Lower Duwamish Waterway Group

Port of Seattle / City of Seattle / King County / The Boeing Company

QUALITY ASSURANCE PROJECT PLAN: SUBSURFACE SEDIMENT SAMPLING FOR CHEMICAL ANALYSES

FINAL

For submittal to

The US Environmental Protection Agency
Region 10
Seattle, WA

The Washington State Department of Ecology
Northwest Regional Office
Bellevue, WA

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TITLE AND APPROVAL PAGE
LDW SUBSURFACE SEDIMENT ANALYSES
QUALITY ASSURANCE PROJECT PLAN

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Acronyms

ACRONYM	Definition
ARI	Analytical Resources, Inc.
Axys	Axys Analytical Services, Ltd.
COC	chain of custody
CSL	cleanup screening level
CSO	combined sewer overflow
DGPS	differential global positioning system
DL	detection limit
DMMP	Dredged Material Management Program
DQI	data quality indicator
Ecology	Washington Department of Ecology
EPA	US Environmental Protection Agency
FC	field coordinator
FS	feasibility study
GPS	global positioning system
HDPE	high density polyethylene
HSP	health and safety plan
LCS	laboratory control sample
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group
MDL	method detection limit
MLLW	mean lower low water
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PM	project manager
PSEP	Puget Sound Estuary Program
QA	quality assurance
QA/QC	quality assurance / quality control
QAPP	quality assurance project plan
RI	remedial investigation
RL	reporting limit
RM	river mile
RPD	relative percent difference
SDG	sample delivery group
SIM	selected ion monitoring

ACRONYM	Definition
SMS	Washington State Sediment Management Standards
SQS	sediment quality standard
SRM	standard reference material
SVOC	semivolatile organic compound
T-117	Terminal 117
TM	task manager
TOC	total organic carbon
TBT	tributyltin
Windward	Windward Environmental LLC

1.0 Introduction

This quality assurance project plan (QAPP) describes the quality assurance (QA) objectives, methods, and procedures for sampling subsurface sediment in the Lower Duwamish Waterway (LDW), and chemically analyzing these samples. In combination with Phase 1 surface and subsurface and Phase 2 surface sediment data, data from this study will be used to determine the nature and extent of chemical contamination for the LDW Remedial Investigation (RI) and to support the feasibility study (FS), as described in the Phase 2 RI work plan (2004b). Section 3.1.10 of the Phase 2 work plan presented a preliminary study design for subsurface sediment sampling and analysis to provide all stakeholders with a common understanding of the objectives, background, and general study design. This QAPP presents the study design, including details on project organization, field data collection, laboratory analysis, and data management. This QAPP was prepared in accordance with guidance for preparing QAPPs from the US Environmental Protection Agency (EPA) (2002a), and guidance on the development of sediment sampling and analysis plans to meet the requirements of the Washington State Sediment Management Standards (SMS) (Ecology 2003).

This plan is organized into the following sections:

- Section 2 – project management
- Section 3 – data generation and acquisition
- Section 4 – assessment and oversight
- Section 5 – data validation and usability
- Section 6 – references
- Section 7 – oversize figures

A health and safety plan (HSP) designed for the protection of on-site personnel from physical, chemical, and other hazards posed during field sampling activities is included as Appendix A. Field collection forms are included as Appendix B. Method detection limits (MDLs) and reporting limits (RLs) are presented in Appendix C. Appendix D contains maps of historical subsurface sediment sampling locations in the LDW. Appendix D also contains a table listing all historical subsurface sediment locations with chemical exceedances of Washington State sediment quality standards (SQS) or cleanup screening levels (CSL) of the SMS. These comparisons are presented for informational purposes only.

2.0 Project Management

This section describes the overall management of the project, including key personnel, project description, problem definition and background, quality objectives and criteria, special training requirements and certification, and documents and record keeping.

2.1 PROJECT ORGANIZATION AND TEAM MEMBER RESPONSIBILITIES

Figure 2-1 presents the overall project organization for the study described in this QAPP. Responsibilities of project team members, as well as those of the laboratory project managers, are described in the following sections.

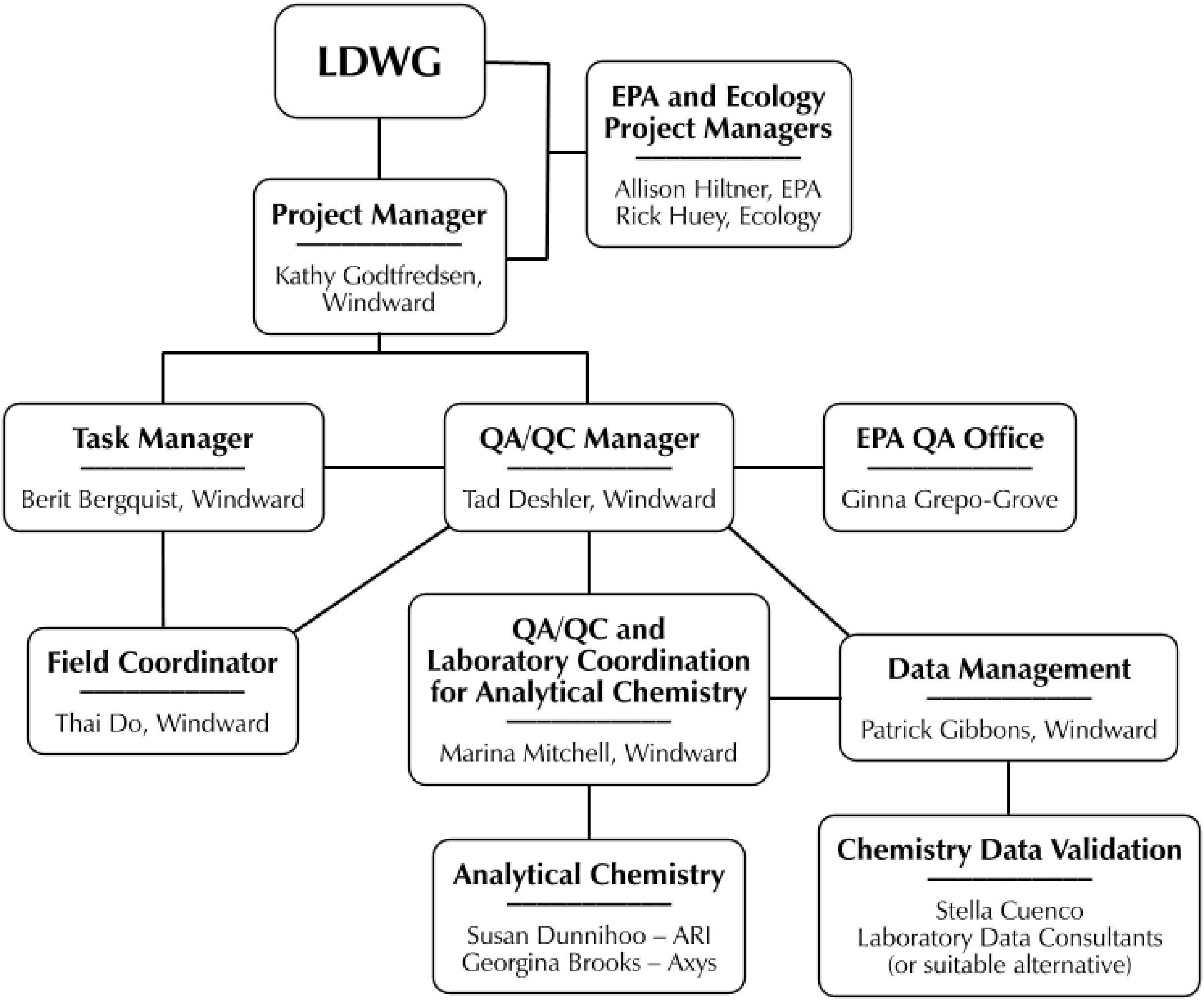

Figure 2-1. Project organization

2.1.1 Project management

The Lower Duwamish Waterway Group (LDWG), EPA, and the Washington Department of Ecology (Ecology) will be involved in all aspects of this project, including discussion, review, and approval of the QAPP, and interpretation of the results of the investigation. EPA and Ecology will be represented by their Project Managers (PMs) for this project, Allison Hiltner and Rick Huey, respectively.

Kathy Godtfredsen will serve as the Windward PM, responsible for overall project coordination and providing oversight on planning and coordination, work plans, all project deliverables, and performance of the administrative tasks needed to ensure timely and successful completion of the project. She will also be responsible for coordinating with LDWG, EPA, and Ecology on schedule, deliverables, and other administrative details. Dr. Godtfredsen can be reached as follows:

Kathy Godtfredsen
Windward Environmental LLC
200 W. Mercer St., Suite 401
Seattle, WA 98119
Telephone: 206.812.5413
Email: kathyg@windwardenv.com

Berit Bergquist will serve as the Windward Task Manager (TM). The TM is responsible for project planning and coordination, production of work plans, production of project deliverables, and performance of the administrative tasks needed to ensure timely and successful completion of the project. The TM is responsible for communicating with the Windward PM on the progress of project tasks and any deviations from the QAPP. Significant deviations from the QAPP will be further reported to LDWG, EPA, and Ecology. Ms. Bergquist can be reached as follows:

Berit Bergquist
Windward Environmental LLC
200 W. Mercer St., Suite 401
Seattle, WA 98119
Telephone: 206.812.5403
Email: beritb@windwardenv.com

2.1.2 Field coordination

Thai Do will be the Windward Field Coordinator (FC). The FC is responsible for managing field activities and general field quality assurance/quality control (QA/QC) oversight. Mr. Do will ensure that appropriate protocols for sample collection, preservation, and holding times are observed and oversee delivery of environmental samples to the designated laboratories for chemical analyses. Deviations from this QAPP will be reported to the Windward TM and PM for consultation. Significant deviations from the QAPP will be further reported to representatives of LDWG, EPA, and Ecology. Mr. Do can be reached as follows:

Thai Do
Windward Environmental LLC
200 W. Mercer St., Suite 401
Seattle, WA 98119
Telephone: 206.812.5407
Email: thaid@windwardenv.com

2.1.3 Quality assurance/quality control

Tad Deshler of Windward will serve as QA/QC manager for the project. As the QA/QC manager, he will provide oversight for both the field sampling and laboratory programs, and will supervise data validation and project QA coordination, including coordination with the EPA QA officer, Ginna Grepo-Grove.

Mr. Deshler can be reached as follows:

Tad Deshler
Windward Environmental LLC
200 W. Mercer St., Suite 401
Seattle, WA 98119
Telephone: 206.812.5406
Email: tad@windwardenv.com

Ms. Grepo-Grove can be reached as follows:

Ginna Grepo-Grove
US Environmental Protection Agency, Region 10
1200 6th Avenue
Seattle, WA 98101
Telephone: 206.553.1632
Email: grepo-grove.gina@epa.gov

Marina Mitchell of Windward will serve as the QA/QC coordinator for chemical analyses. Ms. Mitchell can be reached as follows:

Marina Mitchell
Windward Environmental LLC
200 W. Mercer St., Suite 401
Seattle, WA 98119
Telephone: 206.812.5424
Email: marinam@windwardenv.com

The QA/QC coordinators will ensure that samples are collected and documented appropriately and coordinate with the analytical testing laboratories to ensure that QAPP requirements are followed. Independent third-party review and validation of analytical chemistry data will be provided by Laboratory Data Consultants, Inc. The data validation PM at Laboratory Data Consultants can be reached as follows:

Stella Cuenco
Laboratory Data Consultants, Inc.
7750 El Camino Real, Suite 2C
Carlsbad, CA 92009-8519
Telephone: 760.634.0437
Email: scuenco@lab-data.com

2.1.4 Laboratory project management

Marina Mitchell of Windward will serve as the laboratory coordinator for the analytical chemistry laboratories. Analytical Resources, Inc. (ARI) and Axys Analytical Services, Ltd. (Axys) will perform chemical analyses of the sediment samples. Both laboratories are accredited by Ecology to conduct the sediment chemical analyses specified in this QAPP. The laboratory PM at ARI can be reached as follows:

Susan Dunnihoo
Analytical Resources, Inc.
4611 S 134th Place, Suite 100
Tukwila, WA 98168-3240
Telephone: 206.695.6207
Email: sue@arilabs.com

The laboratory PM at Axys can be reached as follows:

Georgina Brooks
Axys Analytical Services, Ltd.
PO Box 2219
2045 Mills Road
Sidney, British Columbia V8L 3S8
Telephone: 250.656.0881
Email: gbrooks@axys.com

The laboratories will accomplish the following:

- adhere to the methods outlined in this QAPP, including those methods referenced for each procedure
- adhere to documentation, custody, and sample logbook procedures
- implement QA/QC procedures defined in this QAPP
- meet all reporting requirements
- deliver electronic data files as specified in this QAPP
- meet turnaround times for deliverables as described in this QAPP
- allow EPA and the QA/QC third-party auditors to perform laboratory and data audits

2.1.5 Data management

Patrick Gibbons of Windward will oversee data management to ensure that analytical data are incorporated into the LDWG database with appropriate qualifiers following acceptance of the data validation. QA/QC of the database entries will ensure accuracy for use in Phase 2.

2.2 PROBLEM DEFINITION/BACKGROUND

The Phase 2 RI work plan (Windward 2004b) identified the need for additional subsurface sediment samples for chemical analysis. This section presents the objectives and background information to address these data needs. An overview of the study and its schedule is presented in Section 2.3, and a detailed sampling design is presented in Section 3.1.

Collection of additional subsurface sediment chemistry data is needed in specific areas of the LDW to support the Phase 2 RI (Windward 2003). In particular, additional subsurface sediment samples are needed to fulfill the following objectives:

- provide additional characterization of the nature and extent of subsurface chemical concentrations in selected areas where surface concentrations are elevated but subsurface data are not available
- investigate subsurface chemical concentrations in areas that may be subject to erosion or adjacent to potential chemical sources where there is the potential for exposure of sediments containing chemicals at concentrations of concern

There have been many subsurface sediment sampling events since 1990. These events and locations are presented in Figures D-1a through D-1d in Appendix D. All but two historical subsurface sampling events focused on specific areas that were to be dredged or remediated (Table 2-1). The exceptions were EPA's Site Inspection study (Weston 1998), which included the collection of subsurface sediment samples on a reconnaissance level within the LDW and the Preliminary Site Investigation for the South Park Bridge Project (Wilbur Consulting 2004). Subsurface data collected in areas that have since been dredged or remediated do not represent existing conditions, as indicated in Table 2-1. However, these data were evaluated to determine if additional subsurface data are needed to characterize the vertical extent of chemical concentrations in those areas. In addition, dredge material characterization results from suitability determination memorandums were evaluated. These memoranda present the Dredged Material Management Program (DMMP) agencies (USACE, Ecology, Washington State Department of Natural Resources, and EPA) consensus decisions on the suitability of dredged material for open-water disposal based on sediment chemistry and toxicity test results. Table 2-2 lists the determinations made for dredged areas in which material was considered for open-water disposal. Table 2-2 also lists chemicals that exceeded their respective SMS criteria or DMMP guidelines in dredged management units that were determined to be unsuitable for open-water disposal. Table D-1 in Appendix D presents a list of existing subsurface sediment samples with detected chemical concentrations exceeding SQS / SL or CSL / ML. Figures D-1a through D-1d and Figures D-2a through D-2d in Appendix D show historical subsurface locations and locations with chemical exceedances of SMS criteria or DMMP guidelines.

Table 2-1. Summary of historical subsurface sediment samples

SAMPLING EVENT	EVENT CODE	YEAR OF SAMPLING	LOCATION	CHEMICALS	SAMPLE SUMMARY	REFERENCE	SAMPLE LOCATION STATUS
Rhone-Poulenc (Rhodia) sediment & porewater investigation[a]	Rhone Poulenc AugSep 2004	2004	RM 4.0-4.2 east	metals, PCB Aroclors, organochlorine pesticides, SVOCs, conventionals	11 subtidal locations (push cores to a depth of 30 cm below mudline) and 13 intertidal locations (clam gun cores to a depth of 1 m below mudline); 2 samples (0-10 cm and >10 cm) from each subtidal and intertidal location	EPA (2005)	area has not been dredged or remediated
Additional vertical characterization, Duwamish Sediment Other Area[a]	DSOAvert char3	2004	RM 2.9-3.4 east	PCB Aroclors	7 samples (impact corer) from 5 locations; 1 to 3 samples from each location from 60-180 cm below mudline	MCS (2004b)	area has not been dredged or remediated
Triad approach (immunoassay as a real-time measure) to characterize PCBs in a Washington riverine sediment site[a]	Jorgensen August 2004	2004	RM 3.6-3.7 east	metals, PCB Aroclors, conventionals	51 samples (impact corer) from 16 locations; 1-5 samples per location from 45-180 cm below mudline	unpublished data from USACE	area has not been dredged or remediated
Duwamish Sediment Other Area upriver (Area 1) sediment characterization[a]	Jorgensen April 2004	2004	RM 3.6-3.7 east	metals, PCB Aroclors, conventionals	75 samples (impact corer) from 22 locations; 2-9 samples per location from 0-265 cm below mudline	MCS (2004c)	area has not been dredged or remediated
Boyer Towing dock replacement	Boyer Towing	2004	RM 2.4 west	metals, PCB Aroclors, SVOCs, conventionals	3 samples (push core) from 3 locations; 30-60 cm below mudline	WR Consulting (2004)	area has not been dredged
Additional vertical characterization, Duwamish Sediment Other Area[a]	DSOAvert char2	2004	RM 2.8-3.7 east	PCB Aroclors	28 samples (impact corer) from 15 locations; 1-3 samples from each location from 60-144 cm below mudline	MCS (2004a)	area has not been dredged or remediated
PSDDA characterization at the Lehigh Northwest Duwamish Waterway Facility	LehighNW	2004	RM 1.1 east	metals, PCB Aroclors, organochlorine pesticides, SVOCs, conventionals	3 samples (impact corer) from 4 locations; 2 from 0-120 cm, 1 from 120-150 cm below mudline	MCS (2004d)	area was dredged in 2004

SAMPLING EVENT	EVENT CODE	YEAR OF SAMPLING	LOCATION	CHEMICALS	SAMPLE SUMMARY	REFERENCE	SAMPLE LOCATION STATUS
Slip 4 early action area site characterization	Slip4-EarlyAction	2004	Slip 4 (RM 2.8-2.9 east)	PCB Aroclors, mercury	57 samples (vibracorer) from 11 locations; 4-6 samples taken at each location to a depth of 360 cm below mudline	Integral (2004)	area has not been dredged or remediated
Terminal 117 (T-117) early action area site characterization	T-117 Boundary Definition	2003-2004	RM 3.6-3.7 west	metals, PCB Aroclors; SVOCs (selected samples)	107 samples (vibracorer) from 25 locations, 3-6 samples collected at each core location to a depth of 300 cm	Windward (2004a; 2004b)	area has not been dredged or remediated
Preliminary site investigation for the South Park Bridge Project[a]	SouthPark Bridge	2003	RM 3.3 east and west	metals, TBT, VOCs, SVOCs, pesticides, PCB Aroclors	11 samples (mud-rotary drill unit) from 2 locations; 5 to 6 samples from each location at depths from 2.5 to 100 ft below mudline	Wilbur Consulting (2004)	area has not been dredged
Boeing Plant 2 transformer investigation – Phase 1	Plant 2-Trans-former Phase1	2003	RM 3.6 east	PCB Aroclors	46 samples (impact corer) from 13 locations; 3-5 samples at each location from 0-240 cm below mudline	Floyd Snider McCarthy (2004)	area has not been dredged or remediated
Sediment characterization results for the Duwamish River navigational channel turning basin	Turning-basin	2003	RM 4.2-4.7	metals, PCB Aroclors, organochlorine pesticides, SVOCs	5 samples (vibracorer) from 5 locations; collected to depths of 144 to 390 cm	Anchor (2003)	area was most recently dredged in 2004
Glacier NW Cement Terminal[a]	Glacier NW	2002	RM 1.4-1.5 west	metals, PCB Aroclors, organochlorine pesticides, SVOCs, TBT	9 samples (vibracorer), each made from 3 separate cores collected to 90-150 cm below mudline	Pacific International Engineering (2002)	area was dredged in 2005
Glacier NW Duwamish Ready-Mix Facility PSSDA analysis[b]	Glacier NW Ready-Mix	2001	RM 1.7 E (Slip 2)	metals, PCB Aroclors, organochlorine pesticides, SVOCs	2 samples (vibracorer) each made from 2 separate cores collected to 34-200 cm below mudline	Pacific International Engineering (2001)	area was dredged in 2001
Data report, DSOA vertical characterization and outfall 12 data collection. Duwamish sediment other area, Boeing Plant 2	DSOAvert char	2001	RM 2.8-3.7 east	PCB Aroclors	115 samples (impact corer) from 37 locations; 2-6 samples at each location, most locations starting at 60 cm to depths of 150-280 cm below mudline	Pentec (2001)	area has not been dredged or remediated

SAMPLING EVENT	EVENT CODE	YEAR OF SAMPLING	LOCATION	CHEMICALS	SAMPLE SUMMARY	REFERENCE	SAMPLE LOCATION STATUS
Delta Marine Industries site sediment assessment[b]	Delta Marine	2001	RM 4.2 west	metals, PCB Aroclors, organochlorine pesticides, SVOCs, VOCs	3 samples (vibracorer) from 2 locations; 3-5 subsamples from each location; two samples from 0-120 cm below mudline, one sample from 120-180 cm below mudline	AMEC (2001)	area was dredged in 2002
Dredge material characterization Duwamish Yacht Club	Duwam Yacht Club	1999	RM 4.1 west	metals, PCB Aroclors, organochlorine pesticides, SVOCs, VOCs, TBT	6 samples (vibracorer) from 6 locations; each made from 2 separate cores collected to 50-65 cm below mudline	Hart Crowser (1999)	area was dredged in 1999
Sediment sampling and analysis James Hardie Gypsum Inc. – Round 1	Hardie Gypsum-1	1999	RM 1.6-1.7 east	metals, PCB Aroclors, organochlorine pesticides, SVOCs, VOCs	5 samples (vibracorer) made from single cores down to 120 cm below mudline	Spearman (1999)	area was dredged in 1999
Sediment sampling and analysis James Hardie Gypsum Inc. – Round 2	Hardie Gypsum-2	1999	RM 1.6-1.7 east	metals, PCB Aroclors, organochlorine pesticides, SVOCs, VOCs	9 samples (vibracorer) made from single cores down to 90 cm below mudline	Spearman (1999)	area was dredged in 1999
PSDDA sediment characterization of Duwamish River navigation channel: FY2000 operations and maintenance dredging data report	PSDDA99	1999	RM 1.9-3.4	metals, PCB Aroclors, organochlorine pesticides, SVOCs	20 samples (vibracorer) from 20 locations; three borings made at each location; 18 samples from 0 to 120 cm; 2 samples from 120 to 240 cm below mudline	Striplin (2000a); Striplin (2000b)	area was proposed for dredging, but no dredging has been conducted since samples were collected
EPA Site Inspection: Lower Duwamish River	EPA SI	1998	entire LDW study area	metals, PCB Aroclors & selected congeners, dioxins & furans, organochlorine pesticides, SVOCs, VOCs, TBT	33 samples (vibracorer) from 17 locations; 1-2 samples collected at each location, from 0-60 and 60-120 cm below mudline	Weston (1999)	none of the areas were dredged after samples were collected except at RM 0.5 (DR008), which was dredged in 2003/2004

SAMPLING EVENT	EVENT CODE	YEAR OF SAMPLING	LOCATION	CHEMICALS	SAMPLE SUMMARY	REFERENCE	SAMPLE LOCATION STATUS
Dredge material characterization Hurlen Construction Company & Boyer Alaska Barge Lines berthing areas	Hurlen-Boyer	1998	RM 2.4-2.7 west	metals, PCB Aroclors, organochlorine pesticides, SVOCs, TBT, TPH	6 samples (vibracorer) from 2 locations at Boyer and 4 locations at Hurlen; each made from 2 separate cores collected to 60-120 cm below mudline	Hart Crowser (1998)	area was dredged in 1998
PSDDA sediment characterization of Duwamish River navigation channel: FY99 operations and maintenance dredging data report.	PSDDA98	1998	RM 3.5-4.6	metals, PCB Aroclors, organochlorine pesticides, SVOCs	10 samples (vibracorer) from 12 locations; 7 samples from 0 to 60-90 cm, each from single location; 3 samples from 2 or 3 locations (0-60 cm, 0-120 cm, and 120-360 cm below mudline)	Striplin (1998)	area was most recently dredged in 1999
Duwamish/Diagonal cleanup Study – Phase 2	Duw/ Diag-2	1996	RM 0.4-0.6 east	metals, PCB Aroclors, SVOCs, TPH	37 samples (vibracorer) from 14 locations; 1 to 6 samples per core, up to 270 cm below mudline	King County (2000)	area was dredged in 2003/2004
RCRA Facility Investigation Duwamish Waterway sediment investigation, Plant 2 – Phase 2b	Plant 2 RFI-2b	1996	RM 2.8-3.7 east	metals, PCB Aroclors, SVOCs	44 samples (vibracorer) from 16 locations; 2 to 4 samples per core, up to 480 cm below mudline	Weston (1998)	area has not been dredged or remediated
1996 USACE Duwamish O&M	PSDDA96	1996	RM 4.2-4.6	metals, PCB Aroclors, organochlorine pesticides, SVOCs, VOCs	4 samples (vibracorer) from 4 locations; collected to a depth of 120 cm below mudline	Striplin (1996)	area was most recently dredged in 1999
Proposed dredging of Slip No. 4, Duwamish River, Seattle, WA	Slip4-Crowley	1996	RM 2.8 east	metals, PCB Aroclors, organochlorine pesticides, SVOCs, VOCs, TBT	4 samples (vibracorer) composited from sediment at 9 locations; collected to a depth of 70-130 cm below mudline	PTI (1996)	area was dredged in 1996
Lone Star Northwest and James Hardie Gypsum – Kaiser dock upgrade	Lone Star-Hardie Gypsum	1995	RM 1.6 east	metals, PCB Aroclors, organochlorine pesticides, SVOCs, VOCs	5 samples (vibracorer) from 4 locations; 4 collected to a depth of 120-150 cm, 1 at 120-360 cm below mudline	Hartman (1995)	area was dredged in 1995

Sampling Event	Event Code	Year of Sampling	Location	Chemicals	Sample Summary	Reference	Sample Location Status
Norfolk CSO sediment cleanup study – Phase 2	Norfolk-cleanup2	1995	RM 4.9-5.0 east	metals, PCB Aroclors and selected congeners, organochlorine pesticides, SVOCs, VOCs, TPH	27 samples (vibracorer) from 3 locations; collected at 30 or 60 cm intervals up to 180 cm below mudline	King County (1996)	area was dredged and capped in 1999
RCRA Facility Investigation Duwamish Waterway sediment investigation, Plant 2 – Phase 1	Plant 2 RFI-1	1995	RM 2.8-3.7 east	metals, PCB Aroclors, TPH, SVOCs, VOCs	20 samples (vibracorer) from 12 locations; collected at 15-45 cm intervals down to 135 cm below mudline	Weston (1998)	area has not been dredged or remediated
Duwamish/Diagonal cleanup Study – Phase 1	Duw/ Diag-1	1994	RM 0.4-0.6 east	metals, PCB Aroclors, organochlorine pesticides, SVOCs, TBT	12 samples (vibracorer) from 2 locations; collected at 15-30 cm intervals down to 150 cm below mudline	King County (2001)	area was dredged in 2003/2004
Norfolk CSO sediment cleanup study – Phase 1	Norfolk-cleanup1	1994	RM 4.9-5.0 east	metals, PCB Aroclors, organochlorine pesticides, SVOCs, VOCs	3 samples from 1 location; collected at 15-30, 30-45, and 45-60 cm below mudline	King County (1996)	area was dredged and capped in 1999
Lone Star Northwest – West Terminal US ACOE – Seattle	Lone Star 92	1992	RM 1.4-1.5 wast	metals, PCB Aroclors, organochlorine pesticides, SVOCs, VOCs	1 sample (vibracorer), made from 2 separate cores collected to 120 cm below mudline	Hartman (1992)	area was dredged in 1995
Sediment sampling and analysis, South Park Marina, Duwamish Waterway, Seattle, Washington.	South Park Marina	1991	RM 3.5 west	metals, PCB Aroclors, organochlorine pesticides, SVOCs	2 samples (vibracorer), each made from 2 separate cores collected to 120 cm below mudline	Spearman (1991)	area was dredged in 1992
Subsurface sediment chemistry and geotechnical analysis related to proposed dredging at Terminal 105[c]	Terminal 105	1985	RM 0.1-0.3 west	metals, PCBs, SVOCs, and DDT	35 samples (hollow stem auger) from 12 locations, 2 to 5 samples per core, down to approximately 9 m below mudline	Port of Seattle unpublished data (1985)	area has not been dredged

Note: For reference, 1 ft is equal to 30 cm.

[a] To determine whether these data will be considered acceptable for use in Phase 2, the quality of the data collected during this sampling event will be discussed in detail in the technical memorandum titled *Summary of chemistry datasets to be used in the Phase 2 RI/FS – Addendum 2.* This memorandum will be submitted to EPA and Ecology in February 2006.

[b] These data were recently obtained and have not yet been included in the project database.

[c] The data from this sampling event were never validated and were collected prior to 1990, which is the earliest year established in the Phase 1 RI for data to be considered acceptable for all uses in the Phase 2 RI/FS. No additional data quality review will be conducted for these data; therefore, they are not acceptable for all uses in the Phase 2 RI/FS.

CSO – combined sewer overflow

DSOA – Duwamish sediment other area (Boeing Plant 2)

PCB – polychlorinated biphenyl

PSDDA – Puget Sound Dredged Disposal Analysis

RCRA – Resource Conservation and Recovery Act

RM – river mile

SVOC – semivolatile organic compound

TBT – tributyltin

TPH – total petroleum hydrocarbons

VOC – volatile organic compound

Table 2-2. Results of dredged material suitability determinations

		Date			Samples from DMMUs Determined Unsuitable for Open-Water Disposal	
Area	Event Code	Suitability Determination	Most Recent Dredging	Location	Sample ID	Detected Chemicals Exceeding SMS Criteria DMMP Guidelines
Lehigh Northwest[a]	LehighNW	2004	2004	RM 1.1 east	C2	PCBs (SQS)
LDW navigation channel turning basin	Turning-basin	2003	2004	RM 4.2-4.7	none	na
Glacier NW Cement Terminal[b]	Glacier NW	2003	2005	RM 1.4-1.5 west	SCDMMU2R	arsenic (SQS); mercury (CSL)
					SCDMMU3	PCBs and zinc (SQS); DDTs (SL); arsenic (CSL)
Delta Marine	Delta Marine	2002	2002	RM 4.2 west	none	na
Glacier NW Ready-Mix Facility	Glacier NW Ready-Mix	2001	2001	RM 1.7 east (Slip 2)	none	PCBs (SQS)
Duwamish Yacht Club	Duwam Yacht Club	1999	1999	RM 4.1 west	none	na

Area	Event Code	Date		Location	Samples from DMMUs Determined Unsuitable for Open-Water Disposal	
		Suitability Determination	Most Recent Dredging		Sample ID	Detected Chemicals Exceeding SMS Criteria DMMP Guidelines
James Hardie Gypsum Inc.[c]	Hardie Gypsum-1 and Hardie Gypsum-2	1999	1999	RM 1.6-1.7 east	2b	no detected exceedances[d]
					3	no detected exceedances[d]
					5	no detected exceedances[d]
					C	phenanthrene (SQS)
					D	PCBs and mercury (SQS); dieldrin (SL)
LDW navigation channel[c]	PSDDA99	2000	area has not been dredged since suitability determination	RM 1.9-3.4	S1	no detected exceedances[d]
					S3	no detected exceedances[d]
					S4	no detected exceedances[d]
					S15	PCBs (SQS)
					B2	PCBs (SQS)
Hurlen Construction Company & Boyer Alaska Barge Lines[a]	Hurlen-Boyer	1999	1999	RM 2.4-2.7 west	C2	fluoranthene and total PAHs (SQS)
					C3	6 individual PAHs, total LPAHs, and total HPAHs (SQS); acenaphthene (CSL)
LDW navigation channel	PSDDA98	1998	1999	RM 3.5-4.6	none	na
LDW navigation channel[c]	PSDDA96	1996	1999	RM 4.2-4.6	6	no detected exceedances[d]
Slip No. 4[c]	Slip4-Crowley	1996	1996	RM 2.8 east	DMMU1	PCBs, 8 individual PAHs, and total HPAHs (SQS)
					DMMU3	PCBs (SQS)
					DMMU4	PCBs (SQS)
Lone Star Northwest and James Hardie Gypsum[c]	Lone Star-Hardie Gypsum	1995	1995	RM 1.6 east	c-1	no detected exceedances[d]
					c-2	no detected exceedances[d]
					c-3	no detected exceedances[d]
Lone Star Northwest	Lone Star 92	1992	1995	RM 1.4-1.5 west	none	na
South Park Marina	South Park Marina	1991	1992	RM 3.5 west	none	na

[a] Z-samples were collected during these dredge events, but the data reports did not indicate whether those samples were submitted for chemical analyses.

[b] The archived Z-sample from DMMU 2 at Glacier NW Cement Terminal was submitted for analysis of metals and PCBs. The arsenic concentration in this sample exceeded the SQS and the mercury concentration exceeded the CSL. PCBs were not detected.

[c] The data reports for these dredge events did not indicate whether Z-samples were collected or analyzed.

[d] Locations with no chemical exceedances were determined to be unsuitable for open-water disposal based on biological criteria exceedances in the toxicity tests.

Footnotes about the collection and analysis of Z-samples are provided for dredge events for which Z-samples might have been analyzed (i.e., if the sediments to be dredged were determined to be unsuitable for open-water disposal).

Data were obtained from memoranda produced by the Dredged Material Management Office regarding suitability determinations for open-water disposal of dredged material from each area tested.

DMMU – dredged material management unit

na – not applicable

Many sediment cores, as deep as 360 cm (12 ft), have also been collected at five early action areas (i.e., Duwamish / Diagonal combined sewer overflow [CSO] / storm drain, Boeing Plant 2, Slip 4, Terminal 117 [T-117], and Norfolk) for the purposes of remedial action evaluation. Remediation has been conducted at the Duwamish / Diagonal early action site, so no additional subsurface samples will be collected within the dredged or capped areas, although several subsurface samples will be collected in the vicinity of those areas (see Section 3.1). No additional subsurface sediment sampling will be conducted within Boeing Plant 2, Slip 4, or T-117 as part of the Phase 2 RI because additional characterization, if needed, will be conducted by the early action sponsors.

2.3 PROJECT/TASK DESCRIPTION AND SCHEDULE

The sampling of subsurface sediment will be initiated following EPA’s approval of this QAPP, which is currently scheduled for February 2, 2006. This section provides an overview of the sampling and analysis activities and schedule for the study designed to address the data needs outlined in Section 2.2.

Sampling is scheduled to occur from February 6 to February 24, 2006. Sediment cores will be processed by a second field crew immediately following collection. Sediment samples will then be submitted to ARI and Axys for chemical analyses (see Section 3.4.2.1). Chemical analyses of the samples, as described in Section 3.4.2, are expected to be completed three weeks after samples have been collected. Preliminary, unvalidated data will be presented to EPA and Ecology approximately two weeks after chemical data are received from the laboratory. A meeting will be held with EPA and Ecology in mid-April to select archived samples for additional analyses based on the preliminary data, as described in Section 3.1.3. These samples will be submitted for chemical analyses immediately after the sample selection process. Validated data are expected to be received from these analyses by early June 2006. A draft report presenting the chemical data will be submitted to EPA and Ecology on July 28, 2006.

2.4 QUALITY OBJECTIVES AND CRITERIA

The overall data quality objective for this project is to develop and implement procedures that will ensure the collection of representative data of known, acceptable, and defensible quality. Parameters used to assess data quality are precision, accuracy, representativeness, comparability, completeness, and sensitivity. These parameters are discussed, and specific data quality indicators (DQIs) for sediment chemistry analyses are presented in Section 3.4.2.

2.5 SPECIAL TRAINING/CERTIFICATION

The Superfund Amendments and Reauthorization Act of 1986 required the Secretary of Labor to issue regulations providing health and safety standards and guidelines for workers engaged in hazardous waste operations. The federal regulation 29CFR1910.120 requires training to provide employees with the knowledge and skills enabling them to perform their jobs safely and with minimum risk to their personal health. All sampling personnel will have completed the 40-hour HAZWOPER training course and 8-hour refresher courses, as necessary, to meet the Occupational Safety and Health Administration regulations.

2.6 DOCUMENTATION AND RECORDS

The following sections describe documentation and records needed for field observations and laboratory analyses.

2.6.1 Field observations

All field activities will be recorded in a field logbook maintained by the FC. The field logbook will provide a description of all sampling activities, conferences associated with field sampling activities, sampling personnel, and weather conditions, plus a record of all modifications to the procedures and plans identified in this QAPP and the HSP (Appendix A). The field logbook will consist of bound, numbered pages. All entries will be made in indelible ink. The field logbook is intended to provide sufficient data and observations to enable participants to reconstruct events that occurred during the sampling period.

The following forms, included in Appendix B, will also be used to record pertinent information after sample collection:

- sediment core drive log
- bore log
- sediment core processing log
- protocol modification form

Appendix B also presents a key for physical description of sediment samples used in logging the core.

2.6.2 Laboratory records

The various laboratory record requirements for the sediment chemistry data are described below. The contract laboratories to be used for this investigation are accredited by Ecology to conduct the sediment chemical analyses specified in Section 3.4.

The laboratories will be responsible for internal checks on sample handling and analytical data reporting, and will correct errors identified during the QA review. The laboratory data package will be submitted electronically and will include the following:

- **Project narrative**: This summary, in the form of a cover letter, will present any problems encountered during any aspect of analysis. The summary will include, but not be limited to, discussion of quality control, sample shipment, sample storage, and analytical difficulties. Any problems encountered by the laboratory, and their resolutions, will be documented in the project narrative.

- **Records**: Legible copies of the chain-of-custody (COC) forms will be provided as part of the data package. This documentation will include the time of receipt and the condition of each sample received by the laboratory. Additional internal tracking of sample custody by the laboratory will also be documented.
- **Sample results**: The data package will summarize the results for each sample analyzed. The summary will include the following information, when applicable:
    - field sample identification code and the corresponding laboratory identification code
    - sample matrix
    - date of sample extraction / digestion
    - date and time of analysis
    - weight and / or volume used for analysis
    - final dilution volumes or concentration factor for the sample
    - total solids in the samples
    - identification of the instruments used for analysis
    - MDLs and RLs
    - all data qualifiers and their definitions
- **QA/QC summaries:** These summaries will contain the results of all QA / QC procedures. Each QA / QC sample analysis will be documented with the same information required for the sample results (see above). The laboratory will make no recovery or blank corrections. The required summaries are listed below.
    - The calibration data summary will contain the concentrations of the initial calibration and daily calibration standards and the date and time of analysis. The response factor, percent relative standard deviation, relative percent differences (RPD), and retention time for each analyte will be listed, as appropriate. Results for standards to indicate instrument sensitivity will be reported.
    - The internal standard area summary will report the internal standard areas, as appropriate.
    - The method blank analysis summary will report the method blank analysis associated with each sample and the concentrations of all compounds of interest identified in these blanks.

  - The surrogate spike recovery summary will report all surrogate spike recovery data for organic analyses. The names and concentrations of all compounds added, percent recoveries, and QC limits will be listed.
  - The matrix spike recovery summary will report the matrix spike or matrix spike/matrix spike duplicate recovery data for analyses, as appropriate. The names and concentrations of all compounds added, percent recoveries, and QC limits will be included in the data package. The RPD for all matrix spike duplicate analyses will be reported.
  - The matrix duplicate summary will report the RPD for all matrix duplicate analyses. The QC limits for each compound or analyte will be listed.
  - The standard reference material (SRM) analysis summary will report the results and recoveries of the SRM analyses and list the accuracy, as defined in Section 3.4.2, for each analyte.
  - The laboratory control analysis summary will report the results of the analyses of laboratory control samples (LCSs). The QC limits for each compound or analyte will be included in the data package.
  - The relative retention time summary will report the relative retention times for the primary and confirmational columns of each analyte detected in the samples, as appropriate.
- **Original data:** Legible copies of the original data generated by the laboratory will be provided, including the following:
  - sample extraction/digestion, preparation, and cleanup logs
  - instrument analysis logs for all instruments used on days of calibration and analysis
  - reconstructed ion chromatograms for all samples, standards, blanks, calibrations, spikes, replicates, LCSs, and SRMs
  - final gas chromatograph-electron capture detection chromatograms used in the quantification of the sample
  - unenhanced and enhanced spectra of detected compounds with associated best-match spectra for each sample
  - printouts and quantitation reports for each instrument used, including reports for all samples, standards, blanks, calibrations, spikes, replicates, and LCSs, and SRMs

The contract laboratories for this project will submit data electronically, in delimited-text format. Guidelines for electronic data deliverables for chemical data are as follows:

- Each row of data will contain only one analyte for a given sample. Therefore, one complete sample will require multiple rows.
- If a comma separated value file format has been used, all fields must have quotations around each entry to avoid field value confusion. For example, “Indeno(1,2,3-cd)pyrene.”
- Each result, RL, and detection limit (DL) must show the proper significant figures and sensitivity. These entries should have no non-number characters within the field (i.e., apostrophes, commas).
- If a result for an analyte is below the DL, the laboratory qualifier will be U, and the value in the result column will be the RL.
- Analytical results of laboratory samples for QA / QC will be included, and clearly identified in the sample type code field.
- If replicate analyses are conducted on a submitted field sample, they too will be included and clearly identified in the sample type code.
- Wherever possible, all analytes and replicates for a given sample will be grouped together.
- If an analyte is not detected then the laboratory qualifier will be U, and the value in the result column will be the sample-specific RL. Quantified results between the DL and the RL will be laboratory J-qualified.

The electronic data deliverable (EDD) format for chemical data is provided in Table 2-3. All fields are required in the order listed. Entries listed as required must be present for all individual records (rows). Optional entries may not be applicable to all records.

Table 2-3. Electronic data deliverable format for chemical data

FIELD	ENTRY IN FIELD REQUIRED OR OPTIONAL
Project code	required
Event ID	required
Sample name	required
Sample date time	required
Analysis location	required
Laboratory name code	required
Parent sample name	optional
Laboratory sample ID	required
Sample type code	required
Sample delivery group	required
Standard analytical method name	required
Laboratory analytical method name	optional
CAS number	optional

FIELD	ENTRY IN FIELD REQUIRED OR OPTIONAL
Chemical name	required
Result value	required
Result unit	required
Laboratory flag	optional
Validator flag	optional
Result type code	required
Detect flag	required
Reporting detection limit	required
Dilution factor	required
Sample matrix code	required
Total or dissolved	required
Basis	required
Analysis date time	required
Method detection limit	required
Laboratory prep method name	required
Prep date time	required
Test batch ID	required
Result error delta	optional
Tic retention time	optional
Result comment	optional
QC original concentration	optional
QC spike added	optional
QC spike measured	optional
QC spike recovery	optional
QC duplicate original concentration	optional
QC duplicate spike added	optional
QC duplicate spike measured	optional
QC duplicate spike recovery	optional
QC relative percent difference (RPD)	optional
QC spike lower confidence limit	optional
QC spike upper confidence limit	optional
QC RPD confidence limit	optional
Laboratory analytical method description	optional
Laboratory flag description	optional

2.6.3 Data reduction

Data reduction is the process by which original data are converted or reduced to a specified format or unit to facilitate analysis of the data. For example, a final analytical concentration may need to be calculated from a diluted sample result. Data reduction requires that all aspects of sample preparation that could affect the test result, such as sample volume analyzed or dilutions required, be taken into account in the final result. It is the laboratory analyst's responsibility to reduce the data, which are subjected to further review by the laboratory PM, the Windward PM, the Project QA/QC Coordinator, and independent reviewers. The data will be generated in a form amenable to review and evaluation. Data reduction may be performed manually or electronically. If performed electronically, all software used must be demonstrated to be true and free from unacceptable error.

During chemical analysis, samples are occasionally diluted after the initial analysis if the estimated concentration curve for one or more of the target analytes is above the calibration curve. In these instances, concentrations from the initial analysis will be identified as the "best result" for all target analytes other than the chemical(s) that was originally above the calibration range. The "best result" for this qualified analyte(s) will be taken from the diluted sample.

2.6.4 Data report

A data report will be prepared documenting all activities associated with the collection, handling, and analyses of samples. At a minimum, the following will be included in the data report:

- summary of all field activities, including descriptions of any deviations from the approved QAPP
- copies of field forms, including core drive log, bore log, and sediment core processing logs
- summary spreadsheet containing information from field forms
- sediment sampling locations reported in latitude and longitude to the nearest one-tenth of a second (NAD83) and in northing and easting to the nearest foot (Washington State Plane N, NAD83, US survey feet)
- plan view of the project area showing the actual sampling locations
- summary of the QA/QC review of the analytical data
- data validation reports (appendices)
- results from the analyses of field samples, both as summary tables in the main body of the report and appendices with data forms submitted by the laboratories and as cross-tabulated tables produced from Windward's database; sample depth interval will be reported as both actual depth sampled and *in situ* depth calculated from bore logs
- comparison of the subsurface sediment analytical chemistry results to SMS and DMMP numerical criteria

Analytical data will be validated within four weeks of receiving data packages from the respective laboratories. A draft data report will be submitted to EPA and Ecology on July 28, 2006. A final data report will be submitted to EPA and Ecology following revision of the data reports in response to agency comments. Once the data report has been approved by EPA and Ecology, a database export will be created from Windward's database. The data will be exported in SEDQUAL format (Release 5),[1] as well as the format used to export the historical chemistry data, which consists of separate tables for events, locations, samples, and results.

3.0 Data Generation and Acquisition

This section describes the collection and handling of sediment samples for chemical analyses. Elements include sampling design, sampling methods, sample handling and custody requirements, analytical methods, QA/QC, instrument/equipment testing and frequency, inspection and maintenance, instrument calibration, supply inspection/acceptance, and data management.

3.1 SAMPLING DESIGN

This section describes the sampling design developed to fulfill the objectives presented in Section 2.2 for collection of subsurface chemical data to support the Phase 2 RI. The following subsections present the process for selecting subsurface locations, a description of the locations, the plans for sectioning the sediment cores, and the chemical analyses to be conducted on the samples.

3.1.1 Considerations for selecting subsurface sampling locations

The general objective of the Phase 2 subsurface sediment sampling is to characterize the nature and extent of subsurface chemical contamination in the LDW (Section 2.2). A weight-of-evidence approach was used to target locations with a greater potential for subsurface contamination, to target locations that may be subject to erosion, and to provide spatial coverage throughout the LDW. The following information was used in this weight-of-evidence approach to select core locations.

- **Existing surface sediment data –** Both Phase 1 and Phase 2 chemistry and toxicity data were evaluated. Core locations were placed in areas with elevated chemical concentrations in surface sediments based on comparisons to the SQS and CSL of the SMS or to guidelines in the DMMP for chemicals without SMS standards. Locations where the results of surface sediment toxicity tests exceeded SMS biological criteria were also considered for placement of subsurface sediment cores.[2]
- **Existing subsurface sediment data –** Phase 1 and more recent subsurface data were reviewed to determine if existing data characterizing subsurface sediment chemical concentrations are sufficient to evaluate the vertical extent of

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[1] The data entry templates will be pre-tested before submittal by importing them into Release 5.0 of SEDQUAL.

[2] It should be noted that cleanup areas will not be determined solely by SMS exceedances, particularly for bioaccumulative chemicals, such as PCBs.

contamination (e.g., locations were considered for resampling if chemical concentrations were above the CSL of the SMS within the deepest core interval in areas that have not been dredged). Existing subsurface sediment sampling locations and data for samples with chemical concentrations exceeding the SQS or CSL of the SMS are presented in Appendix D.

- **Dredging information –** Much of the upstream LDW navigation channel has been dredged (approximately river mile [RM] 3.5 to 4.7) between 1986 and 2004, and numerous other dredging projects have occurred outside of the channel between 1992 and 2005 (see Figure 2-2). Cores were generally not placed in these areas, for the following reasons. The channel between RM 3.5 and 4.7 was recently dredged, and the pre-dredge cores demonstrated that the sediments had low enough chemical concentrations to be suitable for open-water disposal. Pre-dredge core data are also available for six of the eight dredged areas outside the channel. At the two areas without core data, there were no detected chemical concentrations exceeding SQS at nearby surface sediment locations. Data for core samples with chemical concentrations exceeding the SQS or CSL are presented in Appendix D.
- **Proximity to potential chemical sources –** Source information was considered in conjunction with existing sediment data to identify areas that may have subsurface contamination. Identification of potential historical chemical sources was based on preliminary source control investigations of waterfront properties and outfalls by member agencies of the LDW source control work group, including a review of historical aerial photos, records, and files. Seeps with elevated chemical concentrations in seep water (Windward 2004a) were also considered as potential sources.
- **Erosion potential –**Erosion of surficial sediments to a sufficient degree could result in exposure of subsurface sediment. Erosion potential was determined, in part, by reviewing USACE (2002), which describes LDW Port of Seattle facilities, including docks, wharves, and other locations, where propeller scour could be important. Additional documentation of higher scour-potential areas is being determined as part of sediment stability analyses (Windward and QEA 2005).
- **Early action areas and potential cleanup areas –** Subsurface locations were not placed within the four sponsored early action areas (Duwamish/Diagonal CSO/storm drain, Boeing Plant 2, Slip 4, and T-117) where additional characterization of subsurface sediment, if needed, either has been or is being conducted as part of early action activities. However, cores were placed near RM 2.2, RM 3.8, and Norfolk to better characterize these areas for the LDW FS.
- **Spatial coverage –** Following the placement of cores based on the considerations above, the spatial coverage of sampling locations was reviewed

to ensure that sufficient data will be available to evaluate the nature and extent of subsurface chemical concentrations throughout the LDW in the Phase 2 RI.

3.1.2 Description of subsurface sampling locations

Figures 3-1a through 3-1d (located at the end of this document) summarize the information used in the selection process, including historical subsurface sampling locations, Phase 1 and 2 surface sediment chemical concentrations and toxicity test results, potential scour or erosion areas, outfalls, seeps with elevated chemical concentrations, potential upland sources, dredged areas, and early action areas. Table 3-1 and Figures 3-1a through 3-1d present the 56 subsurface sampling locations that were selected as a result of this selection process.

Figure 2-2 presents the overall spatial coverage of historical and Phase 2 subsurface sediment sampling locations that were selected based on the process described in Section 3.1.1. Table 3-2 summarizes the number of historical and Phase 2 sampling locations for each half RM and each side of the river. Of the 56 proposed Phase 2 sampling locations, 11% are in the channel, 36% are on the west side of the river, and 53% are on the east side. The number of proposed locations outside of the channel is greater than within the channel because core locations were preferentially placed in bench areas closer to potential sources. In addition, there were fewer historical subsurface data in the channel because the channel is frequently dredged upstream from RM 3.2 and more historical subsurface data are available in channel areas where dredging has occurred. The number of proposed locations is greater on the east side than the west side of the LDW because more areas on the east side meet the considerations for sample placement described in Section 3.1.1. The number of proposed locations between RM 3.0 and 3.5 is lower than in other areas because the Boeing Plant 2 proposed removal area is located along this portion of the LDW, and it is being characterized separately as part of an early action. The coordinates for the subsurface sampling locations, along with the estimated depth of the bottom above or below mean lower low water (MLLW) at those locations, are presented in Table 3-3.

Table 3-1. Subsurface sediment chemistry sampling locations for the Phase 2 RI

			Considerations for Placing Sampling Locations								
			Sediment Quality			Near Potential source					
Subsurface Location ID	Phase 1 or Phase 2 Location ID	River Mile	Bioassay Exceedances	Detected Surface Chemical Exceedances	Detected Subsurface Chemical Exceedances	Seeps/ Outfall	Upland Activity	Erosion potential	Spatial Coverage	Rationale
1	LDW-SS2	0.0 E	CSL	SQS	no data				x	PCB and PAH SQS exceedances in surface sediment; bioassay CSL exceedance
2	LDW-SS6	0.1 E	CSL	CSL	no data	x	x	x		PCB and lead CSL exceedances; BEHP, arsenic, and zinc SQS exceedances; bioassay CSL exceedance; adjacent to historical sources of metals to sediments; tug boat activity
3	not previously sampled	0.15 E	no data	no data	no data				x	spatial coverage; potential depositional area
4	not previously sampled	0.15 E	no data	no data	no data			x	x	tug boat activity
5	D3	0.15 W	no data	no data; nearby locations had SQS exceedances	CSL		x			near PCB and PAH SQS exceedances in surface sediment; near PCB, PAH, mercury, and BEHP CSL exceedances in nearby subsurface sediment; potential historical sources
6	LDW-SS16	0.3 W	SQS	SQS	no data	x				PCB SQS exceedance; outfalls nearby
7	DUD043	0.35 E	no data; nearby locations sampled by King County had no exceedances	CSL	no data; nearby location had CSL exceedance	x				BEHP CSL exceedance and PCB SQS exceedance in surface sediment; nearby location had BEHP CSL exceedance; PCB and butyl benzyl phthalate SQS exceedances at 0-3 ft; D/D outfall nearby
8	not previously sampled	0.35 C	no data	no data; nearby location had CSL exceedance	no data				x	near PCB and mercury CSL exceedance in surface sediment

			Considerations for Placing Sampling Locations							
			Sediment Quality			Near Potential source				
Subsurface Location ID	Phase 1 or Phase 2 Location ID	River Mile	Bioassay Exceedances	Detected Surface Chemical Exceedances	Detected Subsurface Chemical Exceedances	Seeps/ Outfall	Upland Activity	Erosion potential	Spatial Coverage	Rationale
9	DUD_8C	0.5 C	no data	CSL	no data	x				PCB and BEHP CSL exceedances; DDT and butyl benzyl phthalate SQS exceedances; D/D outfall nearby
10	near LDW-SS22	0.5 E	no data; nearby location had CSL exceedance	no data; nearby location had CSL exceedance	CSL	x				Nearby BEHP and 4-methylphenol CSL exceedances in surface sediment; PCB CSL exceedance in subsurface sediment; bioassay CSL exceedance at LDW-SS22 nearby; D/D outfall nearby
11	LDW-SS24	0.55 W	CSL exceedance	CSL exceedance	no data	x	x			Benzyl alcohol and mercury CSL exceedance in surface sediment; bioassay CSL exceedance; historical location of Seaboard Lumber; pipes of unknown use
12	DR044	0.6 W	no data	SQS	CSL					PCB CSL and mercury SQS at 2-4 ft
13	not previously sampled	0.85 E	no data	no data	no data				x	delineation of historical PCB spill in Slip 1
14	LDW-SSB2b	0.85 C	CSL	SQS	no data				x	PCB SQS exceedance; bioassay CSL exceedance; spatial coverage
15	not previously sampled	0.9 E	no data	no exceedances	nearby location had CSL exceedances					near historical core with PCB and mercury CSL exceedances at 2-4 ft
16	not previously sampled	0.9 E	no data	no data	no data			x	x	delineation of historical PCB spill in Slip 1; tug boat activity
17	LDW-SS31	1.0 E	CSL	CSL	no	x		x	x	arsenic and zinc CSL exceedances; bioassay CSL exceedance; Seep 76 with elevated arsenic and zinc concentrations nearby; tug boat activity

			Considerations for Placing Sampling Locations							
			Sediment Quality			Near Potential source				
Subsurface Location ID	Phase 1 or Phase 2 Location ID	River Mile	Bioassay Exceedances	Detected Surface Chemical Exceedances	Detected Subsurface Chemical Exceedances	Seeps/ Outfall	Upland Activity	Erosion potential	Spatial Coverage	Rationale
18	LDW-SS35	1.0 E	no data	CSL	no data; nearby location had SQS exceedance					PAH CSL exceedance and PCB SQS exceedance in surface sediment; PCB SQS exceedance in nearby subsurface sediment
19	LDW-SS36	1.0 W	no data	no exceedances	no data	x	x			Seep 64 with elevated PCBs in unfiltered seep water nearby; adjacent to cement plant; moderate dioxin/furan TEQ in surface sediment; pipe of unknown use nearby
20	LDW-SS37	1.05 C	CSL	CSL	no data		x			mercury and PCB CSL exceedance; bioassay CSL exceedance; elevated dioxin/furan TEQ in surface sediment; adjacent to cement plant
21	not previously sampled	1.05 W	no data	no data; nearby location had SQS exceedance	no data		x	x		fluoranthene SQS exceedance in nearby surface sediment; tug boat activity; adjacent to cement plant; historical drum recycling area
22	LDW-SS39	1.1 E	CSL	CSL	no data	x				bioassay CSL exceedance; mercury CSL exceedance in surface sediment; near Brandon CSO
23	DR025	1.2 E	no data	no exceedances	CSL	x				reoccupy historical core location; mercury CSL and PCB SQS exceedance at 2-4 ft; storm drains nearby
24	not previously sampled	1.25 W	no data	no data	no data	x		x		several pipes and outfalls nearby; tug boat activity
25	not previously sampled	1.3 W	no data	no data; nearby location had CSL exceedance	no data; nearby location had CSL exceedance	x	x			nearby metal CSL exceedances in surface sediments; nearby metal CSL exceedances and PAH, PCB and BEHP SQS exceedances at 2-4 ft, area has elevated TBT; nearby shipyard and outfalls

			Considerations for Placing Sampling Locations							
			Sediment Quality			Near Potential source				
Subsurface Location ID	Phase 1 or Phase 2 Location ID	River Mile	Bioassay Exceedances	Detected Surface Chemical Exceedances	Detected Subsurface Chemical Exceedances	Seeps/ Outfall	Upland Activity	Erosion potential	Spatial Coverage	Rationale
26	LDW-SS49	1.35 W	CSL	CSL	no data		x	x		arsenic, zinc, and copper CSL exceedances, bioassay CSL exceedance; tug boat activity
27	LDW-SS50	1.4 E	CSL	SQS	no data	x				PCB and mercury SQS exceedance in surface sediment; bioassay CSL exceedance; near public storm drain
28	not previously sampled	1.4 C	no data	no data	no data		x		x	spatial extent of contamination from cement plant and former PCP manufacturer; elevated dioxin/furan TEQ in surface sediment nearby; near end of dry dock
29	LDW-SS56	1.45 W	SQS	CSL	no data		x			station with highest dioxin TEQ measured in LDW (2,100 ng/kg) and a bioassay SQS exceedance; adjacent to cement plant and former PCP manufacturer
30	LDW-SS60	1.6 E	no exceedances	SQS	no data	x				PCB SQS exceedance (but no toxicity exceedance); Seep 80, with copper exceeding chronic WQC and total petroleum hydrocarbons detected in seep water nearby
31	not previously sampled	1.65 E	no data	no data, nearby location had CSL exceedance	no data, nearby location had SQS exceedance	x	x	x		PCB CSL exceedance nearby, phenanthrene, dieldrin, mercury, and PCB SQS exceedances at 0-3 ft nearby; tug boat activity; pipe of unknown use nearby; cement plant nearby
32	not previously sampled	1.7 E (Slip 2)	no data	no data	no data; nearby locations had SQS exceedance[a]	x	x	x	x	PCB SQS exceedance in nearby subsurface sediment;[a] tug boat activity; adjacent to cement plant; spatial coverage

			Considerations for Placing Sampling Locations							
			Sediment Quality			Near Potential source				
Subsurface Location ID	Phase 1 or Phase 2 Location ID	River Mile	Bioassay Exceedances	Detected Surface Chemical Exceedances	Detected Subsurface Chemical Exceedances	Seeps/ Outfall	Upland Activity	Erosion potential	Spatial Coverage	Rationale
34	LDW-SS70	1.85 W	SQS	SQS; nearby locations had CSL exceedances	no data	x	x	x		BEHP SQS exceedance; bioassay SQS exceedance; adjacent to two locations with phthalate CSL exceedances in surface sediment; located adjacent to area of heavy tug boat activity and 72” storm drain
33	LDW-SS69	1.85 E	CSL	SQS	no data	x				PCB SQS exceedance; bioassay CSL exceedance; pipe of unknown use nearby
35	LDW-SS75	1.95 W	no exceedances	SQS	no data					PCB SQS exceedance (but no toxicity exceedance) and other nearby exceedances
36	not previously sampled	2.05 E	no data	no data; nearby location had ML exceedance	no data		x		x	nearby location had DDT ML exceedance in surface sediment; potential upland sources
37	LDW-SS77	2.1 E	CSL	SQS	no data		x			arsenic SQS exceedance; bioassay CSL exceedance; potential source from waste piles under pier.
38	LDW-B6a	2.1 W	SQS	SQS	no data		x	x		PCB SQS exceedance in surface sediment; bioassay SQS exceedance; potential source from bridge
39	not previously sampled	2.15 W C	no data	no data	no data		x		x	historical ship breaking area
40	not previously sampled	2.25 W	no data	no data; several nearby locations had CSL exceedances	no data	x	x			within unsponsored early action site; several locations with PCB CSL exceedances nearby; delineation of potential cleanup area
41	not previously sampled; near LDW-SS83	2.35 E	no data	no data; nearby locations had no exceedances	no data	x	x			moderate dioxin at LDW-SS83; potential source from scrap metal facility, historical site uses, and Great Western International

			Considerations for Placing Sampling Locations							
			Sediment Quality			Near Potential source				
Subsurface Location ID	Phase 1 or Phase 2 Location ID	River Mile	Bioassay Exceedances	Detected Surface Chemical Exceedances	Detected Subsurface Chemical Exceedances	Seeps/ Outfall	Upland Activity	Erosion potential	Spatial Coverage	Rationale
42	not previously sampled	2.45 E	no data	no data	no data	x	x	x		near pipe of unknown use; potential source from scrap metal facility and historical site uses; tug boat activity
43	LDW-SS88	2.6 E	CSL	CSL	no data	x	x			mercury CSL and PCB SQS exceedances; bioassay CSL exceedance; outfalls nearby; potential source from historical drum recycling
44	not previously sampled	2.7 E	no data	no data; nearby location had SQS exceedance	no data		x			nearby location had PCB SQS exceedance; potential source from historical drum recycling activities
45	not previously sampled	2.8 E	no data	no data	no data	x	x		x	spatial extent; outfalls nearby
46[b]	LDW-SS95	2.75 W	no data	CSL	no data; nearby location had SQS exceedances			x		multiple PAH CSL exceedances in surface sediment; recently dredged sediment nearby had multiple PAH SQS exceedances at 0-3.3 ft; tug boat activity
47	not previously sampled	3.05 W	no data	no data; nearby location had SQS exceedance	no data				x	PCB SQS exceedance in nearby surface sediment; high human use area
48	not previously sampled	3.35 C	no data	no data	no data; nearby location had CSL exceedance			x		PCB CSL exceedance in nearby subsurface sediment; potential erosion from boat traffic in vicinity of bridge
49	not previously sampled	3.55 C	no data	no data	no data			x	x	spatial extent; potential erosion area; no history of dredging
50	LDW-SS114	3.75 E	CSL	CSL	no data		x	x		arsenic CSL exceedance; PCB and PAH SQS exceedance; bioassay CSL exceedance; downstream of early action area; former Slip 5 nearby; erosion potential

			Considerations for Placing Sampling Locations							
			Sediment Quality			Near Potential source				
Subsurface Location ID	Phase 1 or Phase 2 Location ID	River Mile	Bioassay Exceedances	Detected Surface Chemical Exceedances	Detected Subsurface Chemical Exceedances	Seeps/ Outfall	Upland Activity	Erosion potential	Spatial Coverage	Rationale
51	LDW-SS115	3.8 E	no exceedances; nearby location had SQS exceedance	SQS	no data; nearby location had SQS exceedance	x				PAH SQS exceedance in surface sediment; PCB SQS exceedance in nearby subsurface sediment; outfalls nearby; erosion potential
52	LDW-SS120	3.9 E	SQS	SQS	no data	x	x			PCB and butyl benzyl phthalate SQS exceedance; bioassay SQS exceedance; potential upland sources; storm drains nearby
53	not previously sampled	4.2 E (Slip 6)	no data	no data	no data; nearby location had SQS and CSL exceedances	x		x	x	Benzoic acid CSL exceedance and PCB and BEHP SQS exceedances in nearby subsurface location; outfalls nearby; tug boat activity
54	not previously sampled	4.2 W	no data	no data	no data	x	x		x	spatial coverage; nearby seep had elevated pesticide in seep water; mouth of South Fork Hamm Creek nearby
55	LDW-SS143	4.85 E	no exceedances	CSL	no data	x				PCB CSL exceedance, but no toxicity exceedance; outfalls nearby
56	LDW-SS148	4.75 W	CSL	SQS	no data				x	PCB SQS exceedance, bioassay CSL exceedance; spatial coverage

BEHP – bis(2-ethylhexyl) phthalate

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

W – west of navigation channel

E – east of navigation channel

C – in navigation channel

[a] Data from subsurface sampling for the Glacier NW Ready-Mix dredge event were recently obtained and have not yet been incorporated into the project database. PCBs were detected at a concentration of 25 mg/kg OC in a composite sample collected from the two locations in the southwestern portion of the dredge area (i.e., closest to the mouth of the slip), as shown in Figure 3-1b.

[b] Access may be limited; location will be sampled only if accessible

Table 3-2. Spatial distribution of Phase 2 and historical subsurface sediment sampling locations

River Mile	Phase 2 Locations				Historical Locations Outside of Areas Dredged, Remediated, or Planned for Remediation				Historical Locations Within Areas Dredged, Remediated, or Planned for Remediation			
	West Side of Channel	In Channel	East Side of Channel	Total	West Side of Channel	In Channel	East Side of Channel	Total	West Side of Channel	In Channel	East Side of Channel	Total
0-0.5	2	2	5	9	23	0	1	24	0	0	9	9
0.5-1.0	3	1	6	10	1	1	2	4	0	0	5	5
1.0-1.5	6	1	3	10	3	0	1	4	2	1	3	6
1.5-2.0	2	0	4	6	0	13	1	14	1	0	18	19
2.0-2.5	3	0	4	7	4	5	2	11	2	0	0	2
2.5-3.0	1	0	3	4	0	1	2	3	4	0	19	23
3.0-3.5	1	1	0	2	2	2	6	10	2	0	49	51
3.5-4.0	0	1	3	4	6	0	58	64	20	6	18	44
4.0-4.5	1	0	1	2	1	0	21	22	6	9	0	15
4.5-5.0	1	0	1	2	1	0	1	2	0	6	2	8
Total	**20**	**6**	**30**	**56**	**41**	**22**	**95**	**158**	**37**	**22**	**123**	**182**

Table 3-3. Phase 2 subsurface sediment sampling location coordinates

Location Name	X Coordinate[a]	Y Coordinate[a]	Longitude[b]	Latitude[b]	Estimated Depth Above (+) or Below (-) MLLW (ft)[c]
1	1266326	211298	122 20.9290	47 34.1499	-13.3
2	1267028	211197	122 20.7579	47 34.1356	-23.3
3	1266433	210663	122 20.9000	47 34.0459	-48.6
4	1266960	210600	122 20.7716	47 34.0372	na
5	1266034	210529	122 20.9962	47 34.0225	-9.7
6	1266290	209832	122 20.9307	47 33.9087	-35.2
7	1266852	209602	122 20.7930	47 33.8727	-26.8
8	1266611	209587	122 20.8516	47 33.8695	-39.1
9	1266864	208920	122 20.7869	47 33.7606	-31.9
10	1267170	208772	122 20.7118	47 33.7372	-17.6
11	1265896	208303	122 21.0191	47 33.6560	na
12	1266577	208216	122 20.8532	47 33.6439	-8.3
13	1267583	207102	122 20.6036	47 33.4639	-10.2
14	1267397	207052	122 20.6484	47 33.4551	-36.6
15	1267815	206823	122 20.5458	47 33.4188	-28.4
16	1267971	206669	122 20.5071	47 33.3940	-25.0
17	1268449	206550	122 20.3905	47 33.3759	-15.1
18	1267932	206332	122 20.5150	47 33.3384	-13.8
19	1267011	206189	122 20.7381	47 33.3119	na
20	1267737	206172	122 20.5616	47 33.3115	-34.3
21	1267487	206170	122 20.6223	47 33.3103	-28.7
22	1268190	205909	122 20.4503	47 33.2697	-1.0
23	1268230	205416	122 20.4383	47 33.1887	-18.9
24	1267866	205106	122 20.5253	47 33.1367	na
25	1267957	204752	122 20.5015	47 33.0787	-12.0
26	1268100	204472	122 20.4654	47 33.0331	-15.3
27	1268520	204435	122 20.3632	47 33.0283	-9.8
28	1268204	204204	122 20.4387	47 32.9894	-24.4
29	1268032	204056	122 20.4799	47 32.9644	na
30	1268801	203593	122 20.2909	47 32.8908	-3.1
31	1268937	203090	122 20.2556	47 32.8084	-32.4
32	1269349	202951	122 20.1548	47 32.7870	-16.5
33	1269293	202059	122 20.1641	47 32.6401	na
34	1268808	201999	122 20.2816	47 32.6287	-11.3
35	1269266	201575	122 20.1684	47 32.5604	-7.1
36	1269991	201491	122 19.9918	47 32.5489	-12.5

Location Name	X Coordinate[a]	Y Coordinate[a]	Longitude[b]		Latitude[b]		Estimated Depth Above (+) or Below (-) MLLW (ft)[c]
37	1270688	201421	122	19.8223	47	32.5396	-7.1
38	1269737	200931	122	20.0509	47	32.4560	3.8
39	1270032	200660	122	19.9779	47	32.4124	-1.1
40	1270298	200339	122	19.9118	47	32.3604	-2.1
41	1271170	200294	122	19.6999	47	32.3558	-7.4
42	1271362	199902	122	19.6514	47	32.2920	-10.6
43	1271865	199304	122	19.5264	47	32.1952	-0.7
44	1272232	198952	122	19.4356	47	32.1384	-0.8
46	1272117	198577	122	19.4618	47	32.0765	-7.7
45	1272643	198616	122	19.3343	47	32.0846	-9.3
47	1273340	197422	122	19.1595	47	31.8904	1.8
48	1274534	196653	122	18.8657	47	31.7677	-18.2
49	1275489	195853	122	18.6304	47	31.6391	-18.5
50	1276045	194871	122	18.4907	47	31.4794	-2.9
51	1276134	194727	122	18.4684	47	31.4560	0.7
52	1276295	194178	122	18.4267	47	31.3663	1.8
53	1277460	192936	122	18.1382	47	31.1657	-13.1
54	1276342	192179	122	18.4061	47	31.0376	na
55	1278267	190387	122	17.9304	47	30.7490	na
56	1277573	189993	122	18.0971	47	30.6820	na

na - bathymetry data were not available because the area was too shallow to be surveyed or because barges were present during the bathymetry survey

[a] Coordinates are in Washington State Plane N, NAD83, US survey ft

[b] Coordinates are in degrees and decimal minutes, NAD83

[c] Depth estimated from recent bathymetry data (Windward and DEA 2004)

3.1.3 Sectioning of sediment cores

At each location, single cores (up to 3 m [10 ft] or until refusal, whichever is reached first) will be collected. Collection and processing of sediment cores is discussed in detail in Sections 3.2.3 and 3.2.4, respectively. After processing, each core will be sectioned for chemical analyses according to one of two methods, referred to as Method A and Method B. The lengths of the core sections discussed below represent the measurements of actual recovered core lengths rather than *in situ* depths calculated from the bore logs. Core intervals will generally be divided at 0.5-, 1-, or 2-ft (15-, 30-, and 60-cm) intervals, as described below.[3] However, sections may be divided

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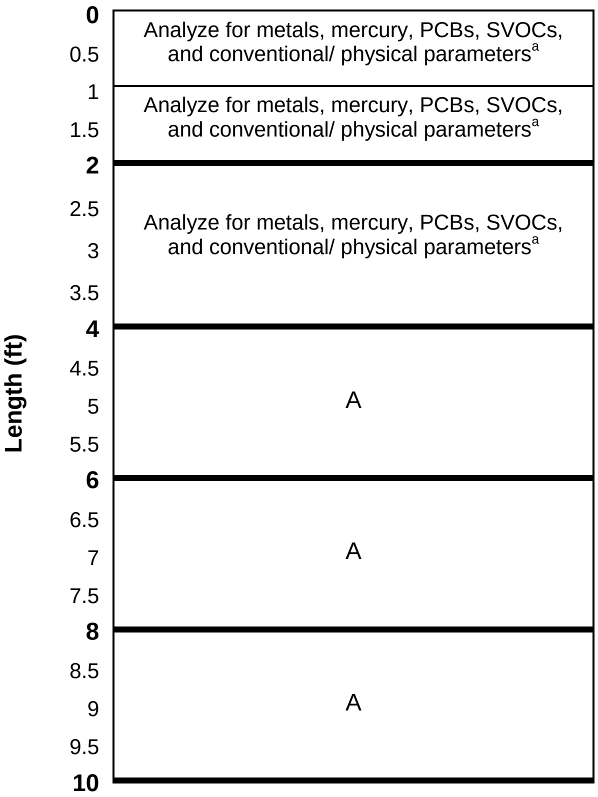
[3] No separate grab samples will be collected from the surface interval (i.e., 0-10 cm or 0-4 in); instead, the results from analyses of the subsurface cores will be evaluated to determine the need for additional surface sediment sampling in the LDW.

at slightly different intervals if clear discontinuities are identified. Any modifications to sampling intervals will be made in consultation with EPA and Ecology oversight personnel, if present while processing the core, and will be documented.

The majority of cores (37 of the 56) will be sectioned according to Method A, which is shown in Figure 3-2. This method involves sectioning the core into a maximum of six intervals (i.e., 0-1, 1-2, 2-4, 4-6, 6-8, and 8-10 ft, depending on the length of core recovered) and submitting the samples for the first three intervals (0-1, 1-2, and 2-4 ft) for initial chemical analyses. Samples collected from the lower three depth intervals (4- to 6-, 6-to 8-, and 8- to 10-ft) will be archived. The selection of archived samples for additional analyses will be determined in consultation with EPA and Ecology based on preliminary, unvalidated data that are expected to be available by April 2006, as well as historical data from nearby cores. Factors that will be considered in selecting archived samples for chemical analyses include the exceedance of SMS criteria or DMMP guidelines in upper intervals or in nearby cores, or the presence of staining/discoloration, sheen, or odor.



Note: For reference, 1 ft is equal to 30 cm

[a] A subset of samples will also be analyzed for TBT, dioxins/furans, and organochlorine pesticides (see Table 3-5).

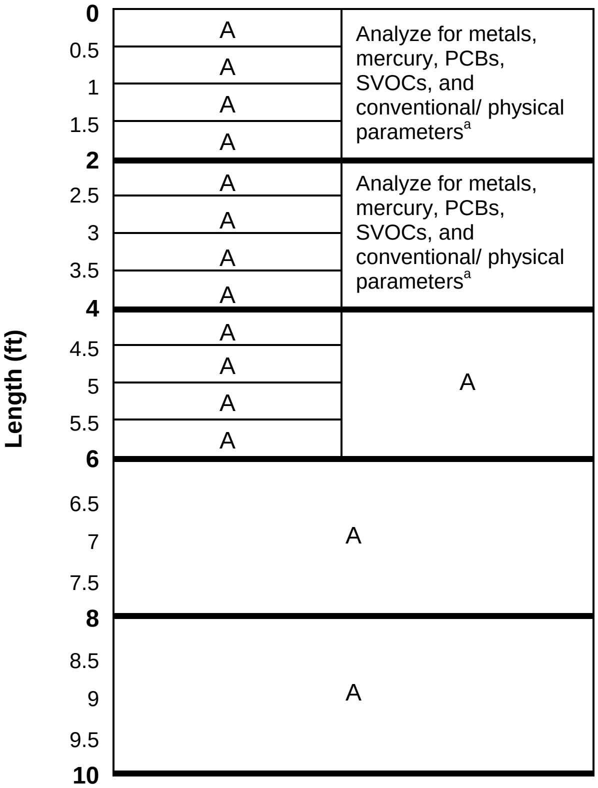
A – Archive for potential chemical analysis of deeper intervals based on results from 0-1, 1-2, and 2-4 ft intervals. If volume is sufficient in the 2-ft intervals, sediment will also be archived for potential grain size analysis.

Figure 3-2. Core processing Method A

The remaining cores (19 of the 56 cores) will be sectioned according to Method B, as shown in Figure 3-3. The uppermost 6 ft of each core will be divided in half lengthwise. One of the halves will then be divided horizontally into three 2-ft (60-cm) sections (i.e., 0-2, 2-4, and 4-6 ft), and the other half will be divided into twelve 0.5-ft (15-cm) sections.. The 0.5-ft sections will not be collected from any intervals that are clearly native alluvial sediments. The bottom portion of the core will be divided into two 2-ft sections (i.e., 6-8 and 8-10 ft), depending on the length of core recovered.

Chemical analyses will initially be conducted on the two 2-ft composite samples from the 0-2 and 2-4 ft intervals. Sediment from 0.5-ft intervals in each core will be archived. These archived samples will be analyzed for a subset of the chemicals analyzed in the 0-2 and 2-4 ft core sections, unless otherwise agreed upon by LDWG, EPA, and Ecology. The specific chemicals to be analyzed in the 0.5-ft intervals will be selected in consultation with EPA and Ecology based on the preliminary, unvalidated chemistry results in the 0-2 and 2-4 ft intervals. The remaining 2-ft composite samples collected from the 4-6, 6-8, and 8-10 ft intervals will also be archived. These samples may be selected for analysis in consultation with EPA and Ecology based on preliminary, unvalidated data from the upper core intervals as well as historical data from nearby cores.

Locations for Method B cores were selected to meet two objectives: 1) to evaluate depositional areas with isolated SQS exceedances to determine if natural recovery may be occurring, and 2) to further evaluate the conceptual site model for sediment stability by obtaining finer vertical resolution of chemical profiles in depositional areas expected to have subsurface SMS exceedances. A list of cores that will be sampled according to Method B and the rationale for their selection is presented in Table 3-4.



Note: For reference, 1 ft is equal to 30 cm

[a] A subset of samples will also be analyzed for TBT, dioxins/furans, and organochlorine pesticides (see Table 3-5).

A – Archive for potential analysis of specific chemicals in 0.5-ft intervals or deeper 2-ft intervals, based on results from the 0-2 ft and 2-4 ft intervals. If volume is sufficient in the 2-ft intervals, sediment will also be archived for potential grain size analysis.

Figure 3-3. Core processing Method B

Table 3-4. Locations selected for core sectioning according to Method B

Subsurface Location ID	River Mile	Existing Sediment Quality: Bioassay Exceedances	Existing Sediment Quality: Detected Chemical Exceedance in Surface Sediment	Existing Sediment Quality: Detected Chemical Exceedance in Subsurface Sediment	SMS Exceedance(s) Greater at Depth than Surface Intervals	Geochronology Core[a]	Higher Potential for Scouring Based on Tug Boat Activity
1	0.0 E	CSL	SQS	no data	no data	none in vicinity	no
2	0.1 E	CSL	CSL	no data	no data	none in vicinity	yes
3	0.15 E	no data	no data	no data	no data	none in vicinity	no
5[b]	0.15 W	no data	no data; nearby locations had SQS exceedances	CSL	yes	near Sg-1	no
12	0.6 W	no data	SQS	CSL	yes	none in vicinity	no
13[c]	0.85 E	no data	no data	no data	no data	none in vicinity	no
16[c]	0.5 E	no data	no data	no data	no data	none in vicinity	yes
20	1.05 C	CSL	CSL	no data	no data	none in vicinity	no
23	1.2 E	no data	no exceedances	CSL	yes	near Sg-3	no
27	1.4 E	CSL	SQS	no data	no data	near Sg-4	no
30	1.6 E	no exceedances	SQS	no data	no data	none in vicinity	no
33	1.85 E	CSL	SQS	no data	no data	none in vicinity	no
35	1.95 W	no exceedances	SQS	no data	no data	near Sg-5	no
43	2.6 E	CSL	CSL	no data	no data	none in vicinity	no
44	2.7 E	no data	no data; nearby location had SQS exceedance	no data	no data	none in vicinity	no
51	3.8 E	no exceedances; nearby location had SQS exceedance	SQS	no data; nearby location had SQS exceedance	no data	near Sg-11b and Sg-11c	no
53	4.2 E (Slip 6)	no data	no data	no data; nearby location had SQS and CSL exceedances	no data	none in vicinity	yes

SUBSURFACE LOCATION ID	RIVER MILE	EXISTING SEDIMENT QUALITY			SMS EXCEEDANCE(S) GREATER AT DEPTH THAN SURFACE INTERVALS	GEOCHRONOLOGY CORE[a]	HIGHER POTENTIAL FOR SCOURING BASED ON TUG BOAT ACTIVITY
		BIOASSAY EXCEEDANCES	DETECTED CHEMICAL EXCEEDANCE IN SURFACE SEDIMENT	DETECTED CHEMICAL EXCEEDANCE IN SUBSURFACE SEDIMENT			
54	4.2 W	no data	no data	no data	no data	near Sg-12	no
56	4.75 W	CSL	SQS	no data	no data	none in vicinity	no

[a] Cores collected as part of sediment stability analyses (Windward and QEA 2005)

[b] If the core collected at location 6 contains a silt layer and is thus comparable to the geochronology core collected at Sg-1, then that core may be analyzed according to Method B instead of the core from location 5. If neither core is comparable, an additional core in the vicinity of Sg-1 may be collected and sampled according to Method B. These decisions will be made in consultation with EPA.

[c] Locations 13 and 16 were selected for finer depth resolution in the area of the historical PCB spill in Slip 1.

For Method A, estimated volumes of 60 and 120 oz of sediment will be available from the 1 and 2-ft sections, respectively. Fifty-two oz are needed for all chemical and physical analyses (see Section 3.3.1). For Method B, an estimated volume of 15 oz will be available from the 0.5-ft sections. The sediment volumes in the 0.5-ft sections will not be sufficient for the full suite of analyses proposed, but will be sufficient for the analysis of a subset of chemicals where a need for finer scale samples is indicated by the results from the 2-ft sections. If major contacts occur in the sediment profiles within these 2-ft sections, and cores are sectioned accordingly, as discussed in Section 3.2.4, it may be necessary to collect more than one core at a particular location to obtain sufficient volume for chemical analyses. The process for collecting and homogenizing additional cores at the same location is discussed in Section 3.2.4. Sampling intervals for the 0.5-ft sections may be adjusted based on the presence of minor contacts in sediment stratigraphy, as described in Section 3.2.4, but the sections will not be divided into intervals of less than 0.5 ft.

3.1.4 Chemical analyses of subsurface samples

Each subsurface sediment sample identified for chemical analyses will be analyzed for SMS chemicals (SVOCs, PCB Aroclors, mercury, and other metals) using analytical methods presented in Section 3.4. In addition, samples will be analyzed by selected ion monitoring (SIM) analysis using GC/MS for selected semivolatile organic compounds (SVOCs) that had elevated RLs in Phase 2 surface sediment samples. This analysis will provide lower detection and RLs for these compounds (see Section 3.4). Each subsurface sediment sample identified for chemical analyses will also be analyzed for total organic carbon (TOC), total solids, and grain size. Atterberg limits, specific gravity, and bulk density will be analyzed on one intact section of core per stratigraphic unit for geotechnical evaluation. It is possible that some cores may have a smaller sample volume than needed for all analyses if debris is present or if a major stratigraphic unit is present within the 1- or 2-ft sections. In cases where an additional core would be needed to obtain sufficient sample volume for geotechnical analyses, the field geologist and the EPA representative will review the availability of geotechnical information in other cores nearby to determine whether an additional core should be collected.

Samples from select locations will also be analyzed for tributyltin (TBT), organochlorine pesticides, or dioxins/furans if historical data indicated elevated concentrations in those areas or if there is a potential nearby source of those chemicals. Locations where these additional chemicals will be analyzed and the rationale for these analyses are presented in Table 3-5.

Table 3-5. Subsurface sediment samples selected for additional chemical analyses

LOCATION ID	TBT	ORGANOCHLORINE PESTICIDES	DIOXINS/FURANS	RATIONALE
1	x			spatial coverage
2		x		public storm drain nearby
3	x			spatial coverage
4	x			spatial coverage
7	x	x		Duwamish/Diagonal CSO nearby
8		x		spatial coverage
9		x		Duwamish/Diagonal CSO nearby
10		x		Duwamish/Diagonal CSO nearby
12	x			spatial coverage
14	x	x		spatial coverage; bioassay CSL exceedance
15	x			spatial coverage
19			x	moderate dioxin/furan TEQ in surface sediment
20	x		x	elevated dioxin/furan TEQ in surface sediment
23	x	x		public storm drain nearby
25	x			elevated TBT concentration in surface sediment
26	x		x	elevated TBT concentration in surface sediment nearby; elevated dioxin/furan TEQ in surface sediment nearby; shipyard nearby
28	x		x	elevated dioxin/furan TEQ in surface sediment nearby; near dry dock
29			x	elevated dioxin/furan TEQ in surface sediment
31	x	x		spatial coverage; dieldrin SL exceedance in subsurface sediment nearby
34		x		public storm drain nearby
36	x			spatial coverage; potential upland source of TBT;
39	x	x	x	spatial coverage
40		x	x	elevated dioxin/furan TEQ and DDT in surface sediment nearby
41			x	moderate dioxin/furan TEQ in surface sediment nearby
53		x		public storm drain nearby
54		x		seep with elevated pesticide in seep water nearby
Total number of locations	**15**	**12**	**8**	

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

TBT – tributyltin

TEQ – toxicity equivalent

3.2 SAMPLING METHODS

This section describes the methods for collecting and processing subsurface sediment cores. Sediment sampling will be conducted at locations shown in Figures 3-1a through 3-1d using a 30-ft pontoon boat operated by MCS Environmental, Inc. All field activities will be performed under the direction of the FC, with EPA and Ecology oversight as appropriate. There may be contingencies during field activities that require modification of the general procedures outlined below. Procedures may be modified at the discretion of the FC after consultation with the Windward PM and the boat operator, if applicable. EPA and Ecology will be consulted in the event that significant deviations from the sampling design are required (e.g., repositioning of a location, as discussed in Section 3.2.3). All modifications will be recorded in the field logbook and on a protocol modification form (Appendix B).

3.2.1 Identification scheme for all locations and samples

Each subsurface sediment core sampling location will be assigned a unique alphanumeric location ID number. The first three characters of the location ID are “LDW” to identify the LDW project area. The next characters are “SC” to indicate the type of samples to be collected (sediment core), followed by a consecutive number identifying the specific location within the LDW.

The sample ID will be similar to the location ID, but will also include a numerical suffix that indicates which depth horizon the sediment sample came from. For example, the sample from the upper 2-ft (60-cm) section of the core collected at location LDW-SC1 will be identified as LDW-SC1-0-2; the 2- to 4-ft (60- to 120-cm) section of sediment from the same core will be identified as LDW-SC1-2-4, and so on. Samples collected at 0.5-ft intervals will be similarly identified; for example, the sample collected from the upper 0.5-ft section of the core collected at location LDW-SC1 will be identified as LDW-SC1-0-0.5. Field replicates will be identified using location numbers starting with 201. For example, the upper 2-ft section of the first field replicate would be identified as LDW-SC201-0-2.

Rinsate blanks, as described in Section 3.5.1, will be assigned the first five characters of the station identifier, followed by “RB” (i.e., LDW-SC-RB). The next character will be a consecutive number beginning with “1.” For example, the first rinsate blank sample collected would be identified as LDW-SC-RB1.

3.2.2 Location positioning

Targeted subsurface sediment sampling locations will be surveyed using a Trimble Pathfinder Pro XR differential global positioning system (DGPS) and Trimble GeoXT data logger. The DGPS includes a global positioning system (GPS) receiver unit onboard the sampling vessel and a Coast Guard beacon differential receiver. The Coast Guard beacon receiver will be used to acquire differential corrections to the GPS signals to produce positioning accuracy to within 1-2 m.

Northing and easting coordinates of the vessel will be updated every second and displayed directly on the Trimble GPS display. The coordinates will be processed in real time and recorded at the time of sampling using the positioning data management software package TerraSync®. Washington State Plane Coordinates, North (NAD 83), Survey Feet, will be used for the horizontal datum. The vertical datum will be the National Ocean Service MLLW datum. Vertical control will be provided using a lead line to sound the water depth and corrected for tidal influence. Tide elevation will be determined by calling the National Ocean Service for data from their automated tide gage located at Pier 54 (206.749.9218).

To ensure the accuracy of the navigation system, a checkpoint will be located at a known point such as a pier face, dock, piling, or similar structure that is accessible by the sampling vessel. At the beginning and end of each day, the vessel will be stationed at the check point, a GPS position reading will be taken, and the reading will be compared with the known land-survey coordinates. The two position readings should agree, within the limits of survey vessel operational mobility, to within 1-2 m.

The GPS will display the vessel's position in relation to the site map during sampling operations. Coordinates for target subsurface sediment locations will have been previously stored in the GPS. The location will be displayed on the area map on the GPS screen, and the vessel's location will be displayed as a moving dot on that map. The range and bearing from the vessel to the target location will be displayed on the screen. The scale of the grid will be magnified as the vessel nears the proposed station location. During sampling, vessel position can be monitored constantly using this display. Actual sample location coordinates will be determined when the sampler is on the bottom, and the cable is taut and perpendicular to the water surface. Sample coordinates will be logged using the GeoXT data logger and also written onto the sediment core drive log (Appendix B) along with the time and sampling station.

3.2.3 Subsurface sediment core collection

Sediment cores will be collected to a 10-ft (3 m) depth below mudline or until refusal, whichever is reached first. Cores will be collected by MCS Environmental using a diver-assisted impact core sampler called the MudMole™. The sampler consists of a 4-in by 4-in square aluminum core tube with a pneumatic powered driving assembly attached to the top with a quick release pin.[4] The core sampler uses the impact from the linear pneumatic hammer delivering approximately 300 blows per minute to drive the core tube into the sediment. The bottom of each core tube will be fitted with a hinged core catcher to prevent loss of the sediment during extraction. Air to operate the pneumatic corer will be provided by an industrial air compressor located on the deck of the sampling vessel.

At each target sampling location, the core sampler will be lowered to the bottom using a winch. At approximately 2-foot intervals, the operator will suspend the driving

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[4] The inside measurements of this tube are 3.75 in by 3.75 in.

operation and the diver will measure the penetration depth of the core tube and internal recovery of the core (total core length minus the void space within the core). During diver operations, the penetration and recovery readings are relayed to the sampling vessel by means of a wireless underwater diver communication system. After driving the core to 10 ft or refusal, the air hammer will be turned off. The final set of penetration and recovery measurements will be made, the actual sampling position will be logged, and the lifting winch will be used to extract the core.

The paired penetration and recovery measurements are used to account for thinning and compaction of the sediments during driving. An on-deck measurement from the top of the core tube to the surface of the sediment within the core tube will also be taken to account for any movement or loss of sediment in the core tube as the core catcher closes during extraction. The penetration and recovery data and the on-deck top-of-sediment measurement will be entered into a spreadsheet program to generate a bore log (Appendix B). Each bore log will include a graph of penetration versus recovery that will be used during processing to identify the *in situ* depth of different sediment horizons, as shown in the example bore log in Appendix B.

Once onboard the sampling vessel, the core catcher will be inspected for signs of sediment loss during retrieval and the average percent recovery will be estimated for each core. The average percent recovery is estimated as the sample length recovered divided by the penetration depth. The following data will be recorded on the Sediment Core Drive Log (Appendix B):

- sampling location, time, and water depth
- mudline elevation
- core tube penetration depth and sample recovery
- physical description of core tube (e.g., intact, bent, full core catcher)

The core tubes will be inspected for adherence to the following criteria:

- core was collected to a depth of at least 10 ft (3.0 m) below mudline
- core tube is not overfilled
- overlying water is present and the surface interval is intact
- estimated recovery is greater than 75 percent
- core tube appears intact without obstructions or blocking

If sample acceptance criteria are not achieved in the first core, the sample will be set aside and up to two additional core drives will be advanced at locations within 10 m of the proposed location. If sample acceptance criteria are not achieved in any of the three cores, oversight personnel will be consulted to discuss whether an alternative location should be sampled. The sampling location may be repositioned at a location greater than 10 m from the proposed location, following discussions with EPA, Ecology, and LDWG representatives. If an alternative location is not selected, the core with the highest sampling depth and recovery will be used.

While the core tube is on deck, the overlying water will be siphoned off using plastic tubing or a similar siphoning device. The cores will be capped, taped, and labeled with the station ID and “top” and “bottom.” Core tubes will be stored horizontally and sealed to minimize loss of moisture during transport. Cores will be transported to a field processing laboratory for subsequent processing, sampling, and logging.

3.2.4 Subsurface sediment core processing

Core tubes will be handled and processed at the field processing laboratory as soon as possible after they are received. Cores will be held for a maximum of 72 hours before processing. Cores that are not processed within four hours will be chilled with ice. Core processing will involve three basic steps: (1) extraction, (2) observation and logging, and (3) sampling.

Sediment will be extracted by cutting the core tube longitudinally with a saw to expose the sediments. If the core was divided into sections on the boat to transport it, this step will be repeated for each section until the entire core is extracted. Sediment in direct contact with the sidewalls of the tube will be carefully removed using stainless steel spatulas, and the profile will be visually logged for major and minor contacts (i.e., regions in the core where sediment characteristics noticeably change), as described below. Photographs of each core will be taken before sampling. The core will be logged by a qualified field geologist, using a key for the physical description of sediment samples and the sediment core processing log (both presented in Appendix B). The field geologist will oversee the sediment core logging process.

Each core will be sub-sectioned into 1- or 2-ft sampling intervals according to the sampling design discussed in Section 3.1 of this document unless a major stratigraphic boundary is present. If a major difference in stratigraphic units is observed, the sample will not be collected at the fixed 1- or 2-ft interval, but will instead include only sediments within the same stratigraphic unit. The sectioning decision for each core will be made in consultation with agency oversight, if present at the time the core is sectioned. For cores processed using Method B as described in Section 3.1, the uppermost 6 ft of half of the core will be sub-sectioned into 0.5-ft sampling intervals (see Figure 3-3). These sampling intervals may be adjusted to maintain consistency in color and grain size within each sample, or based on the presence of odor, sheen, or debris. However, the size of the sampling interval will not be less than 0.5 ft in order to obtain sufficient volume of sediment for chemical analyses. Sediment descriptions and the interpreted *in situ* depths of each sediment horizon (derived from calculations on the bore log) will be recorded on the sediment core processing log (Appendix B). The core processing logs will include:

- sediment type, density/consistency, color, and odor
- debris (wood, paint chips, etc.) or vegetation

- presence of sheen or staining
- measurements of volatile organic compounds (VOCs) using appropriate portable measuring device (e.g., photoionization detector)
- physical soil description
- sediment particle size
- actual sample length and “representative” length before compaction during core collection
- visual stratification and lenses
- biological activity (e.g., shells, tubes, presence of organisms)
- other distinguishing characteristics or features

After a core is logged, sediment from designated sampling intervals in that core will be spooned into stainless steel bowls, homogenized until uniform in color and texture, and placed into pre-cleaned, labeled glass jars for chemical analyses, as specified in Section 3.3.1. If an interval shallower than 2 ft must be collected based on stratigraphy, and insufficient sample volume is available for chemical analyses (< 52 oz), the Windward FC will be notified immediately so that the field crew can collect an additional core at that location. Homogenized material from the individual intervals in the first core will be stored in pre-cleaned, labeled glass jars in a cooler on ice until the second core has been processed. Sediment from corresponding intervals of both cores will then be homogenized together and samples will be collected from the composited material. Organisms and debris will be removed prior to distribution to sample containers; removed materials will be noted in the field logbooks. All sample containers will be labeled on the outside in indelible ink with the sample identification number, date collected, and analysis to be performed.

3.2.5 Field sampling and processing equipment

The items needed in the field for subsurface sediment sampling and sample processing are identified in Table 3-6. The FC will check that all equipment is included and in working order each day before sampling personnel go in the field. As part of the mobilization process, each item will be double-checked by the FC.

Table 3-6. Subsurface sediment collection and processing equipment

GENERAL EQUIPMENT	
QAPP	Cellular phone
Key personnel contact information list	Digital camera
Field sample collection forms	First aid kit
Field notebooks (Rite in the Rain®)	Garbage bags
Chain-of-custody forms	Paper towels
Pens, pencils, Sharpies	Tape measure
Powder-free nitrile exam gloves	
FIELD COLLECTION EQUIPMENT	**SAMPLE PROCESSING EQUIPMENT**
Tide tables	Saw for cutting aluminum core tubes
Study area maps	Stainless-steel plates, spatulas, bowls, and spoons
Hard hats	Sample jars
Head lamps	Sample labels
Personal flotation devices (PFDs)	Clear packing tape
Raingear	Custody seals
Rubber work gloves	Alconox® detergent
Safety glasses, sun glasses	Scrub brushes
Steel-toe boots	Distilled water
Core tubes	Heavy duty aluminum foil
Duct tape	Ziploc® bags
Plastic tubing/turkey basters (to siphon overlying water)	Coolers
	Cooler temperature blanks
	Ice (wet)
	Flashlights and temporary work lights
	Safety glasses

3.2.6 Decontamination procedures

All core tubes will be decontaminated prior to being taken into the field and ends will be sealed to prevent contamination. Sample processing and homogenizing equipment, including the mixing bowls and stainless-steel implements, will be decontaminated following Puget Sound Estuary Program (PSEP) (1997a) guidelines between processing of samples using the following procedures:

- rinse with tap water and scrub until free of sediment
- wash with phosphate-free detergent solution
- rinse with tap water
- rinse with distilled water
- cover with aluminum foil

Acid or solvent washes will not be used in the field laboratory because of safety considerations and problems associated with rinsate disposal and sample integrity. Specifically:

- the use of acids or organic solvents may pose a safety hazard to the field crew
- disposal and spillage of acids and solvents during field activities pose an environmental concern
- residues of solvents and acids on sampling equipment may affect sample integrity for chemical testing

Any equipment that cannot be cleaned in a satisfactory manner will not be used for further sampling or homogenizing activities.

3.2.7 Field-generated waste disposal

Excess sediment from sampled cores and cores that do not meet the acceptance criteria will be discarded into 55-gallon drums and delivered to ARI when full. ARI will assume responsibility for appropriate off-site disposal of these drums and their contents. All disposable sampling materials and personal protective equipment used in sample processing, such as disposable coveralls, gloves, and paper towels, will be placed in heavyweight garbage bags or other appropriate containers. Disposable supplies will be removed from the field laboratory by sampling personnel and placed in a normal refuse container for disposal as solid waste.

3.3 SAMPLE HANDLING AND CUSTODY REQUIREMENTS

This section describes how individual samples will be processed, labeled, tracked, stored, and transported to the laboratory for analysis. In addition, this section describes sample custody procedures and shipping requirements. Sample custody is a critical aspect of environmental investigations. Sample possession and handling must be traceable from the time of sample collection, through laboratory and data analyses, to delivery of the sample results to the recipient.

3.3.1 Sample handling procedures

Samples for chemical analyses will be placed in appropriately sized, certified-clean, labeled, wide-mouth glass jars and capped with Teflon®-lined lids (Table 3-7). All sample containers will be filled leaving a minimum of 1 cm of headspace to prevent breakage during shipping and storage. Sample containers that will be transported to ARI will be placed in individual Ziploc bags in case of breakage, and placed in a cooler with wet ice. Prior to shipment of samples to Axys, each glass container will be wrapped in bubble wrap and placed in a cooler with wet ice.

Table 3-7. Sample containers and laboratory conducting chemical analyses

PARAMETER	CONTAINER	LABORATORY
Sediment Samples		
PCBs (as Aroclors), organochlorine pesticides, SVOCs, SVOCs by SIM, TBT, metals, TOC, and total solids[a]	16-oz glass jar	ARI
Grain size	16-oz glass jar[a]	ARI
Dioxins/furans	8-oz glass jar	Axys

PARAMETER	CONTAINER	LABORATORY
Archive	8 or 16-oz glass jars	ARI
Bulk density, Atterberg limits, and specific gravity	3-inch diameter Shelby tube[b]	ARI
Aqueous Samples (rinsate blanks)		
PCBs (as Aroclors), organochlorine pesticides, SVOCs, SVOCs by SIM, TBT	6 500-mL glass amber jars	ARI
Metals	500-mL HDPE jar	ARI

[a] Sediment archived for potential grain size analysis will be stored in 16-oz HDPE jars.

[b] Approximately 12 oz of sediment is needed for this sample, including the extra sample surrounding the tube that cannot be used for analysis because it has been in contact with the tube.

HDPE – high density polyethylene

Sample labels will be waterproof and self-adhering. Each sample label will contain the project number, sample identification, preservation technique, analyses, date and time of collection, and initials of the person(s) preparing the sample. A completed sample label will be affixed to each sample container. The labels will be covered with clear tape immediately after they have been completed to protect them from being stained or spoiled from water and sediment.

At each laboratory, a unique sample identifier will be assigned to each sample (using either project ID or laboratory ID). The laboratory will ensure that a sample tracking record follows each sample through all stages of laboratory processing. The sample tracking record must contain, at a minimum, the name/initials of responsible individuals performing the analyses, dates of sample extraction/preparation and analysis, and the type of analysis being performed.

3.3.2 Custody procedures

Cores or samples are considered to be in custody if they are: 1) in the custodian’s possession or view, 2) retained in a secured place (under lock) with restricted access, or 3) placed in a container and secured with an official seal(s) such that the sample cannot be reached without breaking the seal(s). Custody procedures will be used for all cores and samples throughout the collection, transport, and analyses, and for all data and data documentation whether in hard copy or electronic format.

Custody procedures will be initiated during sediment core collection. A COC form will accompany cores to the field processing laboratory and samples from the field processing laboratory to the analytical laboratory. Each person who has custody of the cores or samples will sign the COC form and ensure that the cores or samples are not left unattended unless properly secured. Minimum documentation of sample handling and custody will include:

- core or sample location, project name, and unique identification number
- core or sample collection date and time
- any special notations on sample characteristics or problems
- initials of the person collecting the core or sample

- date core or sample was sent to the field processing area or laboratory
- shipping company name and waybill number

The FC will be responsible for all tracking and custody procedures for cores and samples in the field. The FC will be responsible for final sample inventory and will maintain custody documentation. The FC or designee will also complete COC forms prior to transferring cores or samples to the field processing area or to the analytical laboratory. At the end of each day, and prior to transfer, COC entries will be made for all cores and samples. Information on the labels will be checked against sample log entries, and sample tracking forms and samples will be recounted. COC forms will accompany all cores and samples. The COC forms will be signed at each point of transfer. Copies of all COC forms will be retained and included as appendices to QA/QC reports and data reports. Sediment samples will be hand delivered or shipped in sealed coolers to the analytical laboratories. The FC will ensure that the laboratory has accepted delivery of the shipment at the specified time.

The laboratories will ensure that COC forms are properly signed upon receipt of the samples and will note questions or observations concerning sample integrity on the COC forms. The laboratories will contact the FC and Project QA/QC Coordinator immediately if discrepancies are discovered between the COC forms and the sample shipment upon receipt.

The laboratory will ensure that a sample-tracking record follows each sample through all stages of laboratory processing. The sample-tracking record must contain, at a minimum, the name/initials of individuals responsible for performing the analyses, dates of sample extraction/preparation and analysis, and the types of analyses being performed.

3.3.3 Shipping requirements

Sample processing will be conducted at a field laboratory; all sediment analyses, except analysis of dioxins and furans, will be performed at ARI. Coolers containing samples for analysis at ARI will be hand delivered; coolers containing samples for analysis at Axys will be stored frozen at Windward and all samples will be shipped to Axys overnight at the end of the sampling effort. The temperature inside the cooler(s) containing sediment samples will be checked upon receipt at the laboratory by either measuring the temperature of blank water samples packed inside the coolers, or using an infrared (IR) device. The laboratory will specifically note any coolers that do not contain ice packs or that are not sufficiently cold (4° ± 2°C) upon receipt.

3.4 ANALYTICAL METHODS

This section discusses standard methods and DQIs for the chemical analyses.

3.4.1 Laboratory methods and sample handling

A list of the analyses to be conducted is presented in Table 3-8. All analyses will be conducted at ARI except dioxins and furans, which will be conducted at Axys. In addition to the analyses specified, additional sediment from each sample will be archived frozen at ARI in the event that additional chemical analyses are necessary. Analytical methods and sample handling requirements are presented in Table 3-9.

Table 3-8. Analyses to be conducted at each laboratory

ARI	AXYS
PCB Aroclors Organochlorine pesticides (subset of samples) SVOCs (including PAHs and low-level SVOCs by SIM) Metals including mercury TBT (subset of samples) TOC, total solids, grain size Atterberg limits, bulk density, specific gravity	Dioxins and furans (subset of samples)

Table 3-9. Laboratory analytical methods and sample handling requirements for sediment samples

PARAMETER	METHOD	REFERENCE	MAXIMUM SAMPLE HOLDING TIME[a]	PRESERVATIVE
PCBs as Aroclors	GC/ECD	EPA 8082	14 days to extract, 40 days to analyze[b,c]	cool/4°C
Dioxins and furans	HRGC/HRMS	EPA 1613B	1 year to extract, 40 days to analyze	freeze/-20°C
Organochlorine pesticides[d]	GC/ECD	EPA 8081A	14 days to extract, 40 days to analyze[b,c]	cool/4°C
SVOCs (including PAHs)[e,f]	GC/MS	EPA 8270D	14 days to extract, 40 days to analyze[b,c]	cool/4°C
Selected SVOCs[g]	GC/MS	EPA 8270-SIM	14 days to extract, 40 days to analyze[b,c]	cool/4°C
Mercury	CVAA	EPA 7471A	28 days	cool/4°C
Other metals[h]	ICP-AES	EPA 6010B	6 months[b]	cool/4°C[i]
TBT, DBT, MBT (as ions)	GC/FPD	Krone et al. (1989)	14 days to extract, 40 days to analyze[c]	cool/4°C
Grain size	sieve/ hydrometer	PSEP (1986)	none	none
TOC	combustion	Plumb (1981)	28 days	cool/4°C
Total solids	oven-dried	EPA 160.3	7 days[j]	cool/4°C
Atterberg limits	sieve	ASTM D4318	none	none
Specific gravity	pycnometer	ASTM D854	none	none
Bulk density	volumetric/ gravimetric	ASTM D2937	none	none

[a] All sample extracts will be archived frozen at the laboratory until the Windward PM authorizes their disposal

[b] Sediment may be frozen, with a maximum holding time of 1 year

[c] Aqueous rinsate blanks have a maximum holding time of 7 days to extract and 40 days to analyze, and will be stored at 4°C

[d] Target pesticides include: 4,4'-DDT, 4,4'-DDE, 4,4'-DDD, 2,4'-DDT, 2,4'-DDE, 2,4'-DDD, aldrin, alpha-BHC, beta-BHC, delta-BHC, gamma-BHC, oxychlordane, alpha- and gamma-chlordane, cis- and trans-nonachlor, dieldrin, endosulfan, endosulfan sulfate, endrin, heptachlor, heptachlor epoxide, hexachlorobenzene, methoxychlor, mirex, and toxaphene

[e] The SVOC method will be calibrated to quantify DDT isomers in addition to standard SVOC analytes. These data will be used to confirm concentrations determined by Method 8081A where the presence of PCB congeners may interfere with the DDT quantitation

[f] Target PAHs include: anthracene, pyrene, dibenzofuran, benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene, benzo(b)fluoranthene, fluoranthene, benzo(k)fluoranthene, acenaphthylene, chrysene, benzo(a)pyrene, dibenz(a,h)anthracene, benz(a)anthracene, acenaphthene, phenanthrene, fluorene, 1-methylnaphthalene, naphthalene, 2-methylnaphthalene

[g] Selected SVOCs for SIM include: 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 2-methylphenol, benzoic acid, benzyl alcohol, butyl benzyl phthalate, hexachlorobenzene, hexachlorobutadiene, n-nitrosodimethylamine, n-nitrosodiphenylamine, n-nitrosodi-n-propylamine, and pentachlorophenol. Chemicals analyzed using SIM will not be included in the EPA Method 8270 analyte list.

[h] Arsenic, antimony, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc

[i] Aqueous rinsate blanks will be preserved with nitric acid

[j] Sediment may be frozen, with a maximum holding time of 6 months

CVAA – cold vapor atomic absorption
GC – gas chromatography
ECD – electron capture detection
FPD – flame photometric detection
MS – mass spectrometry
HR – high resolution
SIM – selected ion monitoring
ICP – inductively coupled plasma
AES – atomic emission spectrometry
DBT – dibutyltin
MBT – monobutyltin
TBT – tributyltin
PSEP – Puget Sound Estuary Program
SVOC – semivolatile organic compound

3.4.2 Data quality indicators

The parameters used to assess data quality are precision, accuracy, representativeness, comparability, completeness, and sensitivity. Table 3-10 lists specific DQIs for laboratory chemical analyses of sediment samples. These parameters are discussed in more detail in the following sections.

Table 3-10. Data quality indicators for sediment analyses

PARAMETER	UNITS	SENSITIVITY		PRECISION	ACCURACY	COMPLETENESS
		RL[a]	MDL[a]			
PCBs as Aroclors	µg/kg dw	4[b]	0.397	±50%	50 – 150%	95%
Dioxins and furans	ng/kg dw	1.0 – 10	0.036 – 2.390	±50%	50 – 150%	95%
Organochlorine pesticides	µg/kg dw	1.0 – 100	0.013 – 2.96	±50%	50 – 150%	95%
PAHs	µg/kg dw	20	3.9 – 12.24	±50%	40 – 130%	95%
SVOCs[c]	µg/kg dw	20 – 100	5.95 – 67.7	±50%	40 – 130%	95%
Selected SVOCs - SIM	µg/kg dw	6.7 – 67	1.35 – 52.7	±50%	40 – 130%	95%
Mercury	µg/kg dw	0.05	0.003	±30%	55 – 137%	95%
Other metals[d]	mg/kg dw	0.2 – 5.0	0.04 – 1.24	±30%	70 – 130%	95%
Tributyltin, dibutyltin, monobutyltin (as ions)	µg/kg dw	6.0	1.33 – 4.79	±50%	20 – 130%	95%
Grain size	%	0.1	na	±30%	na	95%
TOC	% dw	0.02	0.01	±30%	na	95%
Total solids	% ww	0.01	na	±20%	na	95%
Bulk density	g/cc	0.1	na	na	na	95%
Atterberg Limits	na	na	na	na	na	95%
Specific gravity	na	na	na	na	na	95%

[a] RLs and MDLs for individual chemicals are presented in Appendix C

[b] Samples will be screened prior to PCB Aroclor analysis. Samples with detected Aroclors greater than 30 µg/kg dw will be prepared using a standard preparatory technique providing an RL of 20 µg/kg dw. Samples with no detected Aroclors or with detected Aroclors at concentrations less than 30 µg/kg dw will be prepared using the low-level method with an RL of 4 µg/kg dw.

[c] MDLs for SVOCs other than PAHs and selected SVOCs by SIM

[d] ICP AES MDLs presented. Other methods (i.e., GFAA or ICP-MS) may be used for metals analysis

na – not applicable

3.4.2.1 Precision

Precision is the measure of the reproducibility among individual measurements of the same property, usually under similar conditions, such as multiple measurements of the same sample. Precision is assessed by performing multiple analyses on a sample and is expressed as an RPD when duplicate analyses are performed and as a percent relative standard deviation (% RSD) when more than two analyses are performed on the same sample (e.g., triplicates). Precision is assessed by laboratory duplicate analyses (duplicate samples, matrix spike duplicates, LCS duplicates) for all parameters. When duplicate samples are not available or spiking of the matrix is inappropriate; precision is assessed by laboratory triplicate analyses (e.g., lipid, TOC, grain size measurements). Precision measurements can be affected by the nearness of a chemical concentration to the MDL, where the percent error (expressed as either % RSD or RPD) increases. The DQI for precision varies depending on the analyte (Table 3-10). The equations used to express precision are as follows:

$$\text{RPD} = \frac{(\text{measured conc} - \text{measured duplicate conc})}{(\text{measured conc} + \text{measured duplicate conc}) \div 2} \times 100$$

$$\%\text{RSD} = (\text{SD}/\text{D}_{\text{ave}}) \times 100$$

where:

$$\text{SD} = \sqrt{\left(\frac{\left(\sum \text{Dn} - \text{D}_{\text{ave}}\right)^2}{(n-1)}\right)}$$

D = sample concentration

D_{ave} = average sample concentration

n = number of samples

SD = standard deviation

3.4.2.2 Accuracy

Accuracy is an expression of the degree to which a measured or computed value represents the true value. Accuracy may be expressed as the percent deviation from the certified value for a SRM result and/or a percentage recovery for matrix spike and LCS analyses. The DQI for accuracy varies, depending on the analyte (Table 3-10). Below is the equation used to express accuracy for spiked samples:

$$\text{Percent recovery} = \frac{\text{spiked sample result} - \text{unspiked sample result}}{\text{amount of spike added}} \times 100$$

3.4.2.3 Representativeness

Representativeness expresses the degree to which data accurately and precisely represent an environmental condition. The sampling approach was designed to address the specific data needs described in Section 2.2. Assuming those needs are met, the samples collected should be considered adequately representative of the environmental conditions they are intended to characterize.

3.4.2.4 Comparability

Comparability expresses the confidence with which one dataset can be evaluated in relation to another dataset. The sample collection and chemical and physical testing will adhere to the most recent PSEP QA/QC procedures (PSEP 1997b) and EPA and PSEP analytical protocols.

3.4.2.5 Completeness

Completeness is a measure of the amount of data that is determined to be valid in proportion to the amount of data collected. Completeness will be calculated as follows:

$$\text{Completeness} = \frac{\text{number of valid measurements}}{\text{total number of data points planned}} \times 100$$

The DQI for completeness for all components of this project is 95%. Data that have been qualified as estimated because the QC criteria were not met will be considered valid for the purpose of assessing completeness. Data that have been qualified as rejected will not be considered valid for the purpose of assessing completeness.

3.4.2.6 Sensitivity

Analytical sensitivity is a measure of both the ability of the analytical method to detect the analyte and the concentration that can be reliably quantified. The minimum concentration of the analyte that can be detected is the MDL. The minimum concentration that can be reliably quantified is the RL. ARI uses both MDLs and RLs for reporting analyte concentrations. For this study, MDLs and RLs will be used as measures of sensitivity for each of the analyses conducted by ARI. The data report will present a comparison of these MDLs and RLs to analytical concentration goals presented in Appendix C of the surface sediment QAPP (Windward 2005) and to the practical quantitation limits recommended for sediment analyses by Ecology (Ecology 2003).

Axys calculates a sample-specific DL, which is generally 3x the method blank concentration, and a lower calibration limit defined by the lowest concentration on the calibration curve for which a linear instrument response is observed. The latter limit is analogous to the RL.

Both laboratories will report detected concentrations above the RL without qualification, and will report detected concentrations between the sample-specific DL (Axys) or MDL (ARI) and the RL with a J qualifier indicating that the concentration is an estimate. The RLs and MDLs are presented in Appendix C.

3.5 QUALITY ASSURANCE/QUALITY CONTROL

The QA/QC criteria for the field and laboratory analyses are described below.

3.5.1 Field quality control samples

Field replicate samples will be collected and analyzed to evaluate spatial variability in the field. Field replicate samples will be collected from two separate sediment cores collected from the same location. A minimum of one field replicate will be analyzed for each group of 20 samples. In addition, rinsate blanks will be collected from sample homogenizing equipment at a rate of one blank per week.

Although data validation guidelines have not been established for field quality control samples, the data resulting from the analyses of these samples is useful in identifying possible problems resulting from sample collection or sample processing in the field. All field quality control samples will be documented in the field logbook and verified by the project QA/QC coordinator or a designee.

3.5.2 Chemical analyses quality control criteria

Before analyzing the samples, the laboratory must provide written protocols for the analytical methods to be used, calculate MDLs for each analyte in each matrix of interest,[5] and establish an initial calibration curve for all analytes. The laboratory must demonstrate their continued proficiency by participation in inter-laboratory comparison studies and through repeated analyses of certified reference materials, calibration checks, laboratory reagent blanks, and spiked samples.

3.5.2.1 Determination of MDLs

The MDL is defined as the lowest concentration of an analyte or compound that a method can detect in either a sample or a blank. ARI determines MDLs using standard procedures outlined in 40CFR136, where seven or more replicate samples are fortified at 1 to 5 times (but not to exceed 10 times) the expected MDL concentration. The MDL is then determined by calculating the standard deviation of the replicates and multiplying by the students t-value (a factor of 3.14 for seven MDL replicates). ARI must submit an initial demonstration of MDLs to EPA prior to sample collection.

3.5.2.2 Sample delivery group

Project- and/or method-specific quality control measures such as matrix spikes and matrix spike duplicates will be analyzed per sample delivery group (SDG) or sample

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[5] MDLs are not calculated by Axys; instead sample-specific DLs are calculated, as discussed in Section 3.4.2.6

preparatory batch. An SDG is defined as no more than 20 samples or a group of samples received at the laboratory within a two-week period. Although a SDG may span two weeks, all samples within an SDG will be analyzed within the maximum holding times for each analytical method.

3.5.2.3 Laboratory quality control criteria

The analyst will review results of QC analyses (described below) from each SDG immediately after it has been analyzed. The QC sample results will then be evaluated to determine whether control limits have been exceeded. If control limits are exceeded in the SDG, the project QA/QC coordinator will be contacted immediately, and corrective action, such as method modifications followed by reprocessing of the affected samples, will be initiated before processing a subsequent SDG.

All primary chemical standards and standard solutions used in this project will be traceable to the National Institute of Standards and Technology, Environmental Resource Associates, National Research Council of Canada, or other documented, reliable, commercial sources. The accuracy of the standards will be verified by comparison with an independent standard. Laboratory QC standards are verified a multitude of ways. Second-source calibration verifications are run (i.e., same analytes of interest made by two different manufacturers) immediately following calibrations. New working standard mixes (calibrations, spikes, etc.) are verified against the results of the original solution and must be within 10%. Newly purchased standards are verified against current data. Any impurities found in the standard will be documented. The following sections summarize the procedures that will be used to assess data quality throughout sample analysis. Table 3-11 summarizes the QC procedures and sample analyses to be performed by the laboratory. The associated control limits for precision and accuracy are summarized in Table 3-10.

Table 3-11. QC sample analysis summary

Analysis Type	Initial Calibration	Second Source Initial Calibration Verification	Continuing Calibration Verification	Laboratory Control Samples	Field Replicates	Matrix Replicates	Matrix Spikes	Matrix Spike Duplicates	Method Blanks	Standard Reference Material	Surrogate Spikes
PCB Aroclors	prior to analysis	after initial calibration	every 20 injections or 12 hrs, whichever is more frequent	1 per prep batch	1 per 20 samples	none	1 per prep batch or SDG	1 per prep batch or SDG	1 per prep batch	1 per 20 samples	each sample
Dioxins/furans	prior to analysis	after initial calibration	Prior to 12 hour analytical batch	1 per prep batch	none	none	na	na	1 per prep batch	1 per 20 samples	each sample
Organochlorine pesticides[a]	prior to analysis	after initial calibration	every 20 injections or 12 hrs, whichever is more frequent	1 per prep batch	1 per 20 samples	none	1 per prep batch or SDG	1 per prep batch or SDG	1 per prep batch	1 per 20 samples	each sample
Mercury	Daily, prior to analysis	after initial calibration	every 10 samples	1 per prep batch	1 per 20 samples	1 per prep batch or SDG	1 per prep batch or SDG	na	1 per prep batch	1 per 20 samples	na
Other metals	Daily, prior to analysis	after initial calibration	every 10 samples	1 per prep batch	1 per 20 samples	1 per batch or SDG	1 per prep batch or SDG	na	1 per prep batch	1 per 20 samples	na
SVOCs, including PAHs	prior to analysis	after initial calibration	Prior to 12 hour analytical batch	1 per prep batch	1 per 20 samples	none	1 per prep batch or SDG	1 per prep batch or SDG	1 per prep batch	1 per 20 samples	each sample
SVOCs-SIM	prior to analysis	after initial calibration	Prior to 12 hour analytical batch	1 per prep batch	1 per 20 samples	none	1 per prep batch or SDG	1 per prep batch or SDG	1 per prep batch	1 per 20 samples	each sample
TBT	prior to analysis	after initial calibration	Prior to 12 hour analytical batch	1 per prep batch	1 per 20 samples	none	1 per prep batch or SDG	1 per prep batch or SDG	1 per prep batch	1 per 20 samples	each sample
Grain size	na	na	na	na	1 per 20 samples	1 per batch or SDG	na	na	na	na	na
TOC	Daily, prior to analysis	after initial calibration	every 10 samples	na	1 per 20 samples	1 per batch or SDG	1 per batch or SDG	na	1 per prep batch	na	na
Percent solids	na	na	na	na	1 per 20 samples	1 per batch or SDG	na	na	na	na	na
Atterberg limits	na	na	na	na	1 per 20 samples	na	na	na	na	na	na
Specific gravity	na	na	na	na	1 per 20 samples	na	na	na	na	na	na
Bulk density	na	na	na	na	1 per 20 samples	na	na	na	na	na	na

[a] Aroclor standards will be run as interference check samples for this analysis

Batch – Group of samples of the same matrix analyzed or prepared at the same time, not to exceed 20 samples

na – not applicable

Matrix Replicates

Analytical replicates provide information on the precision of the analysis and are useful in assessing potential sample heterogeneity and matrix effects. Analytical replicates are subsamples of the original sample that are prepared and analyzed separately assuming sufficient sample volume is available. For metals and conventional measurements, a minimum of one matrix replicate will be analyzed for every batch of 20 samples or fewer.

Matrix Spikes and Matrix Spike Duplicates

The analysis of matrix spike samples provides information on the extraction efficiency of the method on the sample matrix. By performing duplicate matrix spike analyses, information on the precision of the method is also provided. For organic analyses except dioxins and furans, a minimum of one matrix spike and matrix spike duplicate will be analyzed for each SDG or preparatory batch of 20 samples or fewer, when possible. For dioxins and furans, an isotope dilution technique is used so matrix spiking is not applicable. For inorganic parameters, a matrix spike will be analyzed in each SDG or preparatory batch, when possible.

Method Blanks

Method blanks are analyzed to assess possible laboratory contamination at all stages of sample preparation and analysis. A minimum of one method blank will be analyzed for each extraction/digestion batch or for every 20 samples, whichever is more frequent.

Standard Reference Material

SRMs are samples of similar matrix and of known analyte concentration that are processed through the entire analytical procedure and used as an indicator of method accuracy. A minimum of one SRM will be analyzed for every 20 samples, as available.

Surrogate Spikes

All project samples analyzed for organic compounds will be spiked with appropriate surrogate compounds as defined in the analytical methods. Surrogate recoveries will be reported by the laboratories; however, no sample results will be corrected for recovery using these values, with the exception of the isotope dilution corrections that are required elements of the dioxin/furan analysis (EPA Method 1613).

Laboratory Control Samples

LCSs are analyzed as a measure of the accuracy of the test methods. LCS recoveries will be reported by the laboratories; however, no sample results will be corrected for recovery using these values.

Interference Check Samples

In order to identify specific organochlorine pesticides that may coelute with PCB congeners, single point mid-concentration PCB standards (Aroclors 1248, 1254, and

1260) will be run with single-component pesticides in the initial calibration for all SDGs analyzed for both pesticides and PCBs. Additional Aroclors will be run if they are detected in sediment samples. The resulting data will be reviewed by data validators in order to assess potential interference issues affecting the reported pesticide results. In addition, DDT isomers will be analyzed in the SVOC analysis. These results will be used to verify higher concentrations of DDT isomers reported by the pesticide method.

Internal Standard Spikes

Internal standards may be used for calibrating and quantifying organic compounds and/or metals by ICP-MS. If internal standards are used, all calibration, QC, and project samples will be spiked with the same concentration of the selected internal standard(s). Internal standard recoveries and retention times must be within method and/or laboratory criteria.

3.6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

Prior to each field event, measures will be taken to test, inspect, and maintain all field equipment. All equipment used, including the GPS unit and digital camera, will be tested for use before leaving for the field event.

The FC will be responsible for overseeing the testing, inspection, and maintenance of all field equipment. The laboratory PM will be responsible for ensuring that laboratory equipment testing, inspection, and maintenance requirements are met. The methods used in calibrating the analytical instruments are described in the following section.

3.7 INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

Multipoint initial calibration will be performed on each instrument at the start of the project, after each major interruption to the analytical instrument, and when any continuing calibration does not meet the specified criteria. The number of points used in the initial calibration is defined in each analytical method. Continuing calibrations will be performed every 12 hrs or 10 to 20 samples for the organic analyses, once every 10 samples for the inorganic analyses, and with every sample batch for conventional parameters to ensure proper instrument performance.

In addition, if an Aroclor is detected in a sample, then the standard for that Aroclor must be analyzed in the continuing calibration within 72 hrs of the original detection of the Aroclor. Gel permeation chromatography calibration verifications will be performed at least once every seven days and corresponding raw data will be submitted by the laboratory with the data package. In addition, florisil performance checks will be performed for every florisil lot and the resulting raw data will be submitted with the data package.

Calibration of analytical equipment used for chemical analyses includes instrument blanks or continuing calibration blanks, which provide information on the stability of the baseline established. Continuing calibration blanks will be analyzed immediately after the continuing calibration verification, at a frequency of one blank for every 10 samples analyzed for inorganic analyses and one blank for every 12 hours or 10-20 samples for organic analyses. If the continuing calibration does not meet the specified criteria, the analysis must stop. Analysis may resume after corrective actions have been taken to meet the method specifications. All project samples analyzed by an instrument found to be out of compliance must be reanalyzed.

None of the field equipment requires calibration.

3.8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

The field team leaders for each sampling event will have a checklist of supplies required for each day in the field (see Section 3.2.5). The FC will gather and check these supplies daily for satisfactory conditions before each field event. Batteries used in the GPS unit and digital camera will be checked daily and recharged as necessary. Supplies and consumables for field sampling will be inspected upon delivery and accepted if the condition of the supplies is satisfactory. For example, jars will be inspected to ensure that they are the correct size and quantity and were not damaged in shipment.

3.9 DATA MANAGEMENT

All field data will be recorded on field forms (see Appendix B), which will be checked for missing information by the FC at the end of each field day and amended. Field forms will be archived in the Windward library. All photographs will be transferred to a compact disk.

Analytical laboratories will submit data in an electronic format, as described in Section 2.6.2, Table 2-2. The laboratory PM will contact the project QA/QC coordinator prior to data delivery to discuss specific format requirements.

A library of routines will be used to translate typical electronic output from laboratory analytical systems and to generate data analysis reports. The use of automated routines ensures that all data are consistently converted into the desired data structures and that operator time is kept to a minimum. In addition, routines and methods for quality checks will be used to ensure such translations are correctly applied.

Written documentation will be used to clarify how field and analytical laboratory duplicates and QA/QC samples were recorded in the data tables and to provide explanations of other issues that may arise. The data management task will include keeping accurate records of field and laboratory QA/QC samples so that project team members who use the data will have appropriate documentation. Data management files will be stored on a secure computer.

4.0 Assessment and Oversight

4.1 COMPLIANCE ASSESSMENTS AND RESPONSE ACTIONS

EPA, Ecology, or their designees may observe field activities during each sampling event, as needed. If situations arise where there is an inability to follow QAPP methods precisely, the Windward PM will determine the appropriate actions and will consult EPA and Ecology if the issue is significant.

4.1.1 Compliance assessments

Laboratory and field performance assessments consist of on-site reviews conducted by EPA of QA systems and equipment for sampling, calibration, and measurement. EPA personnel may conduct a laboratory audit prior to sample analysis. Any pertinent laboratory audit reports will be made available to the project QA/QC coordinator upon request. Analytical laboratories are required to have written procedures addressing internal QA/QC; these procedures will be submitted for review by the project QA/QC coordinator to ensure compliance with the QAPP. All laboratories and QA/QC coordinators are required to ensure that all personnel engaged in sampling and analysis tasks have appropriate training.

4.1.2 Response actions for field sampling

The FC, or a designee, will be responsible for correcting equipment malfunctions throughout field sampling and for resolving situations in the field that may result in nonconformance or noncompliance with the QAPP. All corrective measures will be immediately documented in the field logbook, and protocol modification forms will be completed.

4.1.3 Corrective action for laboratory analyses

Analytical laboratories are required to comply with the standard operating procedures previously submitted to the project QA/QC coordinator. The laboratory PMs will be responsible for ensuring that appropriate corrective actions are initiated as required for conformance with this QAPP. All laboratory personnel will be responsible for reporting problems that may compromise the quality of the data.

The project QA/QC coordinator will be notified immediately if any QC sample exceeds the project-specified control limits (Table 3-10). The analyst will identify and correct the anomaly before continuing with the sample analysis. The laboratory PM will document the corrective action taken in a memorandum submitted to the project QA/QC coordinator within five days of the initial notification. A narrative describing the anomaly, the steps taken to identify and correct the anomaly, and the treatment of the relevant sample batch (i.e., recalculation, reanalysis, re-extraction) will be submitted with the data package using a corrective action form provided by the laboratory.

4.2 REPORTS TO MANAGEMENT

Progress reports will be prepared by the FC for LDWG following each sampling event. The project QA/QC coordinator will also prepare progress reports after the sampling is completed and samples have been submitted for analyses, when information is received from the laboratory, and when analyses are complete. The status of the samples and analyses will be indicated, with emphasis on any deviations from the QAPP. Data reports will be written after validated data are available, as described in Section 2.6.4.

5.0 Data Validation and Usability

5.1 DATA VALIDATION

Data are not considered final until validated. Data validation will be conducted following EPA (1999; 2002b) guidance.

The data validation process begins within the laboratory with the review and evaluation of data by supervisory personnel or QA specialists. The laboratory analyst is responsible for ensuring that the analytical data are correct and complete, that appropriate procedures have been followed, and that QC results are within the acceptable limits. The project QA/QC coordinator is responsible for ensuring that all analyses performed by the laboratories are correct, properly documented, and complete, and that they satisfy the project data quality objectives specified in this QAPP.

Independent third-party data review and summary validation of the analytical data will be conducted by Laboratory Data Consultants, Inc.

For analytical chemistry data, a minimum of 20% or two SDGs will undergo full data validation. Full data validation parameters include:

- quality control analysis frequencies
- evaluation of chain of custody and sample handling procedures
- analysis holding times
- laboratory blank contamination
- instrument calibration
- surrogate recoveries
- LCS recoveries
- matrix spike recoveries
- matrix spike/matrix spike duplicate RPDs
- SRM recoveries

- compound identifications
- compound quantitations
- instrument performance check (tune) ion abundances
- internal standard areas and retention time shifts

If no discrepancies are found between reported results and raw data in the set that undergoes full data validation, then validation can proceed as a summary validation on the rest of the data using all the QC forms submitted in the laboratory data package. As part of the summary validation, all summary forms for calibrations, instrument performance, and internal standard summaries will be reviewed. QA review of the sediment chemistry data will be performed in accordance with the QA requirements of the project, the technical specifications of the analytical methods indicated in Table 3-9, and EPA (1999; 2002b) guidance for organic and inorganic data review. The EPA PM may have EPA peer review the third-party validation or perform data assessment/validation on a percentage of the data.

In addition, dioxin and furan data will undergo full validation following EPA Region 10 guidance for validation of dioxin and furan data (EPA 1996).

Any data qualification resulting from the data validation will be noted in a validation report submitted to the Windward QA/QC coordinator. Qualification will also be added by the validator to the "validator flag" field of the EDD provided by Windward. All laboratory qualifiers that remain unchanged as a result of the data validation must also be carried through into the "validator flag" field of the EDD.

5.2 RECONCILIATION WITH DATA QUALITY OBJECTIVES

Data quality assessment will be conducted by the project QA/QC coordinator in consultation with EPA guidelines. The results of the third-party independent review and validation will be reviewed, and cases where the projects DQIs were not met will be identified. The usability of the data will be determined in terms of the magnitude of the DQI exceedance.

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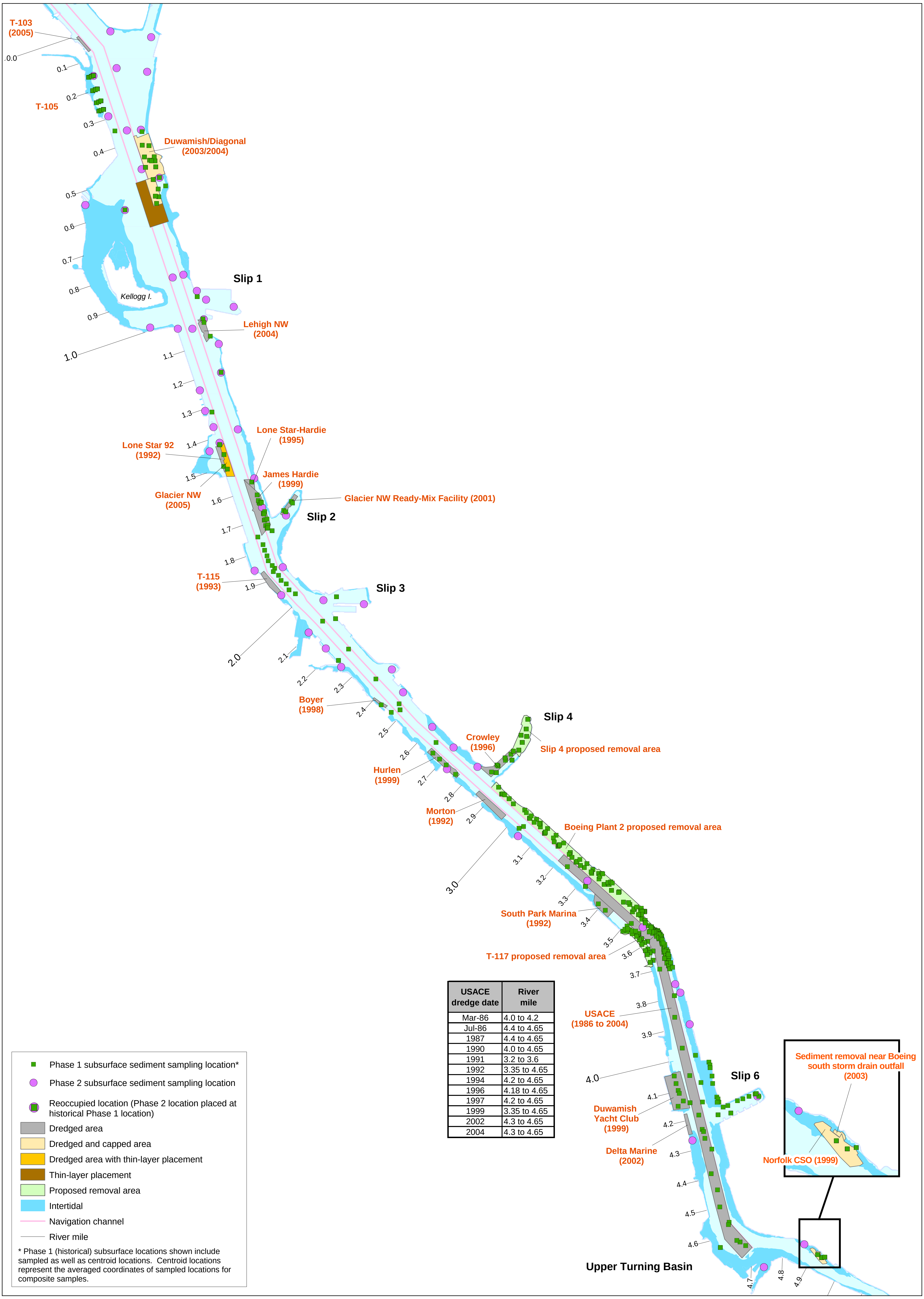
Oversize Figures



USACE dredge date	River mile
Mar-86	4.0 to 4.2
Jul-86	4.4 to 4.65
1987	4.4 to 4.65
1990	4.0 to 4.65
1991	3.2 to 3.6
1992	3.35 to 4.65
1994	4.2 to 4.65
1996	4.18 to 4.65
1997	4.2 to 4.65
1999	3.35 to 4.65
2002	4.3 to 4.65
2004	4.3 to 4.65

- 🟩 Phase 1 subsurface sediment sampling location*
- ● Phase 2 subsurface sediment sampling location
- ● Reoccupied location (Phase 2 location placed at historical Phase 1 location)
- ■ Dredged area
- ■ Dredged and capped area
- ■ Dredged area with thin-layer placement
- ■ Thin-layer placement
- ■ Proposed removal area
- ■ Intertidal
- — Navigation channel
- — River mile

* Phase 1 (historical) subsurface locations shown include sampled as well as centroid locations. Centroid locations represent the averaged coordinates of sampled locations for composite samples.

Figure 2-2. Phase 1 (historical) and Phase 2 subsurface sediment sampling locations

0 0.5 Miles

0 0.5 Kilometers

N

Windward environmental LLC

Prepared by STS 02/03/06 Map 1971

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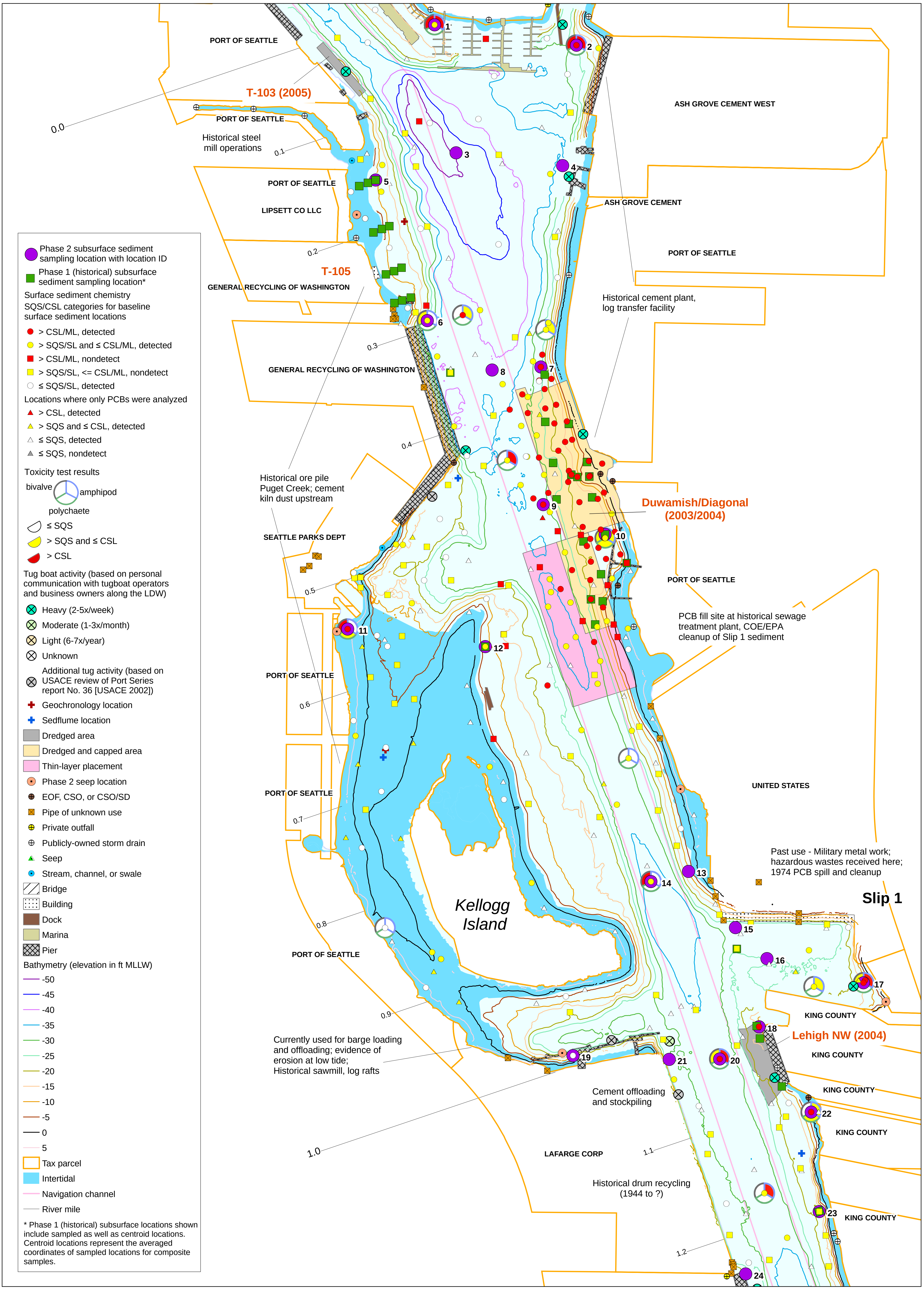

Figure 3-1a. Phase 2 subsurface sediment sampling locations (RM 0.0-1.2)

Wind Ward environmental LLC

Prepared by STS 02/03/06 Map 1934

Source information provided by EPA and Ecology based on a preliminary file search. Tax parcel information provided by Seattle Public Utilities, May 2002. Some tax parcel polygons were edited by Windward to conform to the LDW shoreline for the purpose of map presentation. The locations of outfalls and other pipes shown on this figure were identified during a City of Seattle survey conducted during May-June 2003 (Herrera 2004). As part of the survey, the locations of permitted outfalls were first identified using available drainage and outfall maps for waterfront properties obtained from the Washington Department of Ecology National Pollutant Discharge Elimination System (NPDES) permit files. Outfalls and pipes that were observed in the field during low tides were then surveyed in the field to establish their locations. The status of permitted outfalls is currently being verified by the Lower Duwamish Waterway Group (LDWG) through interviews with agency personnel and individual LDWG members' staff, as appropriate.

In the future, known outfalls will be designated as either "combined sewer overflow, combined sewer overflow/storm drains, or emergency overflows;" "publicly-owned storm drains;" or "private outfalls." Private outfalls will include two categories: 1) NPDES-permitted outfalls (e.g., storm drains, non-contact cooling water, process wastewater), and 2) other outfalls that are not included under an active NPDES permit. Outfalls whose discharge has been terminated and that are no longer included under an active NPDES permit will be identified as "formerly permitted outfalls." Pipes that cannot be identified as an outfall through agency permit file records review will be identified as "pipes of unknown use." A comprehensive survey of property owners will not be conducted.

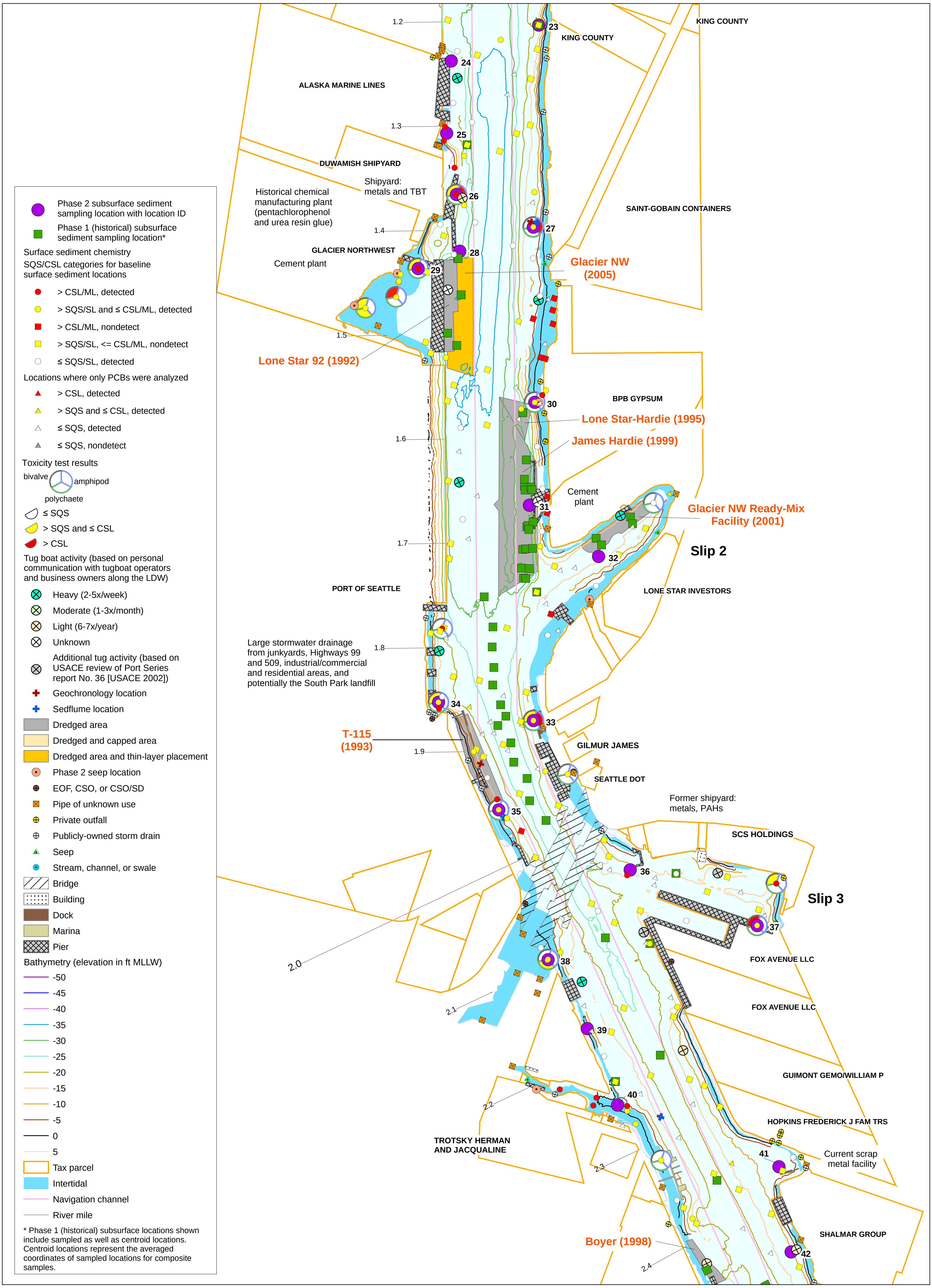

Figure 3-1b. Phase 2 subsurface sediment sampling locations (RM 1.2-2.4)

Prepared by STS 02/03/06 Map 1934

Source information provided by EPA and Ecology based on a preliminary file search. Tax parcel information provided by Seattle Public Utilities, May 2002. Some tax parcel polygons were edited by Windward to conform to the LDW shoreline for the purpose of map presentation. The locations of outfalls and other pipes shown on this figure were identified during a City of Seattle survey conducted during May-June 2003 (Herrera 2004). As part of the survey, the locations of permitted outfalls were first identified using available drainage and outfall maps for waterfront properties obtained from the Washington Department of Ecology National Pollutant Discharge Elimination System (NPDES) permit files. Outfalls and pipes that were observed in the field during low tides were then surveyed in the field to establish their locations. The status of permitted outfalls is currently being verified by the Lower Duwamish Waterway Group (LDWG) through interviews with agency personnel and individual LDWG members' staff, as appropriate.
In the future, known outfalls will be designated as either "combined sewer overflow, combined sewer overflow/storm drains, or emergency overflows;" "publicly-owned storm drains;" or "private outfalls." Private outfalls will include two categories: 1) NPDES-permitted outfalls (e.g., storm drains, non-contact cooling water, process wastewater), and 2) other outfalls that are not included under an active NPDES permit. Outfalls whose discharge has been terminated and that are no longer included under an active NPDES permit will be identified as "formerly permitted outfalls." Pipes that cannot be identified as an outfall through agency permit file records review will be identified as "pipes of unknown use." A comprehensive survey of property owners will not be conducted.

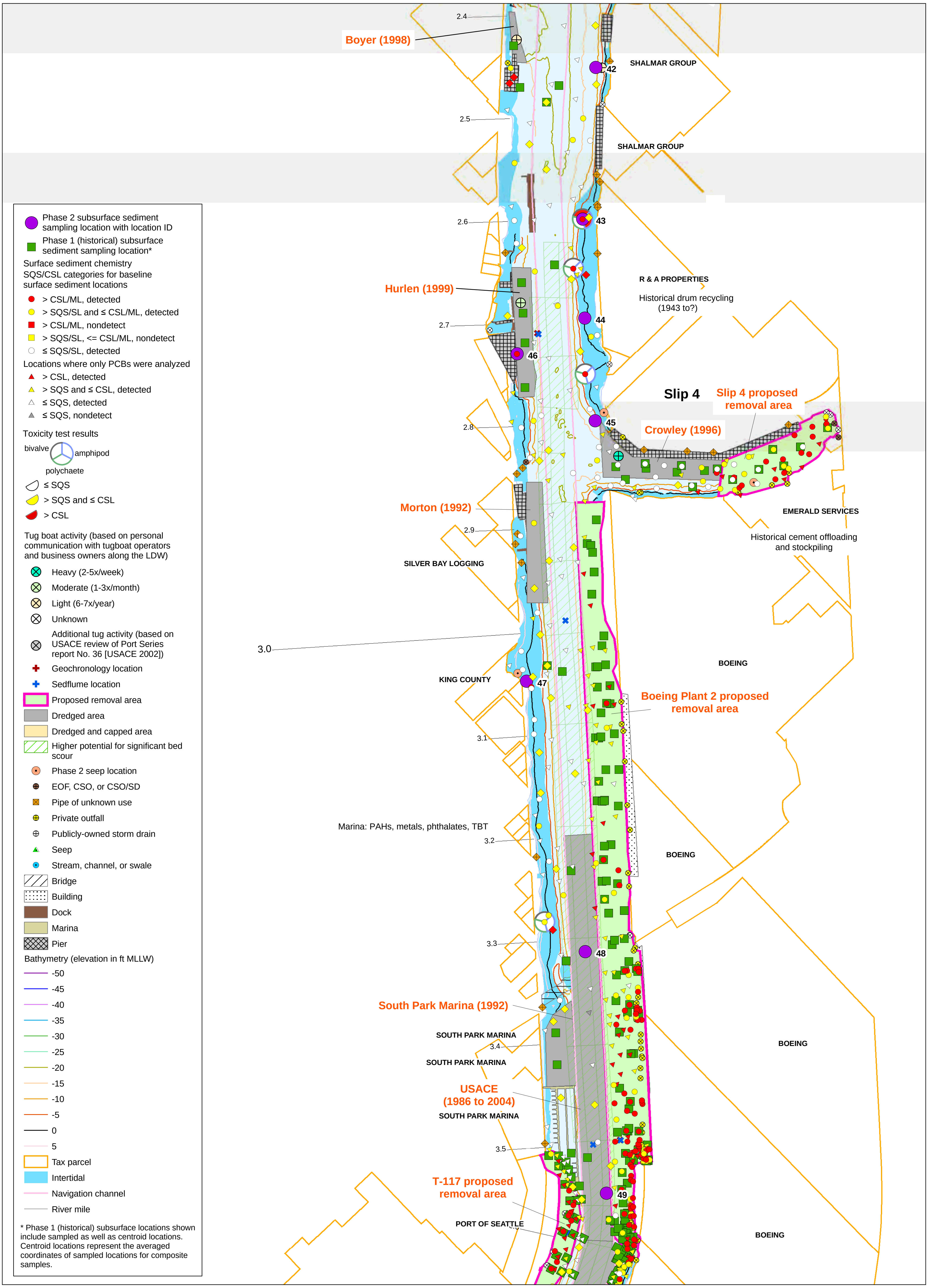

Figure 3-1c. Phase 2 subsurface sediment sampling locations (RM 2.4-3.6)

Windward environmental LLC

Prepared by STS 02/03/06 Map 1934

Source information provided by EPA and Ecology based on a preliminary file search. Tax parcel information provided by Seattle Public Utilities, May 2002. Some tax parcel polygons were edited by Windward to conform to the LDW shoreline for the purpose of map presentation. The locations of outfalls and other pipes shown on this figure were identified during a City of Seattle survey conducted during May-June 2003 (Herrera 2004). As part of the survey, the locations of permitted outfalls were first identified using available drainage and outfall maps for waterfront properties obtained from the Washington Department of Ecology National Pollutant Discharge Elimination System (NPDES) permit files. Outfalls and pipes that were observed in the field during low tides were then surveyed in the field to establish their locations. The status of permitted outfalls is currently being verified by the Lower Duwamish Waterway Group (LDWG) through interviews with agency personnel and individual LDWG members' staff, as appropriate. In the future, known outfalls will be designated as either "combined sewer overflow, combined sewer overflow/storm drains, or emergency overflows;" "publicly-owned storm drains;" or "private outfalls." Private outfalls will include two categories: 1) NPDES-permitted outfalls (e.g., storm drains, non-contact cooling water, process wastewater), and 2) other outfalls that are not included under an active NPDES permit. Outfalls whose discharge has been terminated and that are no longer included under an active NPDES permit will be identified as "formerly permitted outfalls." Pipes that cannot be identified as an outfall through agency permit file records review will be identified as "pipes of unknown use." A comprehensive survey of property owners will not be conducted.

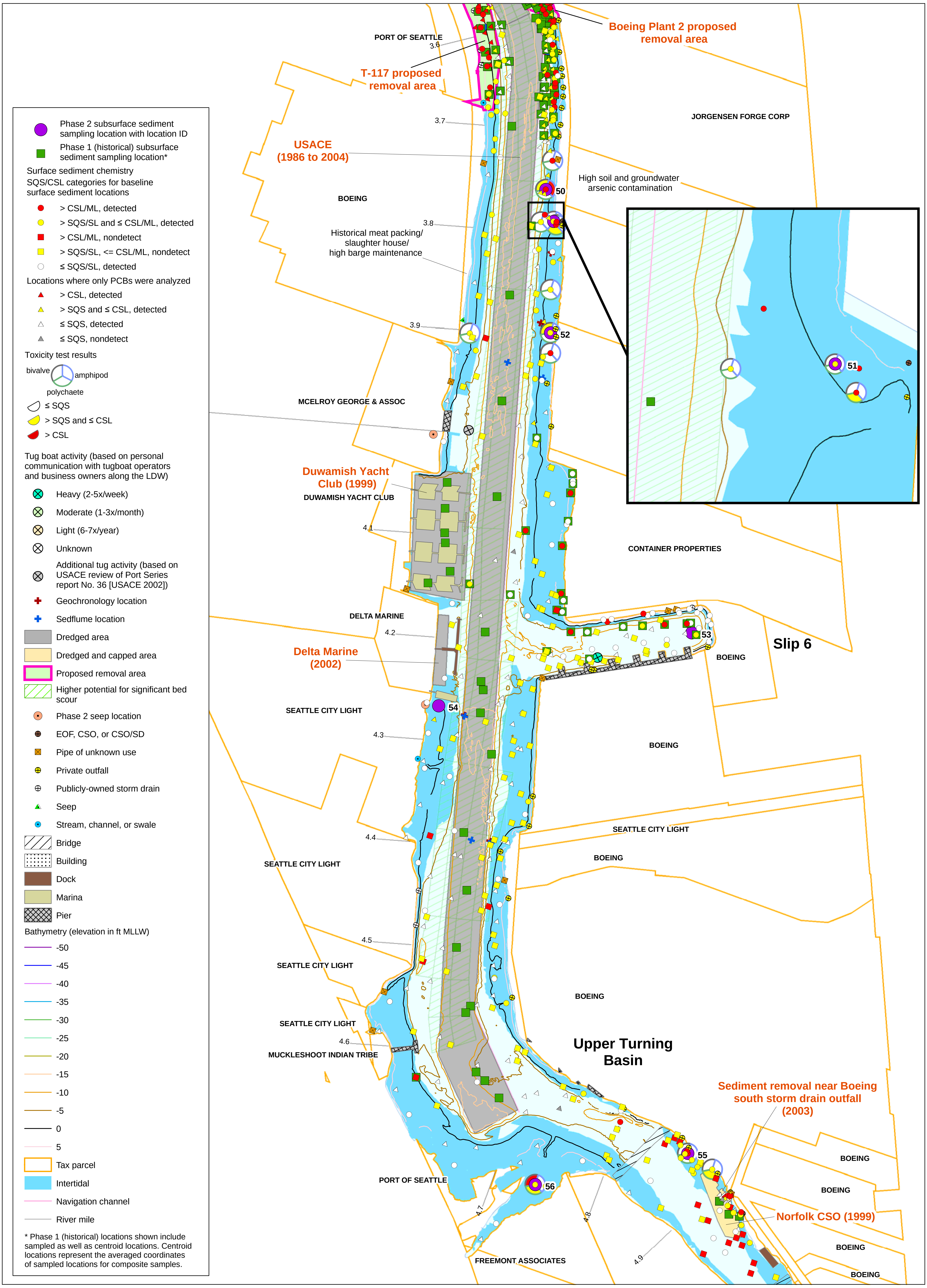

Figure 3-1d. Phase 2 subsurface sediment sampling locations (RM 3.6-4.8)

Prepared by STS 02/03/06 Map 1934

Source information provided by EPA and Ecology based on a preliminary file search. Tax parcel information provided by Seattle Public Utilities, May 2002. Some tax parcel polygons were edited by Windward to conform to the LDW shoreline for the purpose of map presentation. The locations of outfalls and other pipes shown on this figure were first identified during a City of Seattle survey conducted during May-June 2003 (Herrera 2004). As part of the survey, the locations of permitted outfalls were first identified using available drainage and outfall maps for waterfront properties obtained from the Washington Department of Ecology National Pollutant Discharge Elimination System (NPDES) permit files. Outfalls and pipes that were observed in the field during low tides were then surveyed in the field to establish their locations. The status of permitted outfalls is currently being verified by the Lower Duwamish Waterway Group (LDWG) through interviews with agency personnel and individual LDWG members' staff, as appropriate. In the future, known outfalls will be designated as either "combined sewer overflow, combined sewer overflow/storm drains, or emergency overflows;" "publicly-owned storm drains;" or "private outfalls." Private outfalls will include two categories: 1) NPDES-permitted outfalls (e.g., storm drains, non-contact cooling water, process wastewater), and 2) other outfalls that are not included under an active NPDES permit. Outfalls whose discharge has been terminated and that are no longer included under an active NPDES permit will be identified as "formerly permitted outfalls." Pipes that cannot be identified as an outfall through agency permit file records review will be identified as "pipes of unknown use." A comprehensive survey of property owners will not be conducted.