides and PCBs
SRM and Surrogate Recoveries

Parameter	Lower Limit (%)	Upper Limit (%)
4,4'-DDT	10	200
Alpha-Chlordane	48	144
Aroclor 1254	57	139
Decachlorobiphenyl	43	160
2,4,5,6-Tetrachloro-m-xylene	35	144

Table B-9
Laboratory QC Limits for Sediment VOCs, Matrix Spike Recoveries

Parameter	Lower Limit (%)	Upper Limit (%)
1,1,2-Trichloroethene	35	118
Ethylbenzene	70	130
Tetrachloroethene	70	130
Total Xylenes	70	130

Table B-10
Laboratory QC Limits for Sediment VOCs, Surrogate Recoveries

Parameter	Lower Limit (%)	Upper Limit (%)
4-Bromofluorobenzene	91	107
d4-1,2-Dichloroethane	76	120
d8-Toluene	88	105

APPENDIX C
LABORATORY INFORMATION MANAGEMENT SYSTEM (LIMS)
PRODUCTS AND LIST TYPES
TABLE C-1

Table C-1
King County Environmental Laboratory
Laboratory Information Management System (LIMS)
LIMS Products and List Types

Parameter	LIMS Product	LIMS List Type
Ammonia	NH3-KCL	CVNH3-KCL
PSD	PSD	CVPSD
TOC	TOC	CVTOC
Total Solids	TOTS	CVTOTS
Total Sulfide	TOTSULFIDE	CVTOTSULFIDE
Volatile Solids	TVS	CVTVS
Mercury by CVAA	HG-CVAA	MTHG-MIDS, 6-SED
Other Metals by ICP	AS-ICP, CD-ICP, CR-ICP, CU-ICP, PB-ICP, AG-ICP, ZN-ICP	MTICP-SED, 6-SED
BNAs (low-level)	BNASMS	ORBNASMS
Chlorinated Pesticides (low-level)	PESTLL	ORPESTLL
PCBs (low-level)	PCBLL	ORPCBLL
VOCs	VOA-GC/MS-LOWSED	ORVOA-LOWSED

CVAA – Cold vapor atomic absorption spectroscopy.

ICP – Inductively coupled plasma optic emission spectroscopy.