Lower Duwamish Waterway Group

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

QUALITY ASSURANCE PROJECT PLAN: SURFACE SEDIMENT SAMPLING FOR CHEMICAL ANALYSES AND TOXICITY TESTING OF THE LOWER DUWAMISH WATERWAY

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 SURFACE SEDIMENT AND TOXICITY TESTING
QUALITY ASSURANCE PROJECT PLAN

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Distribution List

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Acronyms

ACRONYM	Definition
ACG	analytical concentration goal
ARI	Analytical Resources, Inc.
Axys	Axys Analytical Services, Ltd
COC	chain of custody
COPC	chemical of potential concern
CSL	cleanup screening level
CSO	combined sewer overflow
DMMP	Dredged Material Management Program
DQI	data quality indicator
Ecology	Washington Department of Ecology
EPA	US Environmental Protection Agency
ERA	ecological risk assessment
FC	field coordinator
GPS	global positioning system
HSP	Health and Safety Plan
LCS	laboratory control standard
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group
MDL	method detection limit
ML	maximum level
MLLW	mean lower low water
NAS	Northwestern Aquatic Sciences
NOAA	National Oceanic and Atmospheric Administration
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PM	project manager
PSEP	Puget Sound Estuary Program
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
RI	Remedial Investigation
ROC	receptor of concern
RPD	relative percent difference
SDG	sample delivery group

ACRONYM	Definition
SIM	selective ion monitoring
SL	screening level
SMS	Washington State Sediment Management Standards
SQS	Washington State Sediment Quality Standards
SRM	standard reference material
SVOC	semivolatile organic compound
T-117	Terminal 117
TEQ	toxic equivalence quotient
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 surface sediment in the Lower Duwamish Waterway (LDW), chemically analyzing these samples, and conducting toxicity testing on a subset of these sediment samples. Data from these studies will be used to determine the nature and extent of chemical contamination and to support the ecological and human health risk assessments for Phase 2 of the LDW Remedial Investigation (RI), as described in the Phase 2 RI work plan (Windward 2004c). Section 3.1.8 of the Phase 2 work plan presented a preliminary study design for 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).

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. The derivation of risk-based analytical concentration goals (ACGs) for sediment is presented in Appendix C. The study designs for background sampling for arsenic and dioxins/furans are presented in Appendices D and E, respectively. Appendix F presents a complete listing of analytes and their detection and reporting limits in sediment. Appendix G contains maps of historical surface sediment sampling locations in the LDW. Appendix G also contains a table listing all historical surface sediment locations with chemical exceedances of Washington State Sediment Quality Standards (SQS) or cleanup screening levels (CSLs) of the Washington State Sediment Management Standards (SMS).

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 shows the overall project organization for the studies described in this QAPP. Responsibilities of project team members, as well as those of the laboratory project managers, are described in the following sections.

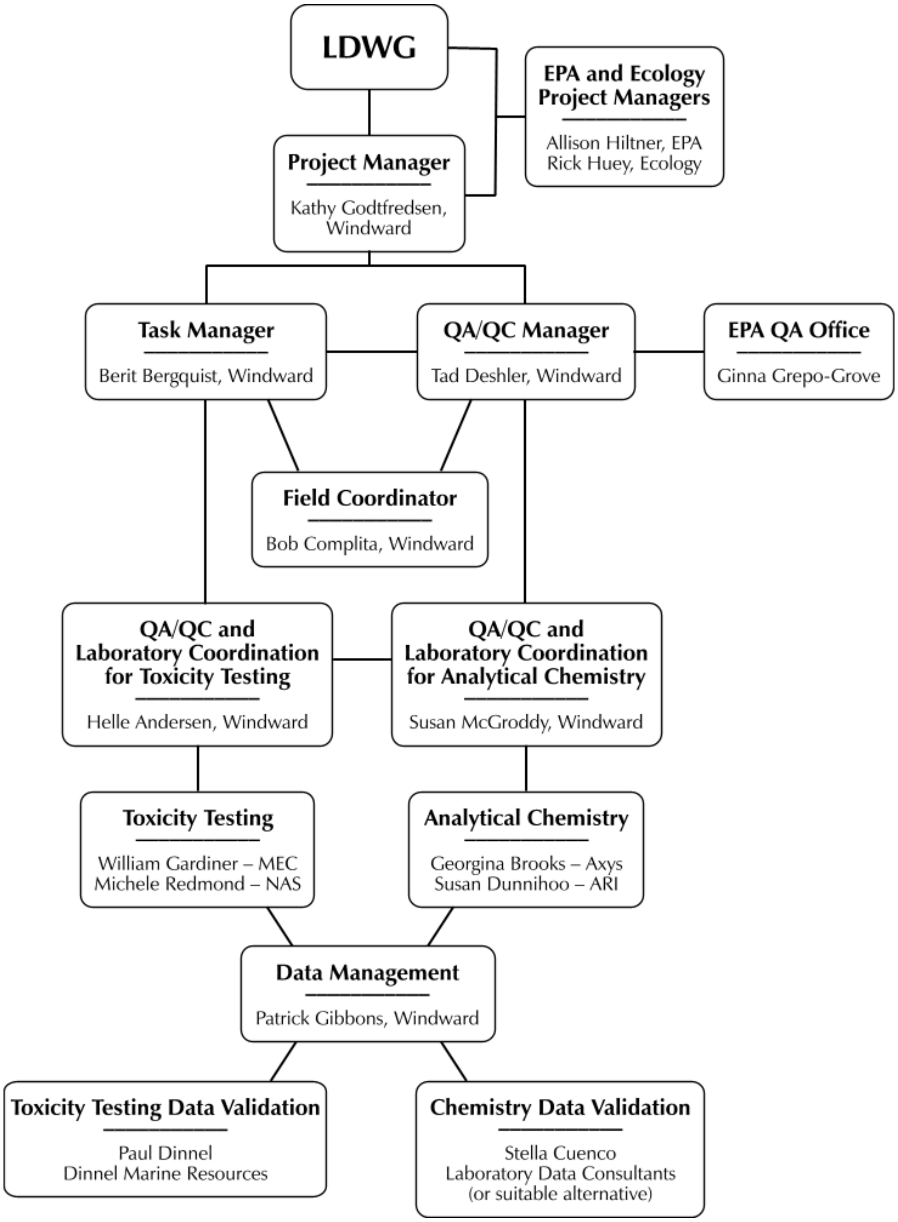

Figure 2-1. Project organization

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: 206.577.1283
Facsimile: 206.217.0089
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: 206.577.1291
Facsimile: 206.217.0089
Email: beritb@windwardenv.com

2.1.2 Field coordination

Bob Complita 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. Complita 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 and toxicological 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. Complita can be reached as follows:

Bob Complita
Windward Environmental LLC
200 W. Mercer St., Suite 401
Seattle, WA 98119
Telephone: 206.577.1297
Facsimile: 206.217.0089
Email: bobc@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
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Telephone: 206.577.1285
Facsimile: 206.217.0089
Email: tad@windwardenv.com

Ms. Grepo-Grove can be reached as follows:

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US Environmental Protection Agency, Region 10
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Seattle, WA 98101
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Email: grepo-grove.gina@epa.gov

Susan McGroddy of Windward will serve as the QA/QC coordinator for chemical analyses. Dr. McGroddy can be reached as follows:

Susan McGroddy
Windward Environmental LLC
200 W. Mercer St., Suite 401
Seattle, WA 98119
Telephone: 206.577.1292
Facsimile: 206.217.0089
Email: susanm@windwardenv.com

Helle Anderson of Windward will serve as the QA/QC coordinator for toxicity testing. Ms. Anderson can be reached as follows:

Helle Anderson
Windward Environmental LLC
200 W. Mercer St., Suite 401
Seattle, WA 98119
Telephone: 206.577.1287
Facsimile: 206.217.0089
Email: hellea@windwardenv.com

The QA/QC coordinators will ensure that samples are collected and documented appropriately and coordinate with the analytical and toxicity 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. (or a suitable alternative). 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
Facsimile: 760.634.1674
Email: scuenco@lab-data.com

Independent third-party review and validation of toxicity test data will be provided by Paul Dinnel. Dr. Dinnel can be reached as follows:

Paul Dinnel
Dinnel Marine Resources
Shannon Point Marine Center
Anacortes, WA 98221
Telephone: 360.299.8468
Email: padinnel@aol.com

2.1.4 Laboratory project management

Susan McGroddy of Windward will serve as the laboratory coordinator for the analytical chemistry laboratories, and Helle Andersen of Windward will serve as the laboratory coordinator for the toxicity testing laboratories. Analytical Resources, Inc. (ARI) and Axys Analytical Services Ltd. (Axys) will perform chemical analyses of the sediment samples. 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
Canada
Telephone: 250.656.0881
Facsimile: 250.656.4511
Email: gbrooks@axys.com

Northwestern Aquatic Sciences (NAS) and MEC Analytical Systems (MEC) will perform toxicity testing. The laboratory PMs can be reached as follows:

William Gardiner
MEC Analytical Systems
152 Sunset View Lane
Sequim, WA 98382
Telephone: 360.582.1758
Facsimile: 360.582.1679
Email: bill.gardiner@westonsolutions.com

Michele Redmond
Northwestern Aquatic Sciences
3814 Yaquina Bay Road, P.O. Box 1437
Newport, OR 97365
Telephone: 541.265.7225
Facsimile: 541.265.2799
Email: mredmond@nwaquatic.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 2004c) identified the need for additional surface sediment samples for chemical analysis and toxicity testing. 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.

2.2.1 Surface sediment sampling and chemical analyses

Collection of additional surface sediment samples for chemical analysis was recommended in the data needs memorandum (Windward 2003b) for specific areas of the LDW to support the Phase 2 RI and associated risk assessments. The objective of this study is to fill these remaining data needs. In particular, additional sediment chemistry data are needed to:

- better understand the areal extent of chemicals of potential concern (COPCs) where concentrations have exceeded the SQS or the CSL of the Washington State SMS[1]
- provide additional characterization of areas with low sampling density based on the Phase 1 database, or other sediment data approved for use or collected in Phase 2 (i.e., benthic invertebrate sampling)
- further characterize the concentration and distribution of COPCs with relatively low sampling density in Phase 1 (e.g., tributyltin [TBT], dichlorodiphenyltrichloroethane (DDT), dioxins/furans, and polychlorinated biphenyl [PCB] congeners), or with elevated detection limits relative to SQS or CSL

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[1] WAC 173-204. The SQS represent numeric chemical concentrations below which sediments are designated as having no adverse effects on biological resources. At chemical concentrations above the SQS but below the CSL, sediments are designated as having minor adverse effects on biological resources. At chemical concentrations above the CSL, there is a high probability of adverse biological affects.

- further characterize the nature and extent of chemical concentrations in sediments near potential current or historical chemical sources
- further characterize the nature and extent of chemical concentrations in sediments near seeps where Phase 2 seep water chemistry data indicate a cause for concern
- further characterize the potential for human or spotted sandpiper exposure in intertidal areas below mean higher high water that may be used for recreation or foraging, respectively
- characterize arsenic and dioxin/furan concentrations in background sediments outside or upstream of the LDW study area
- delineate the upstream boundary of the study area
- support the food web modeling with tissue chemistry data

The Phase 1 RI was based on a dataset of approximately 1,200 surface sediment samples that were collected within the LDW since 1990 (Table 2-1). Nearly all of these samples were collected from the uppermost 10 cm, although 9 samples were collected from the uppermost 15 cm.

Additional surface sediment chemistry data have been collected within the last 2 years that were not included in the Phase 1 RI because they were collected after the cutoff date for incorporation into Phase 1. A draft technical memorandum containing an updated list of sediment chemistry datasets to be used in Phase 2 and the rationale for inclusion was submitted to EPA and Ecology in April 2004. This technical memorandum also summarized the suitability of all datasets previously used in Phase 1, in addition to the more recently collected datasets, for use in Phase 2. The draft final version of this technical memorandum that was submitted to EPA and Ecology on October 15, 2004 is still undergoing review by the agencies. This updated list of sediment chemistry datasets to be used for the Phase 2 RI is presented in Table 2-1.

The results of a data review conducted by EPA (2003) and the review conducted by Windward as part of the 2004 historical data technical memorandum (Windward 2004e) have been incorporated in the Phase 2 RI database. This data review focused on many of the King County events listed in Table 2-1 and resulted in recommendations for data qualifier changes.[2] Two of the datasets used in the Phase 1 RI (Ecology 2000; Rhône-Poulenc 1995) will not be used in the Phase 2 RI because the necessary quality control data were not readily available. Sampling locations for the datasets presented in Table 2-1 are shown in Figures 2-2a through 2-2e.

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[2] The primary qualifier change was to add an 'R' qualifier (rejected) to approximately 700 of the non-detect results for several semi-volatile organic compounds with poor recovery of surrogate compounds or very low matrix spike recoveries. Approximately one-half of the samples analyzed for semi-volatile organic compounds were affected by this change.

Table 2-1. Surface sediment samples collected since 1990 that will be used in the Phase 2 RI

EVENT [a]	CHEMICAL GROUPS ANALYZED	SURFACE SEDIMENT SAMPLES [b]	REFERENCE
Norfolk CSO five-year monitoring program, Year five (Norfolk-monit7; 2004)	metals, PCB Aroclors, SVOCs	8	unpublished data from King County
Slip 4 early action area site characterization (Slip4-EarlyAction; 2004)	PCB Aroclors (all samples); metals and SVOCs (subset of samples)	29	Integral (2004)
Terminal 117 early action area site characterization (T117BoundaryDefinition; 2003-2004)	PCB Aroclors (all samples); metals and SVOCs (subset of samples)	46	Windward (2004a; 2004b)
Duwamish/Diagonal pre- and post-cleanup monitoring data (DuwDiag-Dredge Monitoring; 2003-2004)	metals, pesticides, PCB Aroclors, SVOCs	24 [c]	King County (2004)
Boeing Plant 2 transformer investigation – Phase 1 (Plant 2-Transformer Phase1; 2003)	PCB Aroclors	5	Floyd Snider McCarthy (2004)
Norfolk CSO five-year monitoring program, Year four (Norfolk-monit6; 2003)	metals, PCB Aroclors, SVOCs	8 [d]	King County (2003)
Norfolk CSO (Duwamish River) sediment cap recontamination, Phase I investigation (Ecology-Norfolk; 2002)	PCB Aroclors	20	Ecology (2003)
Norfolk CSO five-year monitoring program, Year three (Norfolk-monit5; 2002)	metals, PCB Aroclors, SVOCs	8 [d]	King County (2002)
Norfolk CSO five-year monitoring program, Year two (Norfolk-monit4; 2001)	metals, PCB Aroclors, SVOCs	8 [d]	King County (2001)
Norfolk CSO five-year monitoring program – Twelve-month post construction (Norfolk-monit3; 2000)	metals, PCB Aroclors, SVOCs	8 [d]	King County (2000c)
Outfall and nearshore sediment sampling report, James Hardie Duwamish Facility (JamesHardieOutfall; 2000)	metals, PCB Aroclors, SVOCs	9	Weston (2000)
Norfolk CSO five-year monitoring program – Supplemental nearshore sampling (Norfolk-monit2b; 2000)	PCB Aroclors	6	King County (2000b)
Norfolk CSO five-year monitoring program – Six-month post construction (Norfolk-monit2a; 1999)	metals, PCB Aroclors, SVOCs	8 [d]	King County (2000d)
Norfolk CSO five-year monitoring program – Post backfill (Norfolk-monit1; 1999)	metals, PCB Aroclors, SVOCs	4 [d]	King County (1999b)
EPA Site Inspection: Lower Duwamish River (EPA SI; 1998)	metals, pesticides, PCB Aroclors, selected PCB congeners, dioxins/ furans, TBT, SVOCs, VOCs	300	Weston (1999)
King County CSO water quality assessment for the Duwamish River and Elliott Bay (KC WQA; 1997)	metals, PCB Aroclors, SVOCs, TBT	69	King County (1999a)
Duwamish Waterway Phase 1 site characterization [e] (Boeing SiteChar; 1997)	metals, PCB Aroclors, SVOCs	88 [e]	Exponent (1998)

EVENT [a]	CHEMICAL GROUPS ANALYZED	SURFACE SEDIMENT SAMPLES [b]	REFERENCE
Duwamish Waterway sediment characterization study (NOAA SiteChar; 1997)	total PCBs, selected PCB congeners, total PCTs	328	NOAA (1997; 1998)
Seaboard Lumber site, Phase 2 site investigation (Seaboard-Ph2; 1996)	metals, PCB Aroclors, SVOCs	20	Herrera (1997)
RCRA Facility Investigation Duwamish Waterway sediment investigation, Plant 2 – Phase 2b (Plant 2 RFI-2b; 1996)	metals, PCB Aroclors, SVOCs	39	Weston (1998)
Duwamish/Diagonal cleanup study – Phase 2 (Duw/Diag-2; 1996)	metals, PCB Aroclors, SVOCs, TPH	36	King County (2000a)
Duwamish/Diagonal cleanup study – Phase 1.5 (Duw/Diag-1.5; 1995)	metals, PCB Aroclors, SVOCs, TBT	12	King County (2000a)
Norfolk CSO sediment cleanup study – Phase 3 (Norfolk-cleanup3; 1995)	PCB Aroclors	16	King County (1996)
Norfolk CSO sediment cleanup study – Phase 2 (Norfolk-cleanup2; 1995)	metals, pesticides, PCB Aroclors and selected congeners, SVOCs, VOCs, TPH	12	King County (1996)
RCRA Facility Investigation Duwamish Waterway sediment investigation, Plant 2 – Phase 2a (Plant 2 RFI-2a; 1995)	metals, PCB Aroclors SVOCs	54	Weston (1998)
RCRA Facility Investigation Duwamish Waterway sediment investigation, Plant 2 – Phase 1 (Plant 2 RFI-1; 1995)	metals, PCB Aroclors, TPH, SVOCs, VOCs	65	Weston (1998)
Duwamish/Diagonal cleanup study – Phase 1 (Duw/Diag-1; 1994)	metals, pesticides, PCB Aroclors, SVOCs, TBT	40	King County (2000a)
Norfolk CSO sediment cleanup study – Phase 1 (Norfolk-cleanup1; 1994)	metals, pesticides, SVOCs, PCB Aroclors, VOCs	21	King County (1996)
Rhône-Poulenc RCRA Facility Investigation for the Marginal Way facility – Round 2 (Rhône Poulenc RFI 2; 1994)	metals, SVOCs, PCB Aroclors 1254 and 1260, pesticides	7	Rhône-Poulenc (1995)
Results of sampling and analysis, sediment monitoring plan, Duwamish Shipyard, Inc. (DuwamishShipyards; 1993)	metals, SVOCs, TBT	5	Hart Crowser (1993)
Harbor Island Remedial Investigation (HIRI; 1991)	metals, pesticides, PCB Aroclors, SVOCs, VOCs, TPH, TBT	34	Weston (1993)

[a] Event code used in project database and the year in which sampling was conducted are given in parentheses

[b] Sample count does not include field duplicates

[c] Includes 12 samples collected both before and after the 2003-2004 remediation. Only the data from the post-remediation sampling are shown in Figures 2-2a to 2-2e because these data are more relevant for the Phase 2 surface sediment sampling design than the pre-remediation data

[d] The data from these samples may be used in the Phase 2 RI, but are not shown in Figures 2-2a to 2-2e because the most recent data from these locations collected during the fifth year of the monitoring program are most relevant for the Phase 2 surface sediment sampling design

[e] Sample total does not include three reference samples that were collected upstream of the study area

CSO – combined sewer overflow

PCB – polychlorinated biphenyl

SVOC – semivolatile organic compound

TPH – total petroleum hydrocarbons

PCT – polychlorinated triphenyl

RCRA – Resource Conservation and Recovery Act

TBT – tributyltin

VOC – volatile organic compound

In addition to the samples collected during events listed in Table 2-1, surface sediment samples were collected as part of Phase 2 benthic invertebrate sampling in August and September 2004. The sampling design presented in Section 3-1 is intended to fill remaining data needs for the Phase 2 RI after consideration of existing LDW sediment samples from other studies as well as completed Phase 2 studies.

2.2.2 Sediment toxicity testing

The benthic invertebrate community is one of the receptors of concern (ROCs) identified in the Phase 1 ecological risk assessment (ERA) (Windward 2003a) and will also be a Phase 2 ROC. In addition, benthic invertebrates are important prey items for fish and wildlife that forage in the LDW. Risks to the benthic community will be assessed by comparison of sediment chemical concentrations to the SQS and CSL and by conducting site-specific toxicity testing of sediment samples (Windward 2004c). As part of the activities specified in the Benthic Invertebrate QAPP (Windward 2004b), qualitative data have also been collected to better characterize the general composition, relative abundance, and distribution of the benthic community.

As identified in the data needs memorandum (Windward 2003b), additional site-specific toxicity testing data are needed to assess risks to benthic invertebrates. The objective of the toxicity testing is to assess potential effects of LDW site sediments on benthic invertebrates through the use of site-specific toxicity testing and synoptic sediment chemistry. These standardized tests are surrogate measures to estimate potential effects on benthic organisms in the LDW.

A large amount of surface sediment chemistry data has been collected in the LDW over the last 13 years (see Table 2-1), but only two studies (Ecology 2000; King County 2000a) have conducted sediment toxicity tests on surface sediments during that time. The seven samples analyzed for the Duwamish/Diagonal cleanup study (King County 2000a) were collected in an area with moderately high chemical concentrations to help define cleanup boundaries. Five of the seven locations sampled were within an area that had been proposed for cleanup by King County (2000a) and have since been removed. The three samples tested by Ecology (2000) were for reconnaissance purposes and were not targeted on a particular chemical source. The chemistry data from the Ecology (2000) study will not be included in the Phase 2 RI because the necessary QA/QC data were not obtained and reviewed.

2.3 PROJECT/TASK DESCRIPTION AND SCHEDULE

The sampling of surface sediment will be initiated following EPA's approval of this QAPP. This section provides an overview of the sampling and analysis activities and schedule for the studies designed to address the data needs outlined in Section 2.2.1. A detailed sampling design is presented in Section 3.1.

Sediment samples will be collected in two rounds in 2005 for chemical analyses and a subset of these samples will be tested for site-specific toxicity following SMS guidelines. Sediment will be collected in two rounds for two reasons. First, this approach enables the analytical and toxicity testing laboratories to better accommodate the total number of samples by allowing them to stagger the analyses/testing. Second, this approach makes it possible for the results of the first round of toxicity testing to be considered in determining which samples should be tested for toxicity in the second round (see Section 3.1.3).

The first round of sediment sampling is scheduled to begin January 17, 2005. These samples will be chemically analyzed at ARI for the analytes specified in Sections 3.1.1 and 3.4.1,[3] with a turn-around time of three weeks.[4] Upon receipt of the unvalidated chemical data, LDWG, EPA, and Ecology will determine within approximately one week which of the samples should be tested for toxicity, based primarily on a comparison of the sediment chemical concentrations with the SQS and CSL (see Section 3.1.3). Splits of these sediment samples will then be tested for toxicity within the maximum sediment holding times for toxicity tests (eight weeks). The initiation times of the tests will be staggered in two to three groups, with each containing 17 to 25 samples (for a total of up to 50 to 60 toxicity test samples in the first round). A second round of sediment sampling is scheduled to begin March 7, 2005. Similar to the first round of samples, these samples will be chemically analyzed and unvalidated data will be received within three weeks. Upon receipt of these data, along with preliminary results from the Round 1 toxicity testing, LDWG, EPA, and Ecology will determine within approximately one to two weeks which of the Round 2 sediment samples will be tested for toxicity. Splits of these sediment samples will then be tested for toxicity within the maximum sediment holding times for toxicity tests (eight weeks). Selection of specific locations for PCB congener analyses will be determined following receipt of both Round 1 and Round 2 data, and these congener data will be presented in the Round 2 data report. The locations for some of the dioxin/furan analyses (i.e., those associated with high PCB concentrations) will also be selected after both Round 1 and Round 2 data are available.

A timeline of the schedule for each round of testing is presented in Figure 2-3. This timeline is approximate and subject to change, but is presented to illustrate the tight time constraints for all involved. This schedule allows for retesting of bivalve larvae and possibly some of the amphipod tests within the eight-week sediment holding time if needed, but will not likely allow for retesting of the polychaete tests (see Section 3.5.2 for rationale for retesting).

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[3] Dioxins and furans and PCBs congeners will not be analyzed with an expedited turn-around-time because no SQS or CSLs exist for these compounds. Appendix F contains a complete listing of analytes.

[4] The turn-around time may be less than 3 weeks, but 3 weeks is assumed for planning purposes in the event that sediments need secondary cleanup prior to chemical analyses.

ID	Task Name	Start	Finish
1	**Round 1**	**1/17/05**	**4/7/05**
2	Round I sediment collection	1/17/05	1/26/05
3	Chemical analysis (a)	1/18/05	2/17/05
4	Preliminary chemistry results	2/17/05	2/17/05
5	Data summary to LDWG and EPA/Ecology	2/22/05	2/22/05
6	Meeting with EPA and Ecology	3/1/05	3/1/05
7	Group A 48-hr bivalve larvae tests	3/3/05	3/5/05
8	Group A 10-d amphipod tests	3/3/05	3/13/05
9	Group A 20-d polychaete tests	3/3/05	3/23/05
10	Group B 48-hr bivalve larvae tests	3/7/05	3/9/05
11	Group B 10-d amphipod tests	3/7/05	3/17/05
12	Group B 20-d polychaete tests	3/7/05	3/27/05
13	Group C 48-hr bivalve larvae tests	3/10/05	3/12/05
14	Group C 10-d amphipod tests	3/10/05	3/20/05
15	Group C 20-d polychaete tests	3/10/05	3/30/05
16	Receive preliminary 48-hr test results	3/21/05	3/21/05
17	Receive preliminary 10-d test results	3/28/05	3/28/05
18	Receive preliminary 20-d test results	4/7/05	4/7/05
19	Sediment holding time for first sediment samples collected	1/17/05	3/14/05
20	Sediment holding time for last sediment samples collected	1/26/05	3/23/05
21			
22	**Round 2**	**3/7/05**	**5/31/05**
23	Round 2 sediment collection	3/7/05	3/16/05
24	Chemical analysis (a)	3/9/05	4/8/05
25	Preliminary chemistry results	4/8/05	4/8/05
26	Rd 1 tox/chem and Rd 2 chem data to LDWG and EPA/Ecology	4/15/05	4/15/05
27	Meeting with EPA and Ecology	4/26/05	4/26/05
28	Group A 48-hr bivalve larvae tests	4/28/05	4/30/05
29	Group A 10-d amphipod tests	4/28/05	5/8/05
30	Group A 20-d polychaete tests	4/28/05	5/18/05
31	Group B 48-hr bivalve larvae tests	5/2/05	5/4/05
32	Group B 10-d amphipod tests	5/2/05	5/12/05
33	Group B 20-d polychaete tests	5/2/05	5/22/05
34	Receive preliminary 48-hr test results	5/9/05	5/9/05
35	Receive preliminary 10-d test results	5/13/05	5/13/05
36	Receive preliminary 20-d test results	5/31/05	5/31/05
37	Sediment holding time for first sediment collected	3/14/05	5/9/05
38	Sediment holding time for last sediment samples collected	3/18/05	5/13/05
39			
40	(a) Dioxin/furan analyses will be conducted February 23 to April 6, 2005 for Round 1, and PCB congener and dioxin/furan analyses will be conducted April 15 to June 3, 2005 for Round 2		

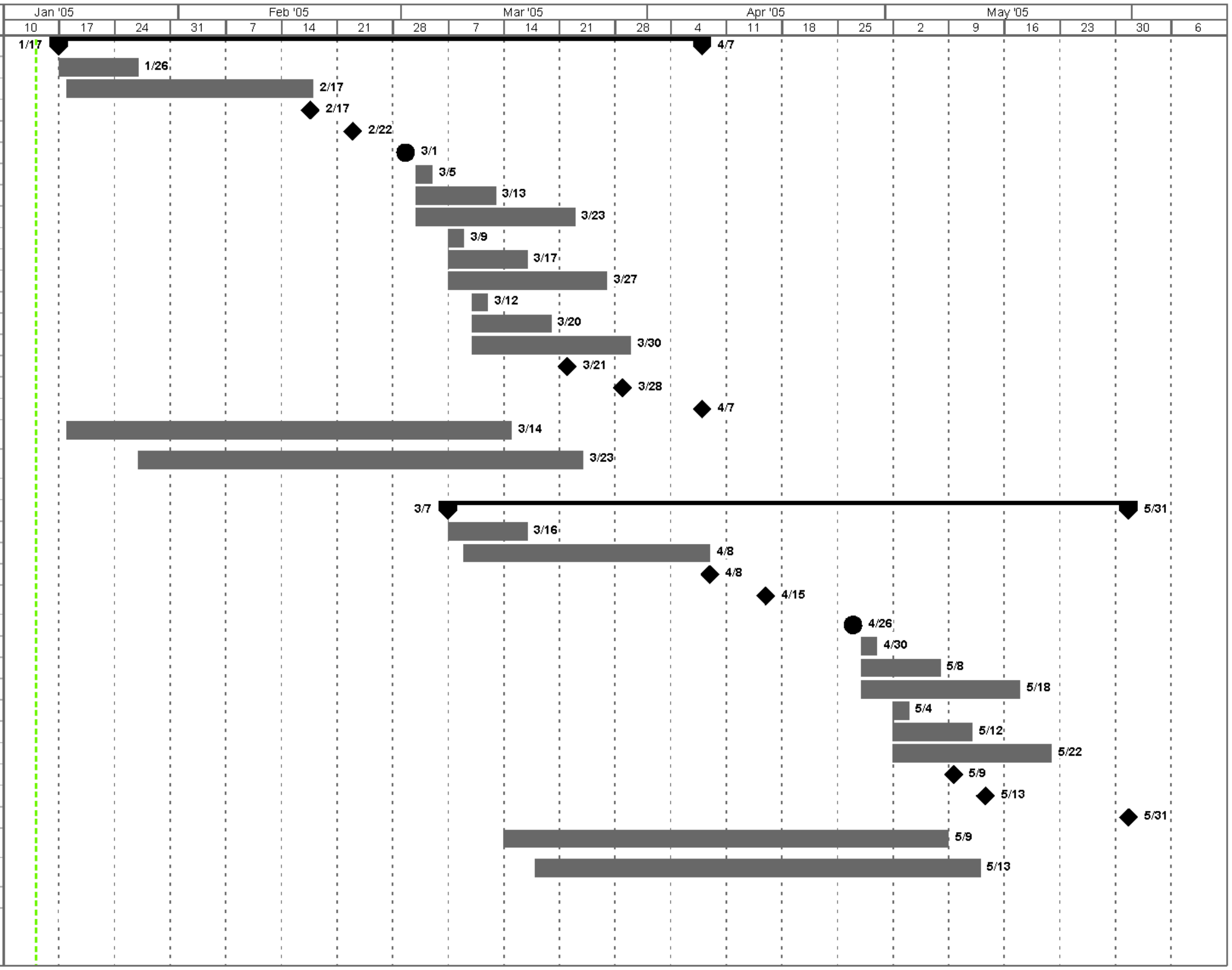

Figure 2-3. Approximate surface sediment testing timeline

The schedule for Round 2 assumes that the number of toxicity tests can be accommodated in two rounds of testing (less than 40 samples). If testing of additional samples in Round 2 is required, the schedule will have to be modified accordingly.

Separate draft data reports with the results of the validated chemical analyses and toxicity tests will be submitted to EPA and Ecology for each round of sediment sampling approximately 10 weeks after the conclusion of each round of toxicity testing to allow for data validation and report preparation and review. All PCB congener data will be submitted with the second data report.

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 analysis and toxicity testing are presented in Sections 3.4.1.2 and 3.4.2.2, respectively.

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 as Appendix B, will also be used to record pertinent information after sample collection:

- surface sediment collection form
- protocol modification form
- corrective action form

2.6.2 Laboratory records

The various laboratory record requirements for the sediment chemistry data and the sediment toxicity test data are described below. All of the contract laboratories to be used for this investigation are accredited by Ecology to conduct the sediment chemical analyses and toxicity tests.

2.6.2.1 Chemistry data for sediment samples

The chemistry laboratory 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
  - method detection and reporting limits
  - 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 the 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 3.4.1.2, for each analyte.
  - The laboratory control analysis summary will report the results of the analyses of laboratory control samples. 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 refrigerator temperature logs
    - sample extraction/digestion, preparation, and cleanup logs
    - instrument specifications and analysis logs for all instruments used on days of calibration and analysis
    - reconstructed ion chromatograms for all samples, standards, blanks, calibrations, spikes, replicates, laboratory control samples, 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 laboratory control samples, and SRMs
    - original data quantification reports for each sample

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

- Each row of data will contain only one for a given sample. Therefore, one complete sample will require multiple rows.
- Each row should contain the following information at a minimum: Windward sample identifier, sample matrix, laboratory sample identifier (if used), date of sampling, date of laboratory analysis, laboratory method, analyte name, measured result, laboratory qualifiers, units, and measurement basis.
- If using a spreadsheet file to produce the electronic deliverable, the value representing the measured concentration or detection limit will be rounded to show the correct number of significant figures and will not contain any trailing digits that are hidden in the formatting.
- If using a database program to produce the electronic deliverable, the value representing the measured concentration or detection limit will be stored in a character field, or a field in addition to the numeric result field will be provided to define the correct number of significant figures.
- 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 reporting limit. Quantified results between the detection limit and the reporting limit will be laboratory J-qualified.

- Analytical results of laboratory samples for QA/QC will be included and clearly identified in the file with unique laboratory sample identifiers. Additional columns may be used to distinguish the sample type (e.g., matrix spike, matrix spike duplicate).
- If replicate analyses are conducted on a submitted field sample, the laboratory sample identifier must distinguish among the replicates.
- Wherever possible, all analytes and replicates for a given sample will be grouped together.

An example of the acceptable organization of the electronic deliverable for chemical data is provided in Table 2-2.

Table 2-2. Example of acceptable organization of electronic deliverable for chemical data

FIELD NAME	REQUIRED OR OPTIONAL
Event name	required
Chain of custody ID	required
Laboratory sample ID	required
Matrix	required
Sample collection date/time	required
Requested analysis	required
Analyte	required
Chemical Abstracts Services registry number	required
Date/time analyzed	required
Detection limit	required
Reporting limit	required
Reporting limit type	required
Sample result	required
Units	required
Number of significant figures in each sample result	required
Laboratory qualifier	required [a]
Analysis batch	required
True value/spiked amount	optional
Percent recovery	required [a]
Upper limit	optional
Lower limit	optional
Analyst	required
Dilution	required
Extraction batch	required
Extraction date/time	required
Extraction method	required
Total solids	required

FIELD NAME	REQUIRED OR OPTIONAL
Laboratory notes	optional
Laboratory	required

[a] Required when available. Not all samples are qualified. Field samples have no percent recovery.

2.6.2.2 Sediment toxicity test data

The toxicity testing laboratory will be responsible for internal checks on sample handling and analytical data reporting and will correct errors identified during the QA review (see Section 3.5.2). Close contact will be maintained with the laboratory to resolve any QC problems in a timely manner. 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 the toxicity testing process. The summary will include, but not be limited to, discussion of quality control, sample shipment, and identification difficulties.
- **Records**: Legible copies of the 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 contain the results for each sample analyzed. The data package will include the following information:
    - field sample identification code and the corresponding laboratory identification code
    - test methods used for toxicity testing and summary statistics
    - source (including collection location) for all test organisms
    - source (location) for reference sediment collection
    - results for survival, growth, abnormalities, water quality parameters, reference toxicants, and summary statistics
    - original quality control checklists
- **QA/QC summary:** The summary will contain the results of the QA/QC procedures, and any corrective actions required.
- **Original data**: Legible copies of the original data generated by the laboratory will be provided, including the following:
    - original data sheets for survival, growth, and abnormalities for all test replicates
    - water quality parameters
    - reference toxicants

- summary statistics for all samples

An example of the acceptable organization of the electronic deliverable for toxicity data is provided in Table 2-3.

Table 2-3. Example of acceptable organization of electronic deliverable for toxicity data

FIELD NAME	REQUIRED OR OPTIONAL
Event name	required
Chain of custody ID	required
Laboratory sample ID	required
Sample collection date/time	required
Test type	required
Replicate number	required
Water quality measurement results	required
Individual replicate and mean and standard deviation data for bivalve larval percent mortality	required
Individual replicate and mean and standard deviation data for bivalve larval percent abnormality	required
Individual replicate and mean and standard deviation data for bivalve larval percent combined mortality and abnormality	required
Bivalve larval stocking density, stocking aliquot size, and initial count data for seawater controls	required
Daily amphipod emergence for each replicate and 10-day mean and standard deviation for each treatment	required
10-day amphipod mortality in each replicate and the mean and standard deviation for each treatment	required
Interstitial water salinity values for control, reference, and test sediments for amphipods and polychaetes	required
20-day polychaete survival in each exposure chamber and the mean and standard deviation for each treatment	required
Initial polychaete total biomass (dry weight) for three groups of five worms	required
20-day total polychaete biomass (dry weight) in each exposure chamber and the mean and standard deviation for each treatment	required
20-day polychaete average individual biomass (dry weight) in each exposure chamber and the man and standard deviation for each treatment	required
Average polychaete individual growth rate (dry weight/day) in each exposure chamber and the man and standard deviation for each treatment	required
LC50 values for reference toxicants	required
Current control limits for reference toxicants (mean ± 2 standard deviations)	required
Laboratory notes	optional
Laboratory	required

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, or mean mortality may need to be calculated from five replicate toxicity test results. 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 analysis of samples, for both chemistry and toxicity testing for each round of sampling. At a minimum, the following will be included in the data reports:

- summary of all field activities, including descriptions of any deviations from the approved QAPP
- summary spreadsheet containing information from field forms
- sediment sampling locations reported in latitude and longitude to the nearest one-tenth of a second and in northing and easting to the nearest foot
- plan view of the project showing the actual sampling locations
- documentation of how toxicity testing locations were selected
- summary of the QA/QC review of the analytical and toxicity test data
- statistical analysis of the toxicity test data in accordance with SMS rules and papers associated with Sediment Management Annual Review Meetings
- complete laboratory toxicity test reports (appendices)
- data validation reports (appendices)
- results from the analysis 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 crosstab tables produced from Windward's database

Analytical and toxicity test data will be validated within four weeks of receiving data packages from the respective laboratories. Draft data reports will be submitted to EPA and Ecology for each round of sediment sampling approximately 10 weeks after completion of each round of sediment toxicity testing. Final data reports will be submitted to EPA and Ecology following revision of the data reports in response to comments. Once the data reports have 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),[5] 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 and toxicity testing. Elements include sampling design, sampling methods, sample handling and custody requirements, analytical methods, quality assurance/quality control, instrument/equipment testing and frequency, inspection and maintenance, instrument calibration, supply inspection/acceptance, non-direct measurements, and data management. The sampling design and methods for collecting surface sediment samples from background areas are described separately in Appendices D and E. All other elements of Section 3 are applicable to both background and LDW sampling and analyses.

3.1 SAMPLING DESIGN

This section describes the sampling designs developed to meet the data needs presented in Section 2.2 for the placement of surface sediment samples, the chemical analyses of these samples, and toxicity testing.

3.1.1 Surface sediment samples

This section describes considerations for selecting Phase 2 surface sediment sampling locations. Note that in addition to the sample collection described in this QAPP, 20 Phase 2 composite surface sediment samples were collected in the LDW synoptically with benthic invertebrate tissue samples in August and September 2004, as described in the benthic invertebrate QAPP (Windward 2004b). Fourteen composite surface sediment samples were also collected in the LDW with clams during the same sampling event (Windward 2004b) for a total of 34 additional sediment samples (Figures 2-2a to 2-2e).

Five primary considerations were used to determine where to collect additional surface sediment chemistry data for Phase 2, in addition to the 34 composite surface sediment samples described above:

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

- low historical spatial coverage, particularly at sites where single SQS or CSL exceedances were observed with few nearby sampling locations
- special use areas (e.g., intertidal areas with public access or used by wildlife) that had previously been incompletely characterized
- potential historical or current chemical sources, including seeps identified as being of concern (based on seep water chemistry data collected for Phase 2)
- historical sediment chemical concentrations above the SQS or CSL
- analyte considerations including chemicals with relatively low numbers of historical samples or historical locations that did not have sufficiently low detection limits for certain chemicals

These considerations were described in the data needs memorandum (Windward 2003b) and the Phase 2 work plan (Windward 2004c) that was approved by EPA and Ecology. Each of the surface sediment chemistry sampling locations described below is based on at least one of the six considerations; many locations are based on multiple considerations. A brief description of the judgment applied within each consideration is provided below.

Low historical spatial coverage – New locations under this consideration were generally at least 50–100 m from any location previously sampled. Areas closer to either bank were given higher priority than areas in the center of the LDW, particularly in the navigation channel. Based on existing data, the latter areas generally contain lower chemical concentrations than many areas closer to shore. Also, areas with existing data showing elevated chemical concentrations (relative to SQS or CSL) were given higher priority than areas without any elevated concentrations.

Special use areas – These areas were limited to intertidal habitat that could potentially be used by humans and/or certain ecological receptors (e.g., sandpipers). Results from Phase 2 studies on human use (Windward 2004d) and sandpiper use (Windward 2004f) were used to identify some sampling locations where data gaps exist.

Near potential chemical sources – Identification of potential chemical sources was based on existing information and the preliminary source control investigations of waterfront properties and outfalls by member agencies of the LDW source control work group, including review of historical aerial photos, records, and agency files. A survey of visible outfalls/pipes within the LDW was completed in 2003 by the City of Seattle. Results from this survey were also used to identify some sediment sampling locations.

Additional characterization of elevated chemical concentrations – New sampling locations under this consideration were placed in areas where one or more samples had concentrations in excess of the CSL, or where small groups of samples had concentrations in excess of the SQS. Additional data from nearby locations not previously sampled will provide important information to better characterize these areas. In addition, sediment from a subset of previously sampled locations with SQS or CSL exceedances will be tested for sediment toxicity (see Section 3.1.3). New chemistry data are needed from these locations because the precise locations that were sampled previously cannot be relocated with accuracy and the chemical conditions documented previously may have changed. Selection of specific toxicity test locations will be made in coordination with EPA and Ecology when the synoptic Phase 2 surface sediment chemistry data are available, based on the criteria and approach described in Section 3.1.3.

Analyte considerations – Some chemical groups (e.g., dioxins/furans, chlorinated pesticides, PCB congeners) have been analyzed less frequently than SMS chemicals, so additional data collection is warranted to better characterize the distribution of these chemicals. In addition, many samples without any detected concentrations above the SQS or CSL had detection limits for one or more semi-volatile organic compounds (e.g., 1,2,4-trichlorobenzene, hexachlorobenzene) above the SQS or CSL.

There are several reasons why the detection limit may exceed the SQS or CSL (e.g., matrix effects, high concentrations of other analytes, low SQS or CSL relative to reporting limits for standard analytical techniques). In some cases, an apparent exceedance of the SQS or CSL by a detection limit may have been caused by a low total organic carbon (TOC) content of the sediment because the SQS and CSLs for these chemicals are expressed on a carbon-normalized basis. Also, the detection limits for many of these analyses were elevated because concentrations of one or more compounds in the target analyte list were high enough during screening[6] to require sample dilution, thus elevating the detection limit for the remainder of the compounds. Additional characterization of areas with detection limits above the SQS or CSL is warranted, particularly in areas with multiple samples in this category. Not every area with samples in this category will be resampled. It is assumed that additional data with sufficiently low detection limits coupled with the large existing database for these chemicals, will provide an adequate level of information to determine whether semi-volatile organic compounds that will be identified with the above approach pose significant risks to ecological or human receptors.

For PCB congeners, previous analyses used low resolution techniques resulting in detection limits greater than risk-based concentrations, so additional analyses for PCB congeners are warranted.

Based on the above considerations, a total of 156 surface sediment samples are the focus of this QAPP and are presented in Table 3-1 and Figures 2-2a to 2-2e (located at end of this document). Table 3-1 lists each location and the considerations addressed by its placement. Including the 34 composite surface sediment samples that were

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[6] Analytical laboratories may perform a screen prior to sample extraction to ensure that the resulting analyte concentrations are within the appropriate calibration curve ranges. Sample dilution may occur prior to extraction based on the results of the screen.

Table 3-1. Surface sediment chemistry sampling locations

LOCATION NAME	CONSIDERATIONS FOR PLACING LOCATIONS					NOTES [b]
	SPATIAL DATA GAP	SPECIAL USE AREA	NEAR POTENTIAL CHEMICAL SOURCE	ADDITIONAL CHARACTERIZATION OF ELEVATED CONC. NEEDED	ANALYTE CONSIDERATIONS [a]	
LDWG-1				x		Reoccupy historical location 546 with phenol and PCB SQS exceedances
LDWG-2			x		x	Coverage near marina; near storm drain; historical location 546 has elevated TBT concentration
LDWG-3	x			x	x	Near historical location 642 with BEHP CSL exceedance; spatial coverage; elevated TBT concentrations in the area
LDWG-4				x	x	Reoccupy historical location 543 with phenol CSL exceedance and elevated TBT concentrations near multiple non-detect SVOC CSL exceedances at historical location 545
LDWG-5				x		Reoccupy historical location 642 with BEHP CSL exceedance
LDWG-6			x	x	x	Near phenol CSL exceedance at historical location 543 and arsenic SQS exceedance at historical location 568; adjacent to historical sources of metals to sediments; elevated TBT in area
LDWG-7	x		x		x	Adjacent to historical sources of metals to sediments; elevated TBT in area
LDWG-8	x				x	Needed for spatial coverage
LDWG-9	x	x	x			Additional intertidal habitat characterization needed in this area; adjacent to drainage channel running through Terminal 105; high potential for sandpiper nesting and foraging; historical location 599 had PAH and PCB SQS exceedances
LDWG-10				x	x	Reoccupy historical location 541 with phenol CSL exceedance; near non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances at historical location 644
LDWG-11	x					No data within 75 m of location
LDWG-12				x		Reoccupy historical location 601 with PCB and mercury SQS exceedances
LDWG-13			x			Coverage near unconfirmed South Nevada St. storm drain outfall
LDWG-14	x		x		x	Near probable source of cement kiln dust, arsenic, and lead near a number of storm drains; near non-detect hexachlorobenzene CSL exceedance at historical location 633 and a non-detect hexachlorobenzene SQS exceedance at historical location 602
LDWG-15				x	x	Reoccupy historical location 645 with BEHP SQS exceedance; near phenol SQS exceedance at historical location 540
LDWG-16					x	Need reduced hexachlorobenzene DL based on non-detect hexachlorobenzene CSL exceedance at historical location 633 and a non-detect hexachlorobenzene SQS exceedance at historical location 602

Location Name	Considerations for Placing Locations					Notes [b]
	Spatial Data Gap	Special Use Area	Near Potential Chemical Source	Additional Characterization of Elevated Conc. Needed	Analyte Considerations [a]	
LDWG-17				x		Reoccupy historical location 1031 with BEHP CSL exceedance
LDWG-18			x	x	x	Reoccupy King County station DUD-11C (historical location 9286); near historical locations 9287, 1032, 1037, and 573 with phthalate CSL exceedances and historical location 1035 with a 4-methylphenol CSL exceedance; sample area with elevated dioxins/furans. King County will take sample and analyze for SMS chemicals and pesticides and provide LDWG with a split for dioxin/furan analyses, SIM, and PCB congener archive.
LDWG-19	x		x		x	Near outfall at General Recycling; needed for spatial coverage; near historical location 635 with non-detect 1,2,4-trichlorobenzene and hexachlorobenzene SQS exceedances; near historical location 605 with non-detect 1,2,4-trichlorobenzene SQS exceedance
LDWG-20			x	x	x	Reoccupy King County station DUD-9C; sample area with elevated dioxins/furans near historical location 575; near phthalate and PCB CSL exceedances at historical locations 9295 and 647. King County will take sample and analyze for SMS chemicals and pesticides and provide LDWG with a split for dioxin/furan analyses, TBT, and PCB congener archive.
LDWG-21	x			x		Sample area west of Duwamish/Diagonal dredge activities (50 feet east of western navigation channel boundary)
LDWG-22				x	x	Reoccupy historical location 9288 (King County DUD-1C); near area with elevated dioxins/furans at historical location 575
LDWG-23	x			x	x	Reoccupy unnumbered historical location (no QA/QC data) with PCB CSL exceedance; near historical location 610 with PAH SQS exceedances; near historical locations 355, 357, and 358 with non-detect 2,4-dimethylphenol exceedances; near historical location 636 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances
LDWG-24	x	x			x	Near human use area (Duwamish tribe canoe launch); near historical locations 1142, 1144, and 1145 with non-detect hexachlorobenzene SQS exceedances
LDWG-25		x			x	Human use area; near public storm drain
LDWG-26				x	x	Within area of PCB SQS exceedances at historical locations 649, 49 and 1026; near non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances at historical locations 579 and 580
LDWG-27		x	x	x	x	Reoccupy historical location 205 with PCB CSL exceedance; near GSA facility; within potential sandpiper habitat; near non-detect hexachlorobenzene SQS exceedance at historical location 581
LDWG-28	x	x	x	x	x	More data needed in this intertidal area; near PCB SQS exceedance at historical location 266; near non-detect hexachlorobenzene SQS exceedance at historical location 611; near source of cement kiln dust; high potential for sandpiper nesting and foraging; most adjacent historical data is for PCBs only

LOCATION NAME	CONSIDERATIONS FOR PLACING LOCATIONS					NOTES [b]
	SPATIAL DATA GAP	SPECIAL USE AREA	NEAR POTENTIAL CHEMICAL SOURCE	ADDITIONAL CHARACTERIZATION OF ELEVATED CONC. NEEDED	ANALYTE CONSIDERATIONS [a]	
LDWG-29	x		x			Needed for spatial coverage; area of cement kiln dust
LDWG-30	x		x		x	Near potential sources at head of Slip 1; near historical location 584 with non-detect hexachlorobenzene SQS exceedance
LDWG-31			x	x	x	Reoccupy historical location 587 with arsenic and zinc CSL exceedances; near PCB SQS exceedance at historical location 202; near Seep 76
LDWG-32				x	x	Reoccupy historical location 586 with benzyl alcohol CSL exceedance; near PCB SQS exceedances at historical locations 200 and 202
LDWG-33	x	x		x	x	More data needed in this intertidal area; near historical locations 269 and 270 with PCB SQS exceedances from NOAA SiteChar; historical location 613 had SQS exceedances for phenol, fluoranthene, and chrysene; high potential for sandpiper nesting and foraging
LDWG-34	x	x			x	Need additional intertidal data in this area; near historical location 614 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances; most adjacent locations were analyzed for PCBs only
LDWG-35	x		x	x		Potential upland source; if no access at this location, closest area to the north will be sampled
LDWG-36	x		x		x	More data needed in this intertidal area; adjacent to cement plant loading berth; near Seep 64 with PCB concentration greater than chronic WQC in seep water
LDWG-37				x		Reoccupy historical location 653 with PCB, PAH, and mercury SQS exceedances; near historical location 628 with non-detect SQS hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances
LDWG-38			x		x	Adjacent to cement plant, a potential source of metals; near historical location 640 with non-detect hexachlorobenzene SQS exceedance; near historical location 616 with fluoranthene SQS exceedance
LDWG-39	x		x		x	Needed for coverage of Brandon CSO; near historical locations 690 and 629 with non-detect hexachlorobenzene SQS exceedances
LDWG-40				x		Reoccupy historical location 654 with PCB SQS exceedance
LDWG-41	x				x	Data near this location for PCBs only at historical location 328
LDWG-42			x			Coverage of double outfalls at RM 1.25 east
LDWG-43			x	x	x	Near historical location 641 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances; adjacent to 24” storm drain from cement plant
LDWG-44				x		Reoccupy historical location 619 with BEHP CSL exceedance
LDWG-45			x		x	Downstream of Duwamish Shipyard
LDWG-46			x	x	x	Near historical location 619 with BEHP CSL exceedance; near shipyard

	CONSIDERATIONS FOR PLACING LOCATIONS					
LOCATION NAME	SPATIAL DATA GAP	SPECIAL USE AREA	NEAR POTENTIAL CHEMICAL SOURCE	ADDITIONAL CHARACTERIZATION OF ELEVATED CONC. NEEDED	ANALYTE CONSIDERATIONS [a]	NOTES [b]
LDWG-47			x		x	Near Duwamish shipyard outfalls; area with elevated TBT
LDWG-48				x	x	Reoccupy historical location 8823 with arsenic, zinc, copper, and lead CSL exceedances; coverage of Duwamish Shipyard outfalls; near historical location 8824 with BEHP and butyl benzyl phthalate SQS exceedances; near historical location 620 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances
LDWG-49				x	x	Reoccupy historical location 8822 with copper CSL exceedance; area with elevated TBT
LDWG-50				x	x	Reoccupy historical location 596 with PCB and mercury CSL exceedances
LDWG-51				x	x	Reoccupy historical location 726 with BEHP CSL exceedance; area of elevated TBT
LDWG-52				x		Reoccupy historical location 631 with PAH CSL exceedances
LDWG-53			x	x	x	Near Duwamish Shipyard and outfall of interest; near historical location 687 with non-detect hexachlorobenzene SQS exceedance
LDWG-54				x	x	Coverage of storm drains at St. Gobain containers; near PAH CSL exceedances at historical location 631; near mercury and PCB CSL exceedances at historical location 596
LDWG-55				x	x	Reoccupy historical location 8821 with arsenic and BEHP CSL exceedances ; near BEHP CSL exceedance at historical location 726; and PAH CSL exceedances at historical location 631
LDWG-56			x	x	x	Near non-detect hexachlorobenzene SQS exceedances at historical location 687, 688, and 691; near non-detect 1,2,4-trichlorobenzene SQS exceedances at historical locations 687 and 688 resample area with elevated dioxins/furans; adjacent to cement plant and former PCP manufacturer
LDWG-57			x	x	x	Reoccupy historical location 689 with elevated dioxins/furans and PCB and mercury SQS exceedances; adjacent to cement plant and former PCP manufacturer
LDWG-58	x	x	x	x	x	Near cement plant and former PCP manufacturer; within under-sampled intertidal area; need additional TBT data; resample area with elevated dioxins/furans; near Seep 61 with arsenic concentration greater than acute WQC and non-detected pesticide concentration greater than chronic WQC in seep water
LDWG-59			x	x	x	Near cement plant and former PCP manufacturer; resample area with elevated dioxins/furans; near historical location 692 with butyl benzyl phthalate SQS exceedance; near historical location 690 with non-detect hexachlorobenzene SQS exceedance; near historical location 8825 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances

LOCATION NAME	CONSIDERATIONS FOR PLACING LOCATIONS					NOTES [b]
	SPATIAL DATA GAP	SPECIAL USE AREA	NEAR POTENTIAL CHEMICAL SOURCE	ADDITIONAL CHARACTERIZATION OF ELEVATED CONC. NEEDED	ANALYTE CONSIDERATIONS [a]	
LDWG-60	x				x	Near Seep 80 with copper concentration greater than acute WQC in seep water; near zinc CSL exceedance at historical location 8990 and non-detect phenol SQS exceedance at historical location 658
LDWG-61	x		x			Near potential upland source
LDWG-62	x				x	Within area of 4 locations with SVOC SQS DL exceedances; non-detect hexachlorobenzene SQS exceedances occurred at historical locations 693, 694, 718, 728; non-detect 1,2,4-trichlorobenzene SQS exceedance occurred at historical location 728
LDWG-63			x		x	Near potential upland source; near historical location 663 with non-detect hexachlorobenzene SQS exceedance
LDWG-64			x	x	x	Reoccupy historical location 8995 with PCB CSL exceedance and non-detect 2,4-dimethylphenol SQS exceedance; near cement plant
LDWG-65			x			Adjacent to pipe of unknown origin; near historical location 8995 with PCB CSL exceedance and non-detect 2,4-dimethylphenol SQS exceedance
LDWG-66	x				x	Adjacent to 2 historical locations with SVOC SQS DL exceedances; non-detect hexachlorobenzene SQS exceedances occurred at historical locations 694 and 719; non-detect 1,2,4-trichlorobenzene SQS exceedances occurred at historical location 719
LDWG-67			x		x	Industrial history including shipyard and battery cracking operation; near Seep 82 with copper and zinc concentrations greater than acute WQC in seep water; sandblast grit observed on water near this area
LDWG-68					x	Near historical locations 885 and 896 with non-detect 1,2,4-trichlorobenzene SQS exceedances; near historical location 696 with non-detect hexachlorobenzene SQS exceedance
LDWG-69	x	x			x	Additional intertidal data needed; PCBs, bunker oil, and metals found in upland soils at Hale Construction; near historical location 86 with PCB SQS exceedance; near historical location 666 with non-detect CSL exceedances for hexachlorobenzene, 1,2,4-trichlorobenzene, and 1,2-dichlorobenzene; near historical location 712 with non-detect hexachlorobenzene SQS exceedance
LDWG-70			x	x	x	Reoccupy historical location 697 with BEHP CSL exceedance; near 72” storm drain; near historical location 907 with BEHP CSL exceedance
LDWG-71	x		x		x	Adjacent to Michigan St CSO; near historical location 713 with PCB SQS exceedance ; near historical location 670 with non-detect hexachlorobenzene SQS exceedance

Location Name	Considerations for Placing Locations					Notes [b]
	Spatial Data Gap	Special Use Area	Near Potential Chemical Source	Additional Characterization of Elevated Conc. Needed	Analyte Considerations [a]	
LDWG-72				x	x	Near historical location 721 with BEHP CSL exceedance; near historical location 951with PCB CSL exceedance; near historical locations 940 and 732 with non-detect 1,2,4 trichlorobenzene SQS exceedances; near historical location 732 with non-detect hexachlorobenzene SQS exceedance
LDWG-73			x		x	Near former Marine, Power, and Equipment (debris, waste paint, material storage issues); near 3 outfalls; near historical location 672 with benzyl alcohol CSL exceedance; near historical location 673 with non-detect hexachlorobenzene SQS exceedance; near historical locations 674 and 675 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene hexachlorobenzene SQS exceedances
LDWG-74			x		x	Sandblasting grit history; near historical location 671 with non-detect hexachlorobenzene SQS exceedance
LDWG-75				x		Reoccupy historical location 951 with PCB CSL exceedance; near historical location 721 with BEHP CSL exceedance and historical location 962 with PCB SQS exceedance
LDWG-76				x	x	Reoccupy historical location 672 with benzyl alcohol CSL exceedance; historical shipyard; recurrent oil sheen in area
LDWG-77			x		x	Potential source from waste piles under pier; will be sampled if access allows; near historical location 674 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances
LDWG-78			x		x	Coverage of former synchro lift (potential sandblasting grit)
LDWG-79				x	x	Reoccupy historical location 38 with PCB CSL exceedance; near historical location 677 with DDT ML exceedance; near historical location 733 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances; near historical locations 676 and 714 with non-detect hexachlorobenzene SQS exceedances
LDWG-80	x	x			x	Lack of intertidal data in this area; adjacent to W Michigan CSO; high potential for sandpiper nesting and foraging; human use area (hand boat launch area)
LDWG-81				x		Reoccupy historical location 679 with PCB CSL exceedance
LDWG-82	x				x	Just downstream of candidate early action site; near historical location 705 with DDT CSL exceedance; near historical location 702 with fluoranthene SQS exceedance; near historical locations 703, 722, and 735 with non-detect hexachlorobenzene SQS exceedances; near historical locations 703 and 705 with non-detect 1,2,4-trichlorobenzene SQS exceedances
LDWG-83			x		x	Coverage of potential source areas and MTCA site; pentachlorophenol in groundwater at Great Western; near historical location 682 with non-detect hexachlorobenzene SQS exceedance

Location Name	Considerations for Placing Locations					Notes [b]
	Spatial Data Gap	Special Use Area	Near Potential Chemical Source	Additional Characterization of Elevated Conc. Needed	Analyte Considerations [a]	
LDWG-84	x	x	x	x	x[c]	Within candidate early action site; near historical location 705 with PCB CSL and DDT MSL exceedances; near 36" storm drain; near Seep 54 with mercury, PCBs, and non-detect pesticide chronic WQC exceedances in seep water; SVOCs were also detected in water from Seep 54
LDWG-85	x	x			x	Just upstream of candidate early action site; lack of intertidal data in this area
LDWG-86	x	x				Just upstream of candidate early action site; lack of intertidal data in this area; near historical location 318 with PCB SQS exceedance; near historical location 706 with non-detect N-nitrosodiphenylamine SQS exceedance; near historical location 707 with PAH SQS exceedances; near historical location 724 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances
LDWG-87			x		x	Coverage of MTCA site; needed to fill pesticide data gap in this area; near historical locations 685 and 717 with PCB SQS exceedances
LDWG-88				x	x	Reoccupy historical location 81 with PCB SQS exceedance; near historical location 166 with PCB SQS exceedance; near historical location 738 with non-detect hexachlorobenzene, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, hexachlorobutadiene, and N-nitrosodiphenylamine CSL exceedances
LDWG-89				x	x	Near historical locations 82 and 169 with PCB SQS exceedances; near historical locations 739 and 778 with non-detect 1,2,4-trichlorobenzene SQS exceedances; near historical location 778 with non-detect hexachlorobenzene SQS exceedance
LDWG-90			x		x	Coverage in potential source area; near historical location 756 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances
LDWG-91	x				x	Needed for spatial coverage; near historical location 787 with fluoranthene SQS exceedance; near historical location 756 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances
LDWG-92				x	x	Reoccupy historical location 170 with PCB SQS exceedance public access area; near historical locations 84 and 740 with PCB SQS exceedances; near historical location 779 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances; near historical location 740 with non-detect chrysene and fluorene SQS exceedances
LDWG-93	x	x			x	Lack of intertidal data in this area
LDWG-94			x	x		Reoccupy historical location 741 with phenanthrene, fluoranthene, and LPAH CSL exceedances; near historical locations 84 and 170 with PCB SQS exceedances; near Seep 12 with copper concentrations greater than acute WQC in seep water
LDWG-95	x					Needed for spatial coverage; location will be sampled only if area inshore of barges is accessible during the sampling event
LDWG-96				x		Near historical locations 33, 34, 165, and 502 with PCB SQS exceedances; near historical location 749 with dieldrin SQS exceedance

LOCATION NAME	CONSIDERATIONS FOR PLACING LOCATIONS					NOTES [b]
	SPATIAL DATA GAP	SPECIAL USE AREA	NEAR POTENTIAL CHEMICAL SOURCE	ADDITIONAL CHARACTERIZATION OF ELEVATED CONC. NEEDED	ANALYTE CONSIDERATIONS [a]	
LDWG-97			x		x	Coverage near outfalls of interest; near historical locations 34 and 311 with PCB SQS exceedances; near historical locations 759 and 798 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances
LDWG-98			x			Coverage near outfalls of interest
LDWG-99		x	x	x	x	Reoccupy historical location 252 with PCB SQS exceedance; need additional intertidal data in Duwamish Waterway Park; human use area; near historical location 762 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances
LDWG-100		x			x	Need additional intertidal data in Duwamish Waterway Park; human use area; near historical locations 762, 763, and 790 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances
LDWG-101		x				Need additional intertidal data in Duwamish Waterway Park; human use area; near Seep 48 with copper concentrations greater than acute WQC in seep water; near historical locations 763 and 790 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances
LDWG-102		x		x		Reoccupy historical location 764 with hexachlorobenzene CSL exceedance; near historical locations 763 and 791 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances; human use area (adjacent to Duwamish Waterway Park)
LDWG-103				x	x	Near historical location 764 with hexachlorobenzene CSL exceedance; near historical location 765 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances
LDWG-104				x	x	Reoccupy historical location 768 with phenol CSL exceedance and with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances; near historical location 766 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances
LDWG-105	x	x			x	Needed for spatial coverage; human use area; near historical location 792 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances
LDWG-106		x				Human use area; near historical location 769 with phenol SQS exceedance; near historical location 770 with 1,2,4-trichlorobenzene CSL exceedance
LDWG-107	x		x		x	No data within 100 m upstream or downstream of location; boat launch area; adjacent to storm drain
LDWG-108	x				x	No data within 100 m upstream or downstream of location
LDWG-109				x		Near historical locations 468, 144, 431, and 514 with PCB CSL exceedances; near historical locations 468 and 513 with metals CSL exceedances

Location Name	Considerations for Placing Locations					Notes [b]
	Spatial Data Gap	Special Use Area	Near Potential Chemical Source	Additional Characterization of Elevated Conc. Needed	Analyte Considerations [a]	
LDWG-110			x	x	x	Reoccupy historical location 505 with PCB and lead CSL exceedances; near historical locations 504, 146 and 515 with PCB CSL and SQS exceedances; near historical location 504 with zinc CSL exceedance; near location 751 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances; sample will target piles of metal debris in intertidal area; near Jorgensen Forge, a potential dioxin source from steel foundry dust
LDWG-111			x	x		Reoccupy historical location 752 with PCB SQS exceedances; near historical locations 148, 149, and 508 with PCB SQS exceedances; near Seep 20 with copper concentrations greater than acute WQC in seep water
LDWG-112	x	x		x		Need additional intertidal data in this area; just downstream of early action candidate site; near historical location 154 with PCB SQS exceedance
LDWG-113				x	x	Reoccupy historical location 776 with PCB SQS exceedance and non-detect hexachlorobenzene and 1,2,4-trichlorobenzene exceedances; near storm drain; near historical locations 897 and 898 with PCB SQS exceedances
LDWG-114	x	x		x		Just downstream of early action candidate site; potential sandpiper habitat; near historical locations 142 and 155 with PCB SQS exceedances
LDWG-115			x	x	x	Reoccupy historical location 900 with PAH and BEHP CSL exceedances; near historical location 143 with PCB SQS exceedance; within early action candidate site; adjacent to Isaacson emergency overflow CSO and 24” storm drain; potential sandpiper habitat; near historical locations 753 and 899 with PAH CSL exceedances; near historical location 753 with PAH and BEHP CSL exceedances
LDWG-116				x	x	Just upstream of candidate early action site; near historical location 903 with PCB and butyl benzyl phthalate SQS exceedances; near historical location 70 with PCB SQS exceedances
LDWG-117				x	x	Reoccupy historical location with BEHP CSL exceedance 901; near historical locations 902 and 777 with non-detect 1,2,4-trichlorobenzene SQS exceedances; near historical location 777 with non-detect hexachlorobenzene SQS exceedance
LDWG-118				x		Just upstream of candidate early action site; near historical location 904 with PCB and BBP SQS exceedances
LDWG-119				x	x	Reoccupy historical location 908 with PCB CSL exceedance; near historical location 904 and 909 with BBP SQS exceedances; near historical location 909 with BEHP SQS exceedance; near historical locations 70, 904, and 138 with PCB SQS exceedances; near historical location 754 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances
LDWG-120			x	x	x	Near outfalls of interest and historical location 138 with PCB SQS exceedance
LDWG-121				x	x	Reoccupy historical location 71 with PCB CSL exceedance; near historical location 802 with butyl benzyl phthalate and PCB SQS exceedances; near historical location 913 with non-detect 1,2,4-trichlorobenzene SQS exceedance

Location Name	Considerations for Placing Locations					Notes [b]
	Spatial Data Gap	Special Use Area	Near Potential Chemical Source	Additional Characterization of Elevated Conc. Needed	Analyte Considerations [a]	
LDWG-122				x	x	Near historical location 824 with butyl benzyl phthalate SQS exceedance; near historical location 911 with non-detect 1,2,4-trichlorobenzene CSL exceedance; near historical location 910 with non-detect 1,2,4-trichlorobenzene SQS exceedance
LDWG-123	x	x		x	x	Reoccupy historical location 139 with PCB CSL exceedance; need additional intertidal data in this area; near historical location 843 with non-detect 1,2,4-trichlorobenzene and hexachlorobenzene SQS exceedances
LDWG-124	x		x		x	Additional nearshore data needed; downstream of marina; near Seep 41
LDWG-125				x	x	Reoccupy historical location 804 with benzyl alcohol CSL exceedance; near historical location 1110 with DDT ML exceedance; near historical location 1111 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances; near historical location 844 with non-detect hexachlorobenzene SQS exceedance
LDWG-126				x	x	Reoccupy historical location 1110 with DDT ML exceedance; near historical location 805 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances; near historical locations 1108 and 1109 with non-detect hexachlorobenzene SQS exceedances
LDWG-127				x	x	Reoccupy historical location 919 with PAH CSL exceedances
LDWG-128			x	x	x	Adjacent to storm drains; near historical location 919 with PAH CSL exceedances
LDWG-129				x	x	Reoccupy historical location 921 with PAH CSL exceedances and several non-detect SVOC CSL exceedances; near historical location 808 with non-detect DDT and dieldrin SQS exceedances; near old shipyard
LDWG-130				x		Reoccupy historical location 924 with PAH CSL exceedances; near historical location 923 with acenaphthene SQS exceedance
LDWG-131	x		x		x	Additional nearshore data needed; near marina; near S 96th St storm drain, which may be a source of dioxins; potential source of cement kiln dust; near historical location 850 with DDT SQS exceedance; near historical locations 827 and 828 with non-detect hexachlorobenzene SQS exceedances
LDWG-132	x			x	x	Near historical locations 936 and 932 with non-detect 1,2,4-trichlorobenzene SQS exceedances; near historical location 812 with non-detect hexachlorobenzene SQS exceedance; near historical location 742 with multiple non-detect PAH SQS exceedances
LDWG-133	x	x			x	Need additional intertidal data in this area; downstream of Seep 39 with heptachlor epoxide detection; human use area (workers at Delta Marine)
LDWG-134				x	x	Near Seep 39 with detected pesticides in seep water; near historical location 241 with PCB SQS exceedance

Location Name	Considerations for Placing Locations					Notes [b]
	Spatial Data Gap	Special Use Area	Near Potential Chemical Source	Additional Characterization of Elevated Conc. Needed	Analyte Considerations [a]	
LDWG-135	x		x		x	Need additional intertidal data in this area; adjacent to area with historical dredge fill; near historical location 24 with PCB SQS exceedance; near historical location 830 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances; near historical location 829 with non-detect hexachlorobenzene SQS exceedance; human use of Hamm Creek area
LDWG-136	x		x		x	Need additional intertidal data in this area; adjacent to location with historical dredge fill; adjacent to new Hamm Creek outlet; near historical locations 829 and 852 with non-detect hexachlorobenzene SQS exceedances; near historical location 852 with non-detect 1,2,4-trichlorobenzene SQS exceedance
LDWG-137				x	x	Near historical location 944 with PAH SQS exceedances; near historical locations 943, 945, and 946 with non-detect 1,2,4-trichlorobenzene SQS exceedances
LDWG-138				x	x	Near historical locations 949, 950, 952, and 953 with non-detect 1,2,4-trichlorobenzene exceedances
LDWG-139	x			x	x	Needed for spatial coverage; near historical location 831 with non-detect 1,2,4-trichlorobenzene CSL exceedance
LDWG-140			x		x	Near outfalls of potential interest; near historical location 832 with non-detect hexachlorobenzene SQS exceedance
LDWG-141	x	x			x	Need additional intertidal data in this area; potential sandpiper habitat; near historical location 833 with hexachlorobenzene, 1,2,4-trichlorobenzene, and 1,2-dichlorobenzene CSL exceedances; near historical locations 834 and 853 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances; near historical location 856 with non-detect hexachlorobenzene SQS exceedance
LDWG-142			x	x	x	Near historical location 820 with lead CSL exceedance; near historical location 963 with non-detect 1,2,4-trichlorobenzene SQS exceedance; near historical location 838 with non-detect hexachlorobutadiene and N-nitrosodiphenylamine SQS exceedances; near outfall of interest
LDWG-143			x	x	x	Reoccupy historical location 1093 with benzoic acid CSL exceedance; near outfalls; near historical locations 1089, 1090, and 1091 with multiple non-detect SVOC CSL exceedances; near historical locations 1092, 1094, and 1095 with PCB SQS exceedances; near historical locations 965 and 966 with non-detect 1,2,4-trichlorobenzene SQS exceedances
LDWG-144			x	x	x	Need co-located dioxin/furan and PCB congener data; near storm drain; near historical location 1101 with multiple non-detect SVOC CSL exceedances
LDWG-145	x					Needed for spatial coverage
LDWG-146	x	x			x	High potential for sandpiper nesting and foraging; near historical locations 839 and 859 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances

Location Name	Considerations for Placing Locations					Notes [b]
	Spatial Data Gap	Special Use Area	Near Potential Chemical Source	Additional Characterization of Elevated Conc. Needed	Analyte Considerations [a]	
LDWG-147	x	x			x	Need additional intertidal data in this area; high potential for sandpiper nesting and foraging; near historical location 836 with non-detect hexachlorobenzene and 1,2,4-trichlorobenzene SQS exceedances; near historical location 835 with non-detect 1,2,4-trichlorobenzene CSL exceedance
LDWG-148				x		Reoccupy historical location 837 with PCB CSL exceedance
LDWG-149	x	x				Near sandpiper habitat area and human use area
LDWG-150	x	x			x	Need additional intertidal data in this potential human use area; high potential for sandpiper nesting and foraging; near historical location 837 with PCB CSL exceedance
LDWG-151	x				x	Needed to establish upstream boundary of study area
LDWG-152	x				x	Needed to establish upstream boundary of study area
LDWG-153	x					Needed to establish upstream boundary of study area
LDWG-154	x				x	Needed to establish upstream boundary of study area
LDWG-155	x				x	Needed to establish upstream boundary of study area
LDWG-156	x					Needed to establish upstream boundary of study area

[a] Some of the analyte considerations, primarily elevated detection limits, are listed in the notes column. Other analyte considerations include the need for additional data on specific chemicals or chemical groups, as described in Table 3-3.

[b] The SQS and CSL exceedances discussed in this column represent the symbols shown in Figures 2a to 2e. In these figures, only one symbol is shown for each station according to the following hierarchy: detect >CSL, detect > SQS, non-detect >CSL, or non-detect >SQS. For information on all SQS or CSL exceedances at historical locations, please see Appendix G.

[c] During a previous visit to this location, a NAPL-like substance was observed in sediment. If this substance is found again during surface sediment sampling at this location, a separate sample will be collected and chemically analyzed for source characterization.

BBP – butyl benzyl phthalate

BEHP – bis(2-ethylhexyl)phthalate

DL – detection limit

LPAH – high-molecular-weight polycyclic aromatic hydrocarbon

ML – maximum level (DMMP)

NAPL – non-aqueous phase liquid

PAH – polycyclic aromatic hydrocarbon

PCP – pentachlorophenol

SIM – selected ion monitoring

SVOC – semivolatile organic compound

WQC – Washington state marine chronic water quality criteria collected synoptically with benthic invertebrate and clam tissue samples (discussed at the beginning of this section; Windward 2004b) and the eight surface sediment samples being collected and analyzed by King County associated with the perimeter of the Duwamish/Diagonal early action (unpublished data), a total of 198 surface sediment samples will be analyzed for the Phase 2 RI. The coordinates and elevations of surface sediment samples collected as part of the RI are provided in Table 3-2. Chemicals to be analyzed in each of the 156 surface sediment samples specified in this QAPP are described later in this section and summarized in Table 3-3.

Table 3-2. Surface sediment sampling location coordinates

LOCATION NAME	X COORDINATE [a]	Y COORDINATE [a]	LATITUDE [b]	LONGITUDE [b]	ESTIMATED DEPTH ABOVE (+) OR BELOW (-) MLLW (FT) [c]
LDWG-1	1266032	211372	47 34.1612	122 21.0009	-13.8
LDWG-2	1266244	211348	47 34.1578	122 20.9491	-10.3
LDWG-3	1265842	211235	47 34.1380	122 21.0463	-3.8
LDWG-4	1266883	211229	47 34.1404	122 20.7934	-28.3
LDWG-5	1265996	211210	47 34.1343	122 21.0087	-34.6
LDWG-6	1267025	211196	47 34.1354	122 20.7586	-24.1
LDWG-7	1266985	211054	47 34.1119	122 20.7677	-29.7
LDWG-8	1266544	210832	47 34.0739	122 20.8737	-39.0
LDWG-9	1265959	210632	47 34.0392	122 21.0149	na
LDWG-10	1266258	210286	47 33.9833	122 20.9407	-27.6
LDWG-11	1266643	210208	47 33.9717	122 20.8467	-46.2
LDWG-12	1266104	210194	47 33.9677	122 20.9777	-11.2
LDWG-13	1266934	210046	47 33.9460	122 20.7752	-18.3
LDWG-14	1266179	209915	47 33.9221	122 20.9580	na
LDWG-15	1266467	209860	47 33.9138	122 20.8878	-38.2
LDWG-16	1266291	209832	47 33.9087	122 20.9304	-35.2
LDWG-17	1266890	209821	47 33.9088	122 20.7848	-23.3
LDWG-18	1266844	209535	47 33.8617	122 20.7946	-27.0
LDWG-19	1266487	209162	47 33.7991	122 20.8797	-34.4
LDWG-20	1266784	209157	47 33.7993	122 20.8073	-33.6
LDWG-21	1266683	209140	47 33.7962	122 20.8320	-33.8
LDWG-22	1267168	208754	47 33.7343	122 20.7122	-17.5
LDWG-23	1266583	208452	47 33.6827	122 20.8529	-9.8
LDWG-24	1265954	208326	47 33.6600	122 21.0050	1.4
LDWG-25	1267292	208141	47 33.6339	122 20.6791	0.1
LDWG-26	1267288	207661	47 33.5549	122 20.6778	-30
LDWG-27	1267542	207310	47 33.4981	122 20.6144	-7.5
LDWG-28	1265916	207206	47 33.4756	122 21.0091	3.9
LDWG-29	1266075	206826	47 33.4136	122 20.9686	1.7
LDWG-30	1268374	206823	47 33.4206	122 20.4100	-21.5
LDWG-31	1268539	206534	47 33.3735	122 20.3686	na
LDWG-32	1268204	206530	47 33.3718	122 20.4500	na
LDWG-33	1266292	206479	47 33.3574	122 20.9143	5.6
LDWG-34	1266952	206472	47 33.3583	122 20.7538	-6.5
LDWG-35	1267924	206395	47 33.3488	122 20.5172	-14.4
LDWG-36	1267007	206188	47 33.3118	122 20.7390	-17.2

Location Name	X Coordinate [a]	Y Coordinate [a]	Latitude [b]	Longitude [b]	Estimated Depth Above (+) or Below (-) MLLW (ft) [c]
LDWG-37	1267735	206171	47 33.3113	122 20.5622	-34.3
LDWG-38	1267635	205939	47 33.2728	122 20.5853	-29.6
LDWG-39	1268190	205909	47 33.2697	122 20.4504	-1.0
LDWG-40	1267960	205507	47 33.2028	122 20.5043	-34.3
LDWG-41	1267766	205457	47 33.1940	122 20.5512	-26.2
LDWG-42	1268296	205276	47 33.1660	122 20.4216	-1.6
LDWG-43	1267881	205161	47 33.1457	122 20.5218	-26.6
LDWG-44	1267941	204908	47 33.1043	122 20.5060	na
LDWG-45	1268041	204842	47 33.0937	122 20.4815	-27.9
LDWG-46	1267939	204779	47 33.0831	122 20.5059	-9.7
LDWG-47	1267947	204708	47 33.0714	122 20.5038	na
LDWG-48	1268050	204599	47 33.0538	122 20.4781	-7.4
LDWG-49	1268107	204476	47 33.0337	122 20.4636	-18.0
LDWG-50	1268521	204436	47 33.0285	122 20.3628	-9.8
LDWG-51	1268236	204365	47 33.0160	122 20.4318	-3167
LDWG-52	1268452	204315	47 33.0083	122 20.3790	-28.6
LDWG-53	1268070	204302	47 33.0050	122 20.4719	-16.8
LDWG-54	1268592	204287	47 33.0043	122 20.3449	-4.2
LDWG-55	1268184	204181	47 32.9856	122 20.4436	-24.6
LDWG-56	1268055	204058	47 32.9649	122 20.4742	na
LDWG-57	1267968	203890	47 32.9370	122 20.4947	na
LDWG-58	1267841	203787	47 32.9195	122 20.5250	na
LDWG-59	1268225	203668	47 32.9012	122 20.4311	-4.4
LDWG-60	1268802	203596	47 32.8912	122 20.2907	-2.6
LDWG-61	1268914	203381	47 32.8563	122 20.2624	1.4
LDWG-62	1268491	203360	47 32.8515	122 20.3651	-35.0
LDWG-63	1269601	203350	47 32.8534	122 20.0955	na
LDWG-64	1269008	203158	47 32.8199	122 20.2385	na
LDWG-65	1269037	202985	47 32.7915	122 20.2307	-8.2
LDWG-66	1268640	202919	47 32.7794	122 20.3268	-32.3
LDWG-67	1269384	202808	47 32.7636	122 20.1457	-1.3
LDWG-68	1268713	202359	47 32.6876	122 20.3064	-20.6
LDWG-69	1269228	202313	47 32.6817	122 20.1811	na
LDWG-70	1268809	201998	47 32.6285	122 20.2813	-11.3
LDWG-71	1269542	201854	47 32.6072	122 20.1027	na
LDWG-72	1269160	201710	47 32.5823	122 20.1948	-16.2
LDWG-73	1270712	201648	47 32.5770	122 19.8174	na
LDWG-74	1269818	201593	47 32.5652	122 20.0344	-6.5
LDWG-75	1269271	201578	47 32.5608	122 20.1673	-8.2
LDWG-76	1270217	201545	47 32.5585	122 19.9373	-14.5
LDWG-77	1270688	201421	47 32.5396	122 19.8223	-7.1
LDWG-78	1270342	201335	47 32.5243	122 19.9060	-16.6
LDWG-79	1269902	201244	47 32.5081	122 20.0124	-24.3
LDWG-80	1269669	201021	47 32.4706	122 20.0679	na
LDWG-81	1270429	200851	47 32.4450	122 19.8825	-12.0
LDWG-82	1270157	200554	47 32.3953	122 19.9471	na
LDWG-83	1271225	200364	47 32.3676	122 19.6869	na
LDWG-84	1270005	200340	47 32.3597	122 19.9830	na

LOCATION NAME	X COORDINATE [a]	Y COORDINATE [a]	LATITUDE [b]	LONGITUDE [b]	ESTIMATED DEPTH ABOVE (+) OR BELOW (-) MLLW (FT) [c]
LDWG-85	1270587	200137	47 32.3281	122 19.8407	-1.9
LDWG-86	1270690	200026	47 32.3102	122 19.8152	na
LDWG-87	1271624	199612	47 32.2450	122 19.5864	-11.0
LDWG-88	1271869	199309	47 32.1961	122 19.5254	-0.3
LDWG-89	1272015	199092	47 32.1608	122 19.4890	-6.9
LDWG-90	1271624	199053	47 32.1532	122 19.5837	na
LDWG-91	1271681	198982	47 32.1417	122 19.5695	1.2
LDWG-92	1272433	198813	47 32.1163	122 19.3862	-1.5
LDWG-93	1271951	198652	47 32.0883	122 19.5026	na
LDWG-94	1272581	198641	47 32.0885	122 19.3495	-6.1
LDWG-95	1272126	198572	47 32.0757	122 19.4596	-7.9
LDWG-96	1272751	198348	47 32.0408	122 19.3068	-17.0
LDWG-97	1272522	198224	47 32.0197	122 19.3617	na
LDWG-98	1272828	197929	47 31.9722	122 19.2862	na
LDWG-99	1273135	197679	47 31.9321	122 19.2104	-0.3
LDWG-100	1273234	197502	47 31.9032	122 19.1855	1.4
LDWG-101	1273283	197433	47 31.8920	122 19.1733	2.9
LDWG-102	1273506	197314	47 31.8732	122 19.1185	-0.2
LDWG-103	1273558	197257	47 31.8640	122 19.1057	-0.1
LDWG-104	1273815	197040	47 31.8292	122 19.0422	-0.8
LDWG-105	1274071	196821	47 31.7939	122 18.9790	0.6
LDWG-106	1274278	196614	47 31.7605	122 18.9279	2.1
LDWG-107	1274616	196393	47 31.7252	122 18.8447	-1.6
LDWG-108	1274974	196037	47 31.6678	122 18.7562	na
LDWG-109	1275743	195745	47 31.6222	122 18.5681	-3.4
LDWG-110	1275863	195545	47 31.5897	122 18.5380	-3.0
LDWG-111	1275958	195288	47 31.5477	122 18.5137	0.9
LDWG-112	1276028	195023	47 31.5044	122 18.4955	-1.1
LDWG-113	1275728	194939	47 31.4897	122 18.5679	2.0
LDWG-114	1276044	194872	47 31.4796	122 18.4909	-2.8
LDWG-115	1276156	194765	47 31.4623	122 18.4632	na
LDWG-116	1276203	194573	47 31.4309	122 18.4509	-3.0
LDWG-117	1275818	194553	47 31.4263	122 18.5442	-1.0
LDWG-118	1276096	194552	47 31.4271	122 18.4768	-8.3
LDWG-119	1276226	194391	47 31.4010	122 18.4445	1.5
LDWG-120	1276295	194179	47 31.3664	122 18.4268	1.8
LDWG-121	1276332	194079	47 31.3501	122 18.4174	4.2
LDWG-122	1275900	194046	47 31.3434	122 18.5221	6.5
LDWG-123	1276329	193933	47 31.3261	122 18.4174	5.3
LDWG-124	1275921	193500	47 31.2536	122 18.5143	na
LDWG-125	1276577	193348	47 31.2307	122 18.3545	3.4
LDWG-126	1276637	193145	47 31.1974	122 18.3389	3.8
LDWG-127	1277453	193044	47 31.1833	122 18.1403	-5.9
LDWG-128	1277368	193013	47 31.1780	122 18.1608	-1.1
LDWG-129	1277567	192917	47 31.1628	122 18.1122	-1.0
LDWG-130	1277407	192810	47 31.1448	122 18.1505	na
LDWG-131	1276248	192710	47 31.1246	122 18.4313	na
LDWG-132	1276751	192578	47 31.1046	122 18.3086	-9.3

Location Name	X Coordinate [a]	Y Coordinate [a]	Latitude [b]	Longitude [b]	Estimated Depth Above (+) or Below (-) MLLW (ft) [c]
LDWG-133	1276328	192324	47 31.0614	122 18.4101	na
LDWG-134	1276278	192169	47 31.0359	122 18.4215	na
LDWG-135	1276334	192030	47 31.0131	122 18.4073	na
LDWG-136	1276362	191857	47 30.9847	122 18.3996	na
LDWG-137	1276936	191788	47 30.9752	122 18.2600	-2.2
LDWG-138	1276907	191426	47 30.9156	122 18.2654	1.9
LDWG-139	1276492	191380	47 30.9067	122 18.3660	0.6
LDWG-140	1276602	191154	47 30.8699	122 18.3382	-6.9
LDWG-141	1276569	190661	47 30.7887	122 18.3439	3.0
LDWG-142	1277873	190498	47 30.7660	122 18.0267	-5.9
LDWG-143	1278219	190415	47 30.7535	122 17.9421	na
LDWG-144	1278433	190320	47 30.7385	122 17.8897	na
LDWG-145	1278123	190207	47 30.7189	122 17.9646	na
LDWG-146	1277768	190183	47 30.7138	122 18.0507	na
LDWG-147	1276848	190135	47 30.7031	122 18.2737	4.0
LDWG-148	1277571	190003	47 30.6836	122 18.0976	na
LDWG-149	1277148	189961	47 30.6755	122 18.2001	na
LDWG-150	1277446	189743	47 30.6405	122 18.1267	na
LDWG-151	1279105	189733	47 30.6440	122 17.7241	na
LDWG-152	1279530	189496	47 30.6063	122 17.6198	na
LDWG-153	1279741	188993	47 30.5244	122 17.5662	na
LDWG-154	1279148	187805	47 30.3271	122 17.7048	na
LDWG-155	1278938	187314	47 30.2457	122 17.7534	na
LDWG-156	1278650	186699	47 30.1436	122 17.8204	na
Sediment samples collected during benthic invertebrate and clam sampling [d]					
LDWG-B1a	1265912	210470	47 34.0124	122 21.0256	0
LDWG-B1b	1266302	210812	47 34.0698	122 20.9325	-51.3
LDWG-B2a	1266358	206667	47 33.3884	122 20.8990	0.9
LDWG-B2b	1267396	207052	47 33.4551	122 20.6487	-36.5
LDWG-B3a	1266670	207458	47 33.5195	122 20.8270	na
LDWG-B3b	1268457	206562	47 33.3779	122 20.3886	-10.8
LDWG-B4a	1267960	203960	47 32.9484	122 20.4969	na
LDWG-B4b	1268471	204605	47 33.0561	122 20.3759	-11.9
LDWG-B5a-1 [e]	1270415	200276	47 32.3504	122 19.8832	na
LDWG-B5a-2	1270183	200299	47 32.3535	122 19.9396	na
LDWG-B5b	1268657	204112	47 32.9757	122 20.3283	-4.3
LDWG-B6a	1269735	200928	47 32.4555	122 20.0514	3.6
LDWG-B6b	1270433	200904	47 32.4538	122 19.8818	-13.1
LDWG-B7a	1273379	197419	47 31.8900	122 19.1499	-0.9
LDWG-B7b	1272090	198899	47 32.1293	122 19.4699	-19.3
LDWG-B8a	1275441	196111	47 31.6815	122 18.6431	0.9
LDWG-B8b	1276633	192758	47 31.1338	122 18.3381	-3.1
LDWG-B9a	1277046	190939	47 30.8359	122 18.2294	0.8
LDWG-B9b	1276294	193929	47 31.3253	122 18.4258	-1.9
LDWG-B10a	1277627	190001	47 30.6835	122 18.0840	na
LDWG-B10b	1276508	191851	47 30.9842	122 18.3642	-1.8
LDWG-C1	1265982	210338	47 33.9909	122 21.0080	na
LDWG-C2-1	1266599	207620	47 33.5459	122 20.8450	na

LOCATION NAME	X COORDINATE [a]	Y COORDINATE [a]	LATITUDE [b]	LONGITUDE [b]	ESTIMATED DEPTH ABOVE (+) OR BELOW (-) MLLW (FT) [c]
LDWG-C2-2	1266806	207045	47 33.4521	122 20.7920	1.5
LDWG-C3-1	1265925	207849	47 33.5814	122 21.0099	7.6
LDWG-C3-2	1265935	207773	47 33.5690	122 21.0071	4.5
LDWG-C4	1267956	204000	47 32.9550	122 20.4980	na
LDWG-C5	1269228	202492	47 32.7110	122 20.1820	na
LDWG-C6	1269684	200978	47 32.4635	122 20.0640	na
LDWG-C7-1	1273401	198872	47 32.1291	122 19.1514	2.8
LDWG-C7-2	1273517	199144	47 32.1742	122 19.1245	na
LDWG-C8	1273492	199444	47 32.2235	122 19.1320	0.4
LDWG-C9	1272400	198325	47 32.0360	122 19.3920	0.4
LDWG-C10-1	1275412	195690	47 31.6121	122 18.6482	-1.6
LDWG-C10-2	1275461	195626	47 31.6018	122 18.6360	-1.1

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 ft

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

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

[d] These samples were collected during August and September 2004 as part of the benthic invertebrate sampling (Windward 2004b). The coordinates are shown here because the results from these samples influence the sampling design described in this QAPP.

[e] Location B5a-1 was analyzed for PCBs and pesticides only

3.1.2 Chemical analyses of surface sediment samples

Chemical data collected from the locations listed in Table 3-1 will satisfy multiple objectives and will be used for multiple purposes in the Phase 2 RI. One of the data needs listed in Section 2.2.1 is to characterize the nature and extent of sediment chemical concentrations**.** Because existing data do not fully address all SMS compounds or all the chemicals relevant to the human and ERAs, each sample for the Phase 2 RI will be analyzed for multiple chemicals. At a minimum, every sediment sample from the LDW will be analyzed for all SMS chemicals and conventional parameters. In addition, samples from select locations will be analyzed for additional chemicals (PCB congeners, dioxins/furans, organochlorine pesticides, and butyltins) as described in this section. The conventional parameters to be analyzed are sediment grain size, TOC, total sulfides, ammonia, and total solids. Grain-size data will be useful for interpretation of sediment transport and are needed for additional habitat characterization and to inform the selection of appropriate toxicity test species and associated reference samples. TOC data are needed to normalize concentrations of some organic compounds for comparison to the SQS or CSL. Sulfides and ammonia may adversely affect some bioassay test organisms, so data are needed for these parameters in samples that will be tested for toxicity to correctly interpret the results. Reference samples used in toxicity testing will also be analyzed for grain size, TOC, total sulfides, and ammonia. Total solids data are needed to correctly report sediment chemistry data on a dry weight basis.

Some samples will also be analyzed for specific chemicals or chemical groups that have been analyzed less frequently in the LDW than SMS chemicals. In addition, a subset of locations have been identified for selected ion monitoring (SIM) analysis by GC/MS of selected semivolatile organic compounds (SVOCs) that had SQS or CSL exceedances as a result of their detection limits. This analysis will provide lower detection and reporting limits for these compounds. Table 3-3 provides the rationale for analyzing organochlorine pesticides, dioxins/furans, TBT, and/or SVOCs by SIM, in addition to SMS chemicals, at specific locations.

Locations for analyses of these chemicals or chemical groups in addition to SMS chemicals are shown in Figures 3-1 (organochlorine pesticides), 3-2 (dioxins/furans), 3-3 (TBT), and 3-4 (SIM). These figures (located at end of the document) show the existing surface sediment chemistry data and the Phase 2 sampling locations for these chemicals (also shown in Figures 2-2a through 2-2e). A subset of the surface sediment samples will also be analyzed for PCB congeners,[7] but these samples will not be selected until after the Aroclor results are reviewed. Additional details on the iterative approach for PCB congener analysis are provided later in this section.

Table 3-3. Surface sediment chemistry analyses

LOCATION	SMS CHEMICALS[a]	ORGANO-CHLORINE PESTICIDES	DIOXINS/ FURANS	TBT	SVOC GC/MS SIM	RATIONALE
LDWG-1	x					
LDWG-2	x	x		x		Elevated TBT concentrations, potential pesticide source from public storm drain
LDWG-3	x			x		Elevated TBT concentrations
LDWG-4	x			x	x	Elevated TBT concentrations; need lower RLs for SVOCs
LDWG-5	x					
LDWG-6	x			x		Elevated TBT concentrations
LDWG-7	x			x		Elevated TBT concentrations
LDWG-8	x			x	x	Near potential source of TBT from marina; need lower RLs for SVOCs
LDWG-9	x	x				Potential pesticide source from public storm drain
LDWG-10	x				x	Need lower RLs for SVOCs
LDWG-11	x					
LDWG-12	x					
LDWG-13	x	x				Potential pesticide source from public storm drain
LDWG-14	x		x	x	x	Near source of cement kiln dust (potential dioxin source) at current mouth of Puget Creek; elevated TBT concentrations; need lower RLs for SVOCs
LDWG-15	x			x		Elevated TBT concentrations
LDWG-16	x			x	x	Elevated TBT concentrations; need lower RLs for SVOCs
LDWG-17	x					

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[7] The PCB congeners to be analyzed in sediment include the 12 congeners identified by the World Health Organization as having dioxin-like properties (i.e., PCBs 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, and 189) and six principal PCB congeners (66, 101, 110, 138, 153 and 180), identified in LDW sediments.

LOCATION	SMS CHEMICALS[a]	ORGANO-CHLORINE PESTICIDES	DIOXINS/ FURANS	TBT	SVOC GC/MS SIM	RATIONALE
LDWG-18	x	x	x		x	Near elevated dioxin/furan concentrations; need lower RLs for SVOCs; King County will conduct SMS and pesticide analyses and LDWG will analyze splits for dioxins/furans and SVOCS-SIM
LDWG-19	x				x	Need lower RLs for SVOCs
LDWG-20	x	x	x	x		Near elevated dioxin/furan concentrations; King County will conduct SMS and pesticide analyses and LDWG will analyze splits for dioxins/furans and TBT
LDWG-21	x					
LDWG-22	x		x		x	Near elevated dioxins/furans from previous sampling; need lower RLs for SVOCs
LDWG-23	x				x	Need lower RLs for SVOCs
LDWG-24	x				x	Need lower RLs for SVOCs
LDWG-25	x	x				Potential pesticide source from public storm drain; near historically elevated DDTs
LDWG-26	x				x	Need lower RLs for SVOCs
LDWG-27	x	x		x	x	Pesticide spatial data gap; elevated TBT concentrations; potential sandpiper habitat
LDWG-28	x	x	x	x	x	Pesticide spatial data gap; elevated TBT concentrations; near source of cement kiln dust (potential dioxin source) at historical mouth of Puget Creek; need lower RLs for SVOCs
LDWG-29	x					
LDWG-30	x				x	Need lower RLs for SVOCs
LDWG-31	x			x		Elevated TBT concentrations
LDWG-32	x	x		x		Pesticide spatial data gap; elevated TBT concentrations
LDWG-33	x			x		Elevated TBT concentration; potential sandpiper habitat
LDWG-34	x			x	x	Barge mooring indicates potential for elevated TBT concentrations; need lower RLs for SVOCs
LDWG-35	x					
LDWG-36	x	x	x			Pesticide spatial data gap; near former cement plant (potential dioxin source)
LDWG-37	x				x	Need lower RLs for SVOCs
LDWG-38	x			x	x	Elevated TBT concentrations; need lower RLs for SVOCs
LDWG-39	x				x	Need lower RLs for SVOCs
LDWG-40	x					
LDWG-41	x	x		x		Pesticide spatial data gap; elevated TBT concentrations
LDWG-42	x	x				Potential pesticide source from public storm drain
LDWG-43	x		x	x	x	Elevated TBT concentrations; near storm drain from cement plant (potential dioxin source); need lower RLs for SVOCs
LDWG-44	x					
LDWG-45	x			x	x	Near elevated TBT; need lower RLs for SVOCs
LDWG-46	x			x		Elevated TBT concentrations
LDWG-47	x			x		Near Duwamish Shipyard
LDWG-48	x					
LDWG-49	x			x		Near elevated TBT
LDWG-50	x	x			x	Potential pesticide source from public storm drain; need lower RLs for SVOCs
LDWG-51	x			x		Near elevated TBT
LDWG-52	x					
LDWG-53	x			x	x	Elevated TBT concentrations; need lower RLs for SVOCs
LDWG-54	x	x				Potential pesticide source from public storm drain
LDWG-55	x	x		x		Pesticide spatial data gap; elevated TBT concentrations

Location	SMS Chemicals[a]	Organo-chlorine Pesticides	Dioxins/ Furans	TBT	SVOC GC/MS SIM	Rationale
LDWG-56	x		x	x	x	Near potential dioxin source from former PCP manufacturer; elevated dioxin/furan concentrations; elevated TBT concentrations; need lower RLs for SVOCs
LDWG-57	x		x			Near potential dioxin source from former PCP manufacturer; elevated dioxin/furan concentrations
LDWG-58	x	x	x	x		Near potential dioxin source from former PCP manufacturer; elevated dioxin/furan concentrations; elevated TBT concentrations; pesticide exceedances in Seep 61
LDWG-59	x		x		x	Elevated dioxin/furan concentrations; need lower RLs for SVOCs
LDWG-60	x				x	Need lower RLs for SVOCs
LDWG-61	x					
LDWG-62	x				x	Need lower RLs for SVOCs
LDWG-63	x	x			x	Pesticide spatial data gap; need lower RLs for SVOCs
LDWG-64	x	x	x		x	Pesticide spatial data gap; near cement plant and former wood treating facility; need lower RLs for SVOCs
LDWG-65	x					
LDWG-66	x				x	Need lower RLs for SVOCs
LDWG-67	x			x		Historical shipyard activities
LDWG-68	x				x	Need lower RLs for SVOCs
LDWG-69	x	x			x	Elevated DDT concentration; need lower RLs for SVOCs
LDWG-70	x	x				Potential pesticide source from public storm drain
LDWG-71	x		x		x	Near CSO; need lower RLs for SVOCs
LDWG-72	x	x			x	Pesticide spatial data gap; need lower RLs for SVOCs
LDWG-73	x	x			x	Need lower RLs for SVOCs; pesticide spatial data gap
LDWG-74	x	x		x	x	History of sandblast grit; need lower RLs for SVOCs; near elevated DDT concentration; potential pesticide source from public storm drain
LDWG-75	x					
LDWG-76	x	x				Near elevated DDT concentration
LDWG-77	x				x	Need lower RLs for SVOCs
LDWG-78	x			x		Sandblasting in this area
LDWG-79	x	x		x	x	Elevated DDT and TBT concentrations; need lower RLs for SVOCs
LDWG-80	x	x				DDT spatial data gap
LDWG-81	x	x				Near elevated DDT sample (B6b)
LDWG-82	x	x			x	Near elevated DDT concentration; need lower RLs for SVOCs
LDWG-83	x		x		x	Pentachlorophenol in groundwater at Great Western; need lower RLs for SVOCs
LDWG-84	x	x	x[b]			Within early action cleanup to investigate potential co-location of dioxins/furans and PCB congeners;; near Seep 54 with mercury and PCBs greater than chronic WQC; elevated DDT concentration
LDWG-85	x	x				Elevated DDT concentration
LDWG-86	x				x	Need lower RLs for SVOCs
LDWG-87	x	x				Pesticide spatial data gap
LDWG-88	x				x	Need lower RLs for SVOCs
LDWG-89	x				x	Need lower RLs for SVOCs
LDWG-90	x				x	Need lower RLs for SVOCs
LDWG-91	x				x	Need lower RLs for SVOCs
LDWG-92	x	x			x	Pesticide spatial data gap; need lower RLs for SVOCs
LDWG-93	x	x				Potential pesticide source from public storm drain
LDWG-94	x					

LOCATION	SMS CHEMICALS[a]	ORGANO-CHLORINE PESTICIDES	DIOXINS/ FURANS	TBT	SVOC GC/MS SIM	RATIONALE
LDWG-95	x					
LDWG-96	x	x				Potentially elevated DDT concentration (DL)
LDWG-97	x				x	Need lower RLs for SVOCs
LDWG-98	x					
LDWG-99	x	x			x	Pesticide spatial data gap; need lower RLs for SVOCs
LDWG-100	x				x	Need lower RLs for SVOCs
LDWG-101	x					
LDWG-102	x				x	Need lower RLs for SVOCs
LDWG-103	x				x	Need lower RLs for SVOCs
LDWG-104	x	x			x	Need lower RLs for SVOCs; potential pesticide source from South Park neighborhood
LDWG-105	x				x	Need lower RLs for SVOCs
LDWG-106	x					
LDWG-107	x			x		Adjacent to marina (potential TBT source)
LDWG-108	x	x		x		Potentially elevated DDT concentration (DL); adjacent to marina (potential TBT source)
LDWG-109	x					
LDWG-110	x		x[b]		x	To investigate potential co-location of dioxins/furans and PCB congeners; need lower RLs for SVOCs
LDWG-111	x					
LDWG-112	x					
LDWG-113	x	x			x	Potential pesticide source from public storm drain; pesticide spatial data gap; need lower RLs for SVOCs
LDWG-114	x					
LDWG-115	x	x				Pesticide spatial data gap; history of PAH, PCB, and BEHP exceedances
LDWG-116	x	x				Potentially elevated DDT concentration (DL)
LDWG-117	x				x	Need lower RLs for SVOCs
LDWG-118	x					
LDWG-119	x				x	Need lower RLs for SVOCs
LDWG-120	x				x	Need lower RLs for SVOCs
LDWG-121	x		x[b]			To investigate potential co-location of dioxins/furans and PCB congeners
LDWG-122	x				x	Need lower RLs for SVOCs
LDWG-123	x		x		x	Need lower RLs for SVOCs
LDWG-124	x			x		Near potential source of TBT
LDWG-125	x	x			x	Near elevated DDT concentration; need lower RLs for SVOCs
LDWG-126	x	x			x	Elevated DDT concentrations; need lower RLs for SVOCs
LDWG-127	x	x	x			Potential pesticide source from public storm drain; potential for elevated dioxin/furan concentrations
LDWG-128	x	x				Potentially elevated DDT concentration (DL > SL)
LDWG-129	x	x			x	Need lower RLs for SVOCs; elevated DDT detection limit in previous sampling
LDWG-130	x					
LDWG-131	x	x	x	x	x	Elevated DDT concentrations; near potential source of TBT from marina and dioxins/furans from 96th St. ditch; need lower RLs for SVOCs
LDWG-132	x				x	Need lower RLs for SVOCs
LDWG-133	x	x		x		Pesticide spatial data gap; potential source of TBT
LDWG-134	x	x				Pesticides detected in water from Seep 39
LDWG-135	x				x	Need lower RLs for SVOCs
LDWG-136	x				x	Need lower RLs for SVOCs
LDWG-137	x				x	Need lower RLs for SVOCs

LOCATION	SMS CHEMICALS[a]	ORGANO-CHLORINE PESTICIDES	DIOXINS/ FURANS	TBT	SVOC GC/MS SIM	RATIONALE
LDWG-138	x				x	Need lower RLs for SVOCs
LDWG-139	x				x	Need lower RLs for SVOCs
LDWG-140	x	x			x	Potential pesticide source from public storm drain; history of a non-detect hexachlorobenzene exceedance; need lower RLs for SVOCs
LDWG-141	x				x	Need lower RLs for SVOCs
LDWG-142	x				x	Need lower RLs for SVOCs
LDWG-143	x				x	Need lower RLs for SVOCs
LDWG-144	x	x	x[b]		x	To investigate potential co-location of dioxins/furans and PCB congeners; potential pesticide source from public storm drain; need lower RLs for SVOCs
LDWG-145	x					
LDWG-146	x				x	Need lower RLs for SVOCs
LDWG-147	x				x	Need lower RLs for SVOCs
LDWG-148	x					
LDWG-149	x					
LDWG-150	x	x				Pesticide spatial data gap
LDWG-151	x				x	Need lower RLs for SVOCs for spatial coverage
LDWG-152	x	x				Pesticide spatial data gap
LDWG-153	x					
LDWG-154	x				x	Need lower RLs for SVOCs for spatial coverage
LDWG-155	x	x				Pesticide spatial data gap
LDWG-156	x					
Total number of analyses	156	53	20[c]	37	78[d]	

[a] All samples will be analyzed for all SMS chemicals at a minimum. A subset of samples will be analyzed for additional chemical groups as indicated in this table. Analytes associated with the various methods cited in Section 3.4 are presented in Appendix F.

[b] Analysis will be conducted if PCBs elevated in initial Aroclor analysis, otherwise alternative samples may be selected for dioxin/furan analyses in consultation with EPA and Ecology

[c] Actual number may increase by one if location 121 is analyzed for dioxins/furans in order to measure dioxins/furans at locations with high PCB concentrations; the nearby sample from location 123 may be sufficient to represent dioxins/furans in this area with high PCB concentrations

[d] Archived sediment sample B9a (identified in the benthic invertebrate QAPP) will also be analyzed using SIM

SL – screening level (DMMP)
ML – maximum level (DMMP)
RL – reporting limit
DL – detection limit
SVOC – semivolatile organic compound
GC/MS-SIM – gas chromatography/mass spectrometry with selected ion monitoring

The locations where these additional chemicals or chemical groups will be analyzed are based on the following general considerations: 1) existing data showing elevated concentrations of these chemicals or chemical groups in surface sediment samples from surrounding locations, 2) proximity to potential sources of these chemicals, or 3) relatively large areas where no such data exist. Considerations specific to each chemical or chemical group are described below.

Organochlorine pesticides – Approximately 110 locations that were sampled for chlorinated pesticides (e.g., DDT) are included in the historical chemistry database that will be used in Phase 2. Some spatial data gaps in the overall characterization of the LDW remain, and some areas with elevated concentrations of DDT, which is used as a surrogate for chlorinated pesticides in general for the purposes of this QAPP, warrant additional characterization. As shown in Table 3-3 and Figure 3-1, 53 of the

156 surface sediment sampling locations shown in Figures 2-2a to 2-2e will be analyzed for chlorinated pesticides. The considerations used to identify a location for pesticide analysis include, in priority order: 1) proximity to previously sampled location with either a maximum level (ML) or screening level (SL)[8] exceedance for DDTs, 2) pesticide spatial data gap, and 3) proximity to potentially elevated DDT concentration, as demonstrated by a detection limit exceedance of the SL for DDTs. The first consideration, if based on an ML exceedance, warranted two additional samples because of the potentially higher risks associated with the higher concentration.

PCB congeners – Approximately 600 locations were sampled for PCB congeners during the late 1990s. However, these data are not suitable for use in the Phase 2 risk assessments because the low-resolution analytical methods used were not able to achieve low enough detection limits for dioxin-like PCB congeners, which tend to be of greatest concern with respect to ecological and human health risks. Consequently, high resolution analyses for the dioxin-like PCB congeners are needed for a subset of the sediment samples to measure the concentrations of these congeners for use in the human health and ERAs, and to assess the general distribution and concentration of dioxin-like PCB congeners (as a dioxin toxic equivalence quotient (TEQ) sum) relative to the distribution and concentration of total PCBs (as an Aroclor sum). The latter information will be used to assess whether risk conclusions and/or food web modeling based on measurements of total PCBs (as an Aroclor sum) would be protective throughout the LDW for dioxin-like effects from PCB congeners as well.

In addition to analysis of the 12 dioxin-like congeners discussed above, six principal PCB congeners will also be analyzed in the same subset of samples. These six principal PCB congeners were selected because they were present in the highest concentrations relative to the other congeners in two historical datasets for the LDW (Weston [1999] and NOAA [1998], as presented in SAIC [2004]). The concentrations of the principal congeners will not be used to estimate total PCB concentrations. Rather, these data may be used to calibrate the food web model because each of the congeners are highly likely to be consistently detected in each of the sediment samples and will thus enable modeling of a single chemical rather than a mixture of PCB congeners. In contrast, the dioxin-like PCB congeners may be less consistent (e.g., PCB congener 126 may not be detected in all samples). In addition, because the log octanol water partitioning coefficients (Kows) of these principal PCB congeners cover the range of the dioxin-like PCB congeners,[9] they are suitable for calibrating the food web model should congener-specific modeling be required.

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[8] The SL and ML are part of the Dredged Material Management Program (DMMP) sediment quality guidelines. These values are used for the evaluation of DDT because no SQS or CSL exist for this chemical.

[9] The range of log Kow values associated with the principal congeners is 6.20 to 7.36. The range of log Kow values associated with the dioxin-like congeners is 6.36 to 7.71.

All sediment samples will be analyzed for total PCBs (as an Aroclor sum). As stated in the Phase 2 work plan (Windward 2004c), approximately 25 to 30 of these sediment samples will also be analyzed for the 12 dioxin-like and six principal PCB congeners.[10] The Aroclor dataset will be reviewed to determine the final number and locations for dioxin-like and principal PCB congener analysis based on the following criteria:

- spatial coverage of the LDW (approximately 5 to 6 stations per mile)
- representation of lower, mid, and higher total PCB concentrations (based on Aroclor sum for the LDW as a whole and potentially within river segments)
- representation of areas with significant differences in Aroclor composition, if observed
- location of preferred human use areas and preferred sandpiper foraging habitat

Dioxins/furans – The historical chemistry database to be used in Phase 2 includes reconnaissance-level data for dioxins/furans, consisting of surface sediment samples from 29 locations throughout the LDW. An additional 20 Phase 2 surface sediment samples will be analyzed for dioxin/furans, as described below.

Samples from two of the 29 historical sediment locations had concentrations an order of magnitude higher than concentrations from the other locations.[11] One of these locations is within the Duwamish/Diagonal early action area, which has recently been dredged. The other is within the intertidal zone on the west side of the LDW near RM 1.5 and the former Reichold Chemical Company facility that manufactured pentachlorophenol, which is known to be commonly associated with dioxins/furans (see Appendix E). Results summarized in the Phase 1 HHRA indicated that LDW-wide risks from direct sediment contact were not unacceptable (i.e., not higher than 10^{-6}). Thus, based on limited areas with elevated dioxin/furan concentrations and results from the Phase 1 HHRA, concerns associated with dioxins and furans in the LDW may be limited to isolated areas. Consequently, one of the Phase 2 data needs for dioxins/furans is to provide additional characterization in those areas. Seven locations (four at RM 1.5 west and three at Duwamish/Diagonal) have been placed in the vicinity of these two historical locations to better assess the nature and extent of the dioxin/furan concentrations in these areas.

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[10] Specific locations for PCB congener analyses will be selected, in consultation with EPA and Ecology, after data from both rounds of sediment sampling are available. Additional sediment from each location will be archived in case additional PCB congener analyses are required.

[11] The range of dioxin TEQ concentrations detected in the LDW (1.2 to 16.1 ng/kg, excluding the two locations with elevated concentrations) is similar to the range of concentrations detected in 11 lakes and reservoirs throughout the US selected by EPA (2000) to represent background conditions in areas removed from known sources (0.12 to 16.3 ng/kg dw; see Appendix E). Both the LDW and the EPA background concentrations were calculated using mammalian toxic equivalence factors from Van den Berg et al. (1998) and one-half the detection limit for undetected dioxins. TEQs were calculated for these sediment samples for inter-sample comparisons only.

Research conducted by EPA and Ecology as part of the Phase 2 work plan scoping suggests that cement kiln dust (a byproduct from cement manufacturers) may be a source of dioxins/furans in the LDW. Therefore, five of the 20 Phase 2 surface sediment sampling locations for dioxin/furan analysis were placed near potential sources of cement kiln dust (Table 3-3, Figure 3-2). Additional samples will be analyzed for dioxins/furans from the following four other locations: 1) LDWG-71 at the Michigan combined sewer overflow (CSO) to address the potential source from nonpoint discharge, 2) LDWG-110 at Jorgensen Forge to address the potential source from steel foundry dust, 3) LDWG-83 at Great Western because of detected PCP concentrations in groundwater, and 4) LDWG-131 at the mouth of the S 96th St ditch because dioxins are suspected contaminants at this site based on Ecology's Confirmed and Contaminated Sites List (Ecology 2005).

To investigate whether locations in the LDW with high PCB concentrations in sediment also have detectable dioxin/furan concentrations, sediment samples from the four locations with the highest PCB concentrations in the Phase 2 sampling event will be analyzed for dioxins/furans. These analyses will be conducted on archived samples after the total PCB data (based on Aroclor sum) are available from both rounds to ensure that the most suitable locations were specified in Table 3-3.

TBT – Reconnaissance-level data for TBT have previously been collected and analyzed at approximately 100 locations within the LDW, as summarized in Figure 3-3. Concentrations were generally higher in the northern half of the LDW than in the southern half. Marinas and shipyards may be the sources of TBT in the LDW. Thus, two primary considerations for selecting locations for TBT sampling in Phase 2 are proximity to elevated TBT concentrations from the Phase 2 RI database and proximity to potential TBT sources. Of the 37 surface sediment sampling locations selected for TBT analysis in Phase 2, most are in the northern half of the LDW (Figure 3-3). At locations with the highest historical TBT concentrations, two new locations have been placed for additional TBT characterization, as identified in Figure 3-3.

SVOCs for SIM analysis – Detection limits for certain SVOCs[12] frequently exceed the SQS or CSL at historical locations. To ensure lower detection limits and reporting limits, a subset of the locations described in this QAPP will be analyzed for those specific SVOCs using SIM with GC/MS. Based on a review of Phase 2 sampling location information presented in Table 3-1, a total of 78 locations that were near historical locations with detection limit exceedances of the SQS were selected for SIM analysis, as presented in Figure 3-4 and Table 3-3. In addition, the archived sediment sample from B9a will also be analyzed using SIM to add spatial coverage for detection limit exceedances of SMS in the area east of Turning Basin 3.

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[12] These SVOCs include 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 2-methylphenol, benzoic acid, benzyl alcohol, butyl benzyl phthalate, diethyl phthalate, dimethyl phthalate, hexachlorobenzene, hexachlorobutadiene, n-nitrosodimethylamine, n-nitrosodiphenylamine, n-nitrosodi-n-propylamine, and pentachlorophenol.

After both rounds of surface sediment sampling and chemical analyses have been completed, the entire dataset, including data associated with the sediment samples collected with clam and market basket benthic invertebrate tissue samples, will be reviewed to determine if any of the archived sediment samples should be analyzed using SIM. Additional analyses would be performed, if needed based on consultation with EPA and Ecology, to ensure adequate spatial coverage of SIM analyses for specific chemicals with reporting or detection limits greater than SQS or CSL, particularly if potential sources of these chemicals are in the vicinity.

3.1.3 Sediment toxicity testing

Site-specific toxicity testing facilitates the assessment of risks to the benthic invertebrate community through direct measurement of toxicity in standardized laboratory toxicity tests. Toxicity tests will be conducted at many of the sediment locations with SQS or CSL exceedances. It is LDWG's, EPA's, and Ecology's expectation that it will be possible to manage some locations exceeding the SQS or CSL on the basis of chemistry results and other site-related factors. Identification of locations for toxicity testing will be made in consultation with EPA and Ecology.

Two rounds of surface sediment sampling for toxicity testing will be conducted. As discussed in Section 2.3, sediment will be collected in two rounds to allow the analytical and toxicity testing laboratories to better accommodate the total number of samples and to allow the results of the first round of toxicity testing to be used in determining which samples should be tested for toxicity in the second round, as discussed below.

In accordance with the Phase 2 work plan (Windward 2004c), 80 locations will be sampled for sediment chemistry in the first round of sampling. These locations, listed in Table 3-4, were selected because they have the greatest likelihood of exceeding SQS or CSL, based on existing chemistry data or proximity to potential or identified sources. Sufficient sediment will be collected at each location to conduct both chemical analyses and toxicity testing. Sediment samples will be homogenized and split samples will be created for each location. Split samples will be submitted to ARI for analyses of PCBs as Aroclors, organochlorine pesticides, SVOCs, metals, TBT, and conventional measurements, and to Axys for dioxin/furan analyses (see Table 3-3 for selected locations) and archiving for potential PCB congener analyses following the analyses of PCB Aroclors (see Section 3.1.2). Additional split samples will be sent to NAS and MEC for toxicity testing.

Table 3-4. Summary of sediment sampling locations in Round 1

LOCATION	RATIONALE
LDWG-1	Reoccupy location with phenol and PCB SQS exceedances (546)
LDWG-4	Reoccupy location with phenol CSL exceedance (543)
LDWG-5	Reoccupy location with BEHP CSL exceedance (642)
LDWG-10	Reoccupy location with phenol CSL exceedance (541)

LOCATION	RATIONALE
LDWG-12	Reoccupy location with PCB and mercury SQS exceedance (601)
LDWG-13	Near storm drain of interest
LDWG-14	Near probable source of metals and cement kiln dust
LDWG-15	Reoccupy location with BEHP SQS exceedance (645)
LDWG-17	Reoccupy location with BEHP CSL exceedance (1031)
LDWG-22	Reoccupy historical location with exceedance of 2-dimethylphenol CSL exceedance (9288)
LDWG-23	Reoccupy historical location with PCB CSL exceedance (no location number because QA/QC data were not available for this dataset)
LDWG-26	Near PCB SQS exceedances
LDWG-27	Reoccupy location with PCB CSL exceedance (205)
LDWG-28	Near PCB SQS exceedances
LDWG-31	Reoccupy location with arsenic and zinc CSL exceedances (587), near Seep 76 with concentrations of copper and zinc greater than acute WQC in seep water
LDWG-32	Reoccupy location with benzyl alcohol CSL exceedances (586)
LDWG-33	Near PCB SQS exceedances
LDWG-36	Near cement plant and Seep 64 with PCB concentrations in unfiltered seep water greater than the chronic WQC
LDWG-37	Reoccupy location with PCB, PAH, and mercury SQS exceedances (653)
LDWG-38	Near cement plant
LDWG-40	Reoccupy location with PCB SQS exceedance (654)
LDWG-42	Near two storm drains of interest
LDWG-43	Near storm drains of interest
LDWG-44	Reoccupy location with BEHP CSL exceedance (619)
LDWG-48	Reoccupy location with arsenic, zinc, copper, and lead CSL exceedances (8823)
LDWG-49	Reoccupy location with copper CSL exceedance (8822)
LDWG-50	Reoccupy location with PCB and mercury CSL exceedances (596)
LDWG-51	Reoccupy location with BEHP CSL exceedance (726)
LDWG-52	Reoccupy location with PAH CSL exceedances (631)
LDWG-54	Near 3 CSL exceedances
LDWG-55	Reoccupy location with BEHP and arsenic CSL exceedances (8821)
LDWG-56	Near cement plant and former PCP manufacturer
LDWG-57	Reoccupy location with PCB and mercury SQS exceedance (689)
LDWG-58	Near Seep 61 with arsenic concentrations greater than acute WQC in seep water
LDWG-60	Near Seep 80 with copper concentrations greater than acute WQC in seep water
LDWG-63	Near potential upland source
LDWG-64	Reoccupy location with PCB CSL exceedance (8995)
LDWG-67	Near Seep 82 with copper and arsenic concentrations greater than acute WQC
LDWG-70	Reoccupy location with BEHP CSL exceedance (697); very near historical location 907 with BEHP CSL exceedance
LDWG-72	Near PCB or BEHP CSL exceedances
LDWG-75	Reoccupy location with PCB CSL exceedance (951) and near BEHP CSL exceedance (721)
LDWG-76	Reoccupy location with benzyl alcohol CSL (672)
LDWG-79	Reoccupy location with PCB CSL exceedance (38)
LDWG-81	Reoccupy location with PCB CSL exceedance (679)
LDWG-83	Near Great Western MTCA site
LDWG-84	Early action area and PCB CSL exceedances and Seep 54 with mercury and PCB concentrations in unfiltered seep water greater than chronic WQC

LOCATION	RATIONALE
LDWG-87	Near Seattle Iron & Metals MTCA site
LDWG-88	Reoccupy location with PCB SQS exceedance (81)
LDWG-89	Near PCB SQS exceedances
LDWG-92	Reoccupy location with PCB SQS exceedance (170)
LDWG-94	Reoccupy location with PAH CSL exceedances (741); near Seep 12 with copper concentration greater than acute WQC
LDWG-96	Near PCB SQS exceedances
LDWG-97	Near outfalls of interest
LDWG-99	Reoccupy location with PCB SQS exceedance (252)
LDWG-101	Near Seep 48 with copper concentration greater than acute WQC
LDWG-102	Reoccupy location with hexachlorobenzene CSL exceedance (764)
LDWG-104	Reoccupy location with phenol CSL exceedance (768)
LDWG-109	Near PCB and metals CSL exceedances
LDWG-110	Reoccupy location with PCB and lead CSL exceedances (505)
LDWG-111	Reoccupy location with PCB SQS exceedance (752), near Seep 20 with copper concentration greater than acute WQC
LDWG-112	Near PCB SQS exceedance
LDWG-113	Reoccupy location with PCB SQS exceedance (776)
LDWG-114	Near PCB SQS exceedances
LDWG-115	Reoccupy location with PAH and BEHP CSL exceedances (900)
LDWG-116	Near PCB and butyl benzyl phthalate SQS exceedances
LDWG-117	Reoccupy location with BEHP CSL exceedance (901)
LDWG-118	Near PCB and BBP SQS exceedances
LDWG-119	Reoccupy location with PCB CSL exceedances (908)
LDWG-120	Reoccupy location with BBP and BEHP SQS exceedances (909)
LDWG-121	Reoccupy location with PCB CSL exceedance (71)
LDWG-123	Reoccupy location with PCB CSL exceedance (139)
LDWG-125	Reoccupy location with benzyl alcohol CSL exceedance (804)
LDWG-126	Reoccupy location with DDT ML exceedance (1110)
LDWG-127	Reoccupy location with PAH CSL exceedances (919)
LDWG-128	Near PAH CSL exceedances
LDWG-129	Reoccupy location with PAH CSL exceedances (921)
LDWG-130	Reoccupy location with PAH CSL exceedance (924)
LDWG-134	Near Delta Marine and downstream from Seep 39 with heptachlor epoxide detection
LDWG-142	Near lead CSL exceedance (820)
LDWG-143	Reoccupy location with PCB and benzoic acid CSL exceedances (1093)

BEHP - bis(2-ethylhexyl)phthalate

BBP - butyl benzyl phthalate

PAH – polycyclic aromatic hydrocarbon

PCP - pentachlorophenol

MTCA - Model Toxics Control Act

WQC - Washington State marine water quality criteria

When the chemical data from the Round 1 stations are received from ARI,[13] the unvalidated data will be evaluated by LDWG, EPA, and Ecology, who will meet approximately one week after receipt of the data to determine which locations will be tested for toxicity to benthic invertebrates. In accordance with the Phase 2 work plan (Windward 2004c), up to 50 or 60 of these locations will be selected for toxicity testing. In consultation with EPA and Ecology, locations will be selected based on several criteria: 1) a comparison of concentrations of chemicals to SQS and CSL, 2) similarity of SQS exceedances among specific groups of stations, 3) proximity of stations to each other with similar chemical groups exceeding SQS, and 4) proximity to potential or known sources. The toxicity laboratories will be informed which samples to test, and the chemical data for all locations will then be submitted for validation.

The remaining 76 surface sediment sampling locations will be sampled in Round 2 approximately eight weeks after the first round of sampling (Figure 2-3).[14] When the chemical data from this second round of samples are available, locations for the second round of toxicity testing will be selected in consultation with EPA and Ecology based on a comparison of chemical concentrations to the SQS and CSL, sample location, and the results of the first round of toxicity testing. In this way, if any relationships are found in the first round of toxicity tests between observed toxicity and sediment chemistry, this information can be used to select which stations are most appropriate to test in the second round of toxicity testing.

3.2 SAMPLING METHODS

The sampling methods for surface sediment sampling are described in this section. There may be contingencies during field activities that require modification of the general procedures outlined below. Modification of procedures will be at the discretion of the FC after consultation with the Windward PM and the boat operator, if applicable. EPA and Ecology will be consulted immediately in the event that significant deviations from the sampling design are required (e.g., significant relocation of a sample). All modifications will be recorded in the field logbook.

3.2.1 Identification scheme for all locations and samples

Each surface sediment sampling location will be assigned a unique alphanumeric location ID number. The first three characters of the location ID are "LDW" to identify

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[13] PCB congeners and dioxin/furans will not be analyzed with an expedited turn-around-time because no SQS or CSL exist for these chemicals, so their concentrations would not influence the selection of samples for toxicity testing.

[14] A subset of the sediment locations sampled as part of the benthic invertebrate QAPP (Windward 2004a) will be resampled as part of Round 2. These stations will be resampled because SQS or CSL standards were exceeded, and thus they may be suitable candidates for toxicity testing. Selection of these stations, in consultation with EPA and Ecology, will occur prior to Round 2 sampling and will be documented in a separate technical memorandum. The sediment samples from these stations will be submitted to the laboratories for chemical analyses in addition to the toxicity tests.

the LDW project area. The next characters are "SS" to indicate the type of samples to be collected (surface sediment), followed by a consecutive number identifying the specific location within the LDW.

The sample ID will be similar to the location ID, but will include a suffix of '010' to indicate that sediment from the 0-10 cm depth range is included in the sample. For example, the sediment sample collected at location LDW-SS1 will be identified as LDW-SS1-010. Field duplicates will be identified using location numbers starting with 200. For example, the field duplicate at LDW-SS1 would be identified as LDW-SS200-010.

Rinsate blanks, as described in Section 3.5.1, will be assigned the same characters as the station identifier, followed by the identifier "RB." For example, the rinsate blank collected at LDW-SS1 would be LDW-SS1-RB.

3.2.2 Location positioning

Target sample locations will be located using a Trimble NT300D differential global positioning system (DGPS). The DGPS includes a global positioning system (GPS) receiver unit onboard the sampling vessel and a Coast Guard beacon differential receiver. The GPS unit will receive radio broadcasts of GPS signals from satellites. The Coast Guard beacon receiver will acquire 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 a computer onboard the vessel. The coordinates will then be processed in real time and stored at the time of sampling using the positioning data management software package. Washington State Plane Coordinates, North (NAD 83) will be used for the horizontal datum. The vertical datum will be the National Ocean Service mean lower low water (MLLW) datum. Vertical control will be provided by the ship's depth finder and corrected for tidal influence after sampling is completed. Tidal elevation will be determined by calling the National Ocean Service for data from their automated tide gage located at Pier 54 (206.749.9218). At intertidal locations sampled on shore at low tide, vertical elevations will be estimated by noting the tide level at the time of sampling, along with the approximate elevation of the sampling location relative to water level.

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.

A handheld GPS (Magellan ColorTrak) unit enabled with Wide Area Augmentation System (WAAS) will be used during sampling in intertidal areas that cannot be sampled from the primary sampling vessel. The WAAS enhancements produce positioning accuracy to within 3 m. Washington State Plane coordinates North (NAD83) will be used for the horizontal datum.

3.2.3 Surface sediment collection

Surface sediment collection and processing will follow standardized procedures for the Puget Sound area that have been developed by PSEP (1997). Surface sediments will be collected from each location shown in Figures 2-2a through 2-2e using a double 0.1-m^2 van Veen grab sampler from a sampling vessel, if feasible. Some intertidal locations may be too shallow to access from the sampling vessel, in which case surface sediments will be sampled from the shoreline during low tide (e.g., LDWG-28, LDWG-31, LDWG-33, LDWG-77, and LDWG-84). In addition, surface sediments at six locations will be sampled on the shore during low tide to ensure that human access areas are targeted (i.e., LDWG-24, LDWG-25, LDWG-100, and LDWG-101), and one location will be sampled on the shore to ensure that sediments near metal debris piles on the shoreline are targeted (LDWG-110).

The 0-10-cm sediment interval will be collected to represent the biologically active horizon and to compare directly with previous surface sediment studies conducted in the LDW. Multiple grab samples for a given location are likely to be necessary to collect sufficient volume of sediment for toxicity testing.

The surface sediment samples will be collected using a double van Veen grab sampler as described in the following steps:

1. Using GPS, maneuver the sampling vessel to the approximate pre-identified sampling location.
2. Open the grab sampler jaws into the deployment position.
3. Guide the sampler overboard until it is clear of the vessel.
4. Using GPS, position the sampling vessel such that the GPS receiver, mounted on the winch arm right over the grab sampler, is within 1-2 m of the intended sampling location.
5. Lower the sampler through the water column to the bottom at approximately 0.3 m/s.
6. Record the GPS location of the boat when the sampler reaches bottom.
7. Record the water depth and time
8. Retrieve the sampler and raise it at approximately 0.3 m/s.
9. Guide the sampler aboard the vessel and place it on the work stand on the deck, using care to avoid jostling that might disturb the integrity of the sample.
10. Examine the sample using the following sediment acceptance criteria:
    - sediment is not extruded from the upper face of the sampler

- overlying water is present (indicating minimal leakage)
- the sediment surface is relatively flat (indicating minimal disturbance or winnowing)
- a penetration depth of at least 11 cm is achieved

If these sample acceptance criteria are not achieved, the sample will be rejected. If an acceptable grab sample cannot be obtained in three attempts, the target sampling location will be moved as close as possible to the original location, but no further than 10 m away. If it is not possible to obtain a sample at this second location, EPA and Ecology will be consulted to discuss repositioning the station.

After sample acceptance, the following observations will be noted in the field logbook:

- GPS location
- depth as read by the boat's depth sounder
- gross characteristics of the surficial sediment including texture, color, biological structures, odor, and presence of debris or oily sheen
- gross characteristics of the vertical profile (i.e., changes in sediment characteristics and redox layer, if visible)
- maximum penetration depth (nearest 0.5 cm)
- comments relative to sample quality

For intertidal locations that must be sampled from the shoreline, sediment will be collected by scooping sediment from a depth of 10 cm with a clean, stainless steel spoon.

A minimum of 6 L of sediment will be collected at each location. Sediment for sulfide analysis will be removed from the first grab sample and placed, with no headspace, into the appropriate sample container with preservative, prior to homogenizing the remaining sediments. The remaining sediment from the first grab and subsequent grabs at each location will be transferred directly from the sampler into a pre-cleaned stainless-steel bowl and stirred with a clean, stainless-steel spoon or spatula until textural and color homogeneity are achieved (PSEP 1997). For intertidal samples collected by hand at low tide, sediment from the 0-10 cm depth will be spooned by hand into a pre-cleaned stainless-steel bowl and homogenized as described above. Any large non-sediment items such as rocks, shells, wood chips, or organisms (e.g., clams) will be removed prior to homogenization. Homogenized sediment will then be split into the appropriate sample containers as described in Sections 3.1.3 and 3.3.1. Excess sediment will be returned to the sampling location. For decontamination procedures between collection activities, see Section 3.2.5.

3.2.4 Field equipment

The following items will be needed in the field for sediment collection:

- QAPP
- field sample sheets
- study area maps
- field notebooks and pens/pencils/Sharpies
- cellular phone
- digital camera
- GPS
- batteries
- stainless-steel bowls and spoons
- stainless steel ruler
- rubber tubing/turkey basters (used to decant surface water from van Veen)
- Alconox detergent
- scrub brushes
- distilled water
- spray bottles for distilled water
- coolers
- powder-free nitrile exam gloves and rubber work gloves
- boots or waders
- duct tape
- Ziploc bags
- aluminum foil
- paper towels
- first aid kit
- double 0.1-m2 van Veen grab sampler
- wet ice
- personal flotation devices (PFDs)
- hard hats
- safety glasses
- foul weather gear (rain jacket/pants)

- waterproof labels
- clear packing tape
- box cutters
- bubble wrap
- COC forms
- flashlights and temporary work lights
- sample jars
- custody seals
- cooler temperature blanks

Prior to mobilization, these lists will be consulted to ensure all equipment is available and pre-cleaned. As part of the mobilization process, each item will be double-checked by the FC.

3.2.5 Decontamination procedures

All sediment sampling and homogenizing equipment, including the mixing bowl and stainless-steel implements, will be decontaminated following PSEP (1997) guidelines between locations or samples using the following procedures:

1. Rinse with site water and wash with a scrub brush until free of sediment.
2. Wash with phosphate-free detergent.
3. Rinse with site water.
4. Rinse with distilled water.

Acid or solvent washes will not be used in the field 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 sampling equipment that cannot be cleaned to the satisfaction of the FC will not be used for further sampling activity.

3.2.6 Field-generated waste disposal

Excess sediment, generated equipment rinsates, and decontamination water will be returned to each sampling location after sampling is completed for that location. 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 site 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

Sediment samples for chemical analyses will be placed in appropriately sized, certified-clean, labeled, wide-mouth glass jars and capped with Teflon®-lined lids (Table 3-5). Sediment submitted for toxicity testing will be obtained from the same homogenate as the sediment submitted for bulk chemical analyses. The homogenized sediment will be placed into five I-Chem 1-L high-density polyethylene (HDPE) wide-mouth jars. All sediment sample containers will be filled leaving a minimum of 1 cm of headspace to prevent breakage during shipping and storage. Sediment for ammonia and total sulfides analyses at NAS will be collected at the time of test initiation from a separate beaker treated in the same manner as test beakers prior to test initiation. Prior to shipment, each glass container will be wrapped in bubble wrap and placed in a cooler with wet ice.

Table 3-5. Sample containers and laboratory conducting chemical analyses of sediment samples

PARAMETER	CONTAINER	LABORATORY
PCBs (as Aroclors), organochlorine pesticides, and SVOCs [a]	16-oz glass jar	ARI
PCB congeners and dioxins/furans	8-oz glass jar	Axys
Metals and TBT [a]	8-oz glass jar	ARI
Grain size, TOC, and total solids	16-oz glass jar	ARI
Amphipod and polychaete toxicity testing, including ammonia and total sulfides[b, c]	Four 1-L HDPE wide-mouth jars	NAS
Bivalve larvae toxicity testing	One 1-L HDPE wide-mouth jar	MEC
Total sulfides (preserved) [c]	2-oz glass wide-mouth jar (no headspace)	ARI
Ammonia [c]	4-oz glass wide-mouth jar	ARI

[a] Remaining sediment will be archived frozen at ARI in the event that additional chemical analyses are necessary

[b] Eleven 1-L jars will be collected at each of the reference sites

[c] In addition to the analyses of ammonia and total sulfides conducted by ARI on sediment samples preserved at the time of sampling, ammonia and total sulfides will be analyzed by NAS in sediment used for toxicity testing at the time of test initiation.

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 Sample custody procedures

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 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 sample collection. A COC form will accompany samples to the analytical laboratory. Each person who has custody of the samples will sign the COC form and ensure that the samples are not left unattended unless properly secured. Minimum documentation of sample handling and custody will include:

- sample location, project name, and unique sample number
- sample collection date and time
- any special notations on sample characteristics or problems
- initials of the person collecting the sample
- date sample was sent to the laboratory
- shipping company name and waybill number

The FC will be responsible for all sample tracking and custody procedures for samples in the field. The FC will be responsible for final sample inventory and will maintain sample custody documentation. The FC will also complete COC forms prior to removing samples from the sampling area. At the end of each day, and prior to transfer, COC entries will be made for all 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 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 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 coolers with sediment samples for chemical, toxicity, and grain-size analyses will be shipped overnight or couriered to the appropriate analytical and toxicity testing laboratory. The temperature inside the cooler(s) containing chemistry samples will be checked upon receipt at the laboratory by measuring the temperature of blank water samples packed inside the coolers. The laboratories will specifically note any coolers that do not contain ice packs or that are not sufficiently cold (4° ± 2°C) upon receipt. Each sample will be assigned a unique laboratory number, and samples will be grouped in appropriate sample delivery groups (SDGs). Samples for toxicity testing will be stored in a refrigerator at the toxicity testing laboratories until the decision is made regarding which sediments to test.

Samples will be assigned a specific storage area within the laboratory and will be kept there until analyzed. The laboratories will not dispose of the environmental samples for this project until notified in writing by the QA/QC coordinator.

3.4 ANALYTICAL METHODS

A summary of the analyses to be conducted is presented in Table 3-6. This section discusses standard methods and DQIs for the chemical analyses.

Table 3-6. Summary of number of surface sediment samples and analyses

STUDY	# SEDIMENT SAMPLES	SAMPLING GEAR	ANALYSES
Surface sediment samples for chemical analyses	156 sediment samples	van Veen grab or by hand (intertidal)	SVOCs, metals, PCBs (as Aroclors), mercury, total solids, TOC, grain size, ammonia and sulfides 25 to 30 samples for PCB congeners; 20 samples for dioxins/furans; 53 samples for organochlorine pesticides; 37 samples for TBT, 78[a] samples for SIM analysis
Background surface sediment samples for chemical analyses[b]	21 sediment samples	van Veen grab or by hand (intertidal or diver)	8 samples for arsenic; 13 sediment samples for dioxins/furans
Sediment toxicity testing	Number to be determined in consultation with EPA and Ecology	van Veen grab or by hand (intertidal)	Acute 10-day amphipod mortality test with *Eohaustorius estuarius;* acute 48-hr bivalve larvae combined mortality/abnormality test with *Mytilus galloprovincialis*; chronic 20-day juvenile polychaete survival and growth test with *Neanthes arenaceodentata*; total sulfides and ammonia

[a] Archived sediment sample B9a will also be analyzed using SIM (for a total of 79 SIM analyses)

[b] See Appendices D and E for details

3.4.1 Chemical analysis of sediment

Laboratory methods, sample handling, and DQIs for the sediment samples collected for chemical analysis are described in this section.

3.4.1.1 Laboratory methods and sample handling

Chemical analyses of the sediment samples will be conducted at two different laboratories. Analyses to be conducted at each laboratory are presented in Table 3-7. In addition to the analyses specified, additional sediment from each sample will be archived at ARI in the event that additional chemical analyses are necessary. Analytical methods and sample handling requirements are presented in Table 3-8.

Table 3-7. Procedures to be conducted at each analytical laboratory

ARI	AXYS
PCB Aroclors organochlorine pesticides (subset of samples) SVOCs (including PAHs and low level SVOCs by SIM) metals TBT (subset of samples) mercury TOC, total solids, grain size, ammonia, total sulfides	PCB congeners (subset of samples) dioxins and furans (subset of samples)

Table 3-8. 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]	cool/4°C
PCB congeners[c]	HRGC/HRMS	EPA 1668	1 year to extract, 40 days to analyze	freeze/-20°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]	cool/4°C
SVOCs (including PAHs)[e,f]	GC/MS	EPA 8270	14 days to extract, 40 days to analyze[b]	cool/4°C
Selected SVOCs [g]	GC/MS	EPA 8270C-SIM	14 days to extract, 40 days to analyze[b]	cool/4°C
Mercury	CVAA	EPA 7471A	28 days	cool/4°C
Other metals[h]	ICP-OES & ICP-MS	EPA 6010 and EPA 6020[i]	1 year	cool/4°C
TBT, DBT, MBT (as ions)	GC/FPD	Krone et al. (1989)	14 days to extract, 40 days to analyze	cool/4°C
Grain size	sieve/pipette	PSEP (1986)	6 months	cool/4°C
TOC	combustion	Plumb (1981)	28 days	cool/4°C
Total solids	oven-dried	PSEP (1986)	7 days	cool/4°C
Total sulfides	spectro-photometric	EPA 376.2	7 days	2 ml 2N ZnOAc
Ammonia	automated phenate	EPA 350.1	28 days	cool/4°C

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

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

[c] Dioxin-like PCB congeners (77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, 189), as defined by the World Health Organization, and principal PCB congeners (66, 101, 110, 138, 153, 180), identified in LDW sediments

[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] Target PAHs include: anthracene, pyrene, dibenzofuran, benzo(g,h,i)perylene, benzo(e)pyrene, indeno(1,2,3-cd)pyrene, perylene, 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, and 2-methylnaphthalene

[f] 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 8081 where the presence of PCB congeners may interfere with the DDT quantitation

[g] Selected SVOCs include: 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 2-methylphenol, benzoic acid, benzyl alcohol, butyl benzyl phthalate, di-ethyl phthalate, di-methyl phthalate, hexachlorobenzene, hexachlorobutadiene, n-nitrosodimethylamine, n-nitrosodiphenylamine, n-nitrosodi-n-propylamine, and pentachlorophenol

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

[i] If concentrations of vanadium and zinc are elevated, EPA 6010 (ICP-atomic emission spectrometry) will be used

CVAA – cold vapor atomic absorption

DBT – dibutyltin

GC/ECD – gas chromatography electron capture detection

GC/FPD – gas chromatography flame photometric detection

GC/MS – gas chromatography mass spectrometry

HRGC/HRMS – high resolution gas chromatography/high resolution mass spectrometry

ICP-AES – inductively coupled plasma atomic emission spectrometry

ICP-MS – inductively coupled plasma mass spectrometry

MBT – monobutyltin

SIM – selected ion monitoring

TBT – tributyltin

3.4.1.2 Data quality indicators

The parameters used to assess data quality are precision, accuracy, representativeness, comparability, completeness, and sensitivity. Table 3-9 lists specific DQIs for laboratory chemical analyses of sediment samples. These parameters are discussed in more detail in the following sections.

Table 3-9. Data quality indicators for sediment analyses

PARAMETER	UNITS	SENSITIVITY		PRECISION	ACCURACY	COMPLETENESS
		RL[a]	MDL[a]			
PCBs as Aroclors	µg/kg dw	20	0.98	±50%	50-150%	95%
PCB congeners	ng/kg dw	2.0	na	±50%	50-150%	95%
Dioxins and furans	ng/kg dw	1.0-10	na	±50%	50-150%	95%
Organochlorine pesticides[b]	µg/kg dw	1.0-100	0.034-2.94	±50%	50-150%	95%
PAHs[c]	µg/kg dw	20	7.3 – 10.4	±50%	40-130%	95%
SVOCs	µg/kg dw	20-100	5.9-106[d]	±50%	40-130%	95%
Selected SVOCs - SIM[e]	mg/kg dw	0.0067-0.033	tbd [f]	±50%	40-130%	95%
Mercury	mg/kg dw	0.05	0.003	±30%	55-137%	95%
Other metals [g]	mg/kg dw	0.2-5.0	0.005-0.4	±30%	70-130%	95%
Tributyltin, dibutyltin, monobutyltin (as ions)	µg/kg dw	6.0	1.76-4.51-	±50%	20-130%	95%
Grain size	% dw	na	na	±30%	na	95%
TOC	% dw	0.02	0.01	±30%	na	95%
Total solids	% ww	0.1	na	±20%	na	95%
Total sulfides	mg/kg dw	1.0	na	±20%	75-125%	95%
Ammonia	mg/kg dw	0.1	0.04	±20%	75-125%	95%

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

[b] 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, gamma-BHC, delta- BHC, oxychlordane, alpha- and gamma-chlordane, cis- and trans-nonachlor, dieldrin, endosulfan, endosulfan sulfate, endrin, heptachlor, heptachlor epoxide, hexachlorobenzene, methoxychlor, mirex, and toxaphene

[c] Target PAHs include: anthracene, pyrene, dibenzofuran, benzo(g,h,i)perylene, benzo(e)pyrene, indeno(1,2,3-cd)pyrene, perylene, 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,

[d] Method detection limits (MDLs) for SVOCs other than PAHs

[e] Selected SVOCs include: 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol,2-methylphenol, benzoic acid, benzyl alcohol, butyl benzyl phthalate, diethyl phthalate, dimethyl

phthalate, hexachlorobenzene, hexachlorobutadiene, n-nitrosodimethylamine, n-nitrosodiphenylamine, n-nitrosodi-n-propylamine, and pentachlorophenol

[f] To be determined – ARI is currently conducting an MDL study for the compounds to be analyzed by EPA 8270C-SIM

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

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, laboratory control standard [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 method detection limit (MDL), where the percent error (expressed as either % RSD or RPD) increases. The DQI for precision varies depending on the analyte (Table 3-9). The equations used to express precision are as follows:

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

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

where:

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

D = sample concentration
D_{ave} = average sample concentration
n = number of samples
SD = standard deviation

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 laboratory control sample analyses. The DQI for accuracy varies, depending on the analyte (Table 3-9). Below is the equation used to express accuracy for spiked samples:

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

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.

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 Puget Sound Estuary Program (PSEP) QA/QC procedures (PSWQAT 1997) and EPA and PSEP analytical protocols.

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.

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 reporting limit (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 ARI analysis.

Axys calculates a sample-specific detection limit (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 the concentration is an estimate. The RLs and MDLs are presented in Appendix F.

Appendix C presents a detailed evaluation of whether MDLs and RLs for sediment samples are sufficiently sensitive to meet the needs of the Phase 2 ecological and human health risk assessments. Based on that evaluation, the MDLs specified in

Table 3-9 for all chemicals are generally sufficiently sensitive to meet the needs of the risk assessments, with the following exceptions. MDLs are higher than the lowest applicable ACG for four PAHs (benzo[a]pyrene, benzo[a]anthracene, benzo[b]fluoranthene, and indeno[1,2,3-c,d]pyrene), six SVOCs (1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, hexachlorobenzene, N-nitrosodiphenylamine, and N-nitrosodimethylamine), six Aroclors, three metals (arsenic, cadmium, and mercury), and two pesticides (dieldrin and total DDTs).

The four PAHs listed above, as well as arsenic, mercury, and TBT were detected in over 90% of the historical sediment samples.[15] Total PCBs and cadmium were detected in over 95% and 75%, respectively, of the historical sediment samples. Based on these historical results, the PAHs, PCBs, and metals listed above are also likely to be detected in most or all the sediment samples described in this QAPP. Consequently, the fact that the ACGs are lower than both the MDL and RL should not compromise the quality of the data to be used in the risk assessments for these chemicals because these assessments will be based largely on detected results.

All six of the other SVOCs listed above will also be analyzed in a subset of samples by at least one other method beside EPA 8270C to achieve lower RLs. The chlorobenzene compounds 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, and 1,4-dichlorobenzene will be analyzed by EPA 8270C-SIM in 78 new samples, as shown in Table 3-3. The ACGs for 1,2-dichlorobenzene and 1,4-dichlorobenzene are higher than the SIM RLs. However, the ACG for 1,2,4-trichlorobenzene (0.0041 mg/kg dw) remains slightly lower than the SIM RL (0.0067 mg/kg ww). The MDL is not available because ARI is currently conducting an MDL study for this compound using 8270C-SIM. The ACG for hexachlorobenzene (0.0019 mg/kg dw) is lower than the 8081A RL (0.00928 mg/kg dw). The hexachlorobenzene ACG is also slightly lower than the 8270C-SIM RL (0.0067 mg/kg dw), which will be analyzed in 78 samples. The MDL is not available because ARI is currently conducting an MDL study for this compound using 8270C-SIM.

N-nitrosodiphenylamine and N-nitrosodimethylamine will also be analyzed by 8270C-SIM in 78 samples. The ACG for N-nitrosodiphenylamine is higher than the SIM RL. The ACG for N-nitrosodimethylamine of 0.0095 mg/kg dw, which was derived from the human health RBC, is slightly lower than the SIM RL (0.033 mg/kg dw). N-nitrosodimethylamine has never been detected in LDW sediments (87 surface sediment samples analyzed for this chemical). It was formerly used to make rocket fuel, but it is now produced in the US only for use as a research chemical, and does not persist in the environment (ATSDR 1989). Thus, an RL higher than the ACG for n-nitrosodimethylamine should not adversely affect the quality of the HHRA.

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[15] More sensitive analytical methods are available for PAHs and mercury. Based on a review of the dataset, certain archived samples may be re-analyzed using these methods if analytes are not detected and MDLs are greater than ACGs in the initial dataset and if these data are expected to be important in decision making for the site. This decision will be made in consultation with EPA and Ecology.

The MDL and RL for dieldrin is higher than the ACG. Dieldrin was detected in 6/115 of the historical sediment samples and was not identified as a COPC in sediment. Dieldrin was never detected in historical tissue samples. Consequently, it is very unlikely that food web modeling, which is the primary basis for sediment ACGs for bioaccumulative chemicals, would ever be conducted for dieldrin.

The MDL for total DDTs was equated to the highest MDL of the six DDT isomers (0.0011 mg/kg dw for 2,4′ DDD), which was slightly higher than the ACG (0.00092 mg/kg dw). The highest MDL would only be applied if all DDT isomers were undetected. The uncertainty associated with non-detected results for dieldrin, total DDTs, and other pesticides will be discussed in the HHRA report.

3.4.2 Sediment toxicity testing

Laboratory methods, sample handling, and DQIs for the sediment samples collected for toxicity testing are described in this section.

3.4.2.1 Laboratory methods and sample handling

Sediment submitted for toxicity testing will be obtained from the same homogenate as the sediment submitted for bulk chemical analyses. The homogenized sediment will be placed into five I-Chem 1-L high-density polyethylene wide-mouth jars. Four of these 1-L jars will be shipped to NAS for the amphipod and polychaete tests, and one of the 1-L jars will be shipped to MEC for the bivalve larvae test. These sediment volumes include sufficient sediment to perform re-testing, if needed. Any headspace will be filled with nitrogen upon arrival at the laboratory. The sediment samples will be stored in the dark at 4°C ± 2°C. The toxicity tests will be initiated within 8 weeks of sample collection.

Three standard SMS sediment toxicity tests will be conducted on each sample collected from locations identified for toxicity testing. These tests are:

- Acute 10-day amphipod mortality test (*Eohaustorius estuarius*)
- Acute 48-hr bivalve larvae combined mortality and abnormality test (*Mytilus galloprovincialis*)
- Chronic 20-day juvenile polychaete survival and growth test (*Neanthes arenaceodentata*)

Biological testing will be conducted according to *Recommended Guidelines for Conducting Laboratory Bioassays on Puget Sound Sediments* (PSEP 1995), with modifications as periodically specified in annual Sediment Management Annual Review Meetings. In addition, the polychaete and amphipod tests will be modified for potential low salinity as described later in this section.

Short-term adverse effects of potentially contaminated sediment will be evaluated by measuring survival of adult amphipods (*Eohaustorius estuarius*). This species is well suited for testing with Puget Sound sediment and can be used for testing over grain size distributions ranging from 0.6 to 100% sand (DMMP 1999) and interstitial salinities ranging from 2–28 ppt (PSEP 1995). Amphipods will be exposed to the LDW sediments and reference sediments for a 10-day period. The test will be performed according to the procedures and QA/QC performance standards described in PSEP (1995), with survival as the primary endpoint. The salinity of interstitial sediments from the LDW may vary,[16] so salinity of the test sediment will be equilibrated with the overlying water by mixing the sediment with overlying seawater at the appropriate test salinity prior to initiating the test (PSEP 1995). Mixing the sediment with the bioassay water, which constitutes the overlying water, ensures that the salinity of test sediments equilibrates quickly and is in equilibrium with the overlying water when the organisms are added the following day. This will provide the preferred salinity of at least 20 ppt and a more consistent salinity for all tests. This procedure will be done only on those sediment samples in which the interstitial salinity is below 20 ppt.

Three endpoints are assessed in bivalve larvae after a 48-hour exposure period: mortality, abnormal development, and combined mortality and abnormality. Larvae of *Mytilus galloprovincialis* will be used in this study. Test protocols and QA/QC performance standards will be in accordance with PSEP (1995). All beakers will be aerated to maintain correct levels of saturation throughout the tests.

The juvenile polychaete sublethal bioassay is used to characterize the toxicity of marine sediments based on worm growth. The target initial worm weight for test organisms will be 0.5 mg (dry weight) and not less than 0.25 mg (dry weight). Parameters measured after 20-day sediment exposure are survival and growth in juvenile polychaetes *(Neanthes arenaceodentata)*. The test will be performed according to the procedures and QA/QC performance standards described in PSEP protocols (PSEP 1995) and (Johns et al. 1990). The salinity of interstitial sediments from the LDW may vary, so salinity of the test sediment will be equilibrated with the overlying water by mixing the sediment with overlying seawater at the appropriate test salinity prior to initiating the test (PSEP 1995). Mixing the sediment with the bioassay water, which constitutes the overlying water, ensures that the salinity of test sediments equilibrates quickly and is in equilibrium with the overlying water when the organisms are added the following day. This will provide the preferred salinity of at least 20 ppt and a more consistent salinity for all tests. This procedure will be done only on those sediment samples in which the interstitial salinity is below 20 ppt.

Toxicity testing protocols require that test sediments be matched and tested simultaneously with appropriate reference sediment to factor out sediment grain-size and TOC effects on bioassay organisms. Three reference sediment samples will be collected from the northern end of Carr Inlet, corresponding to the following ranges of percent fines: 70–90%, 40–60%, and 10-30%. Additional sediment from the three

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[16] When intertidal sediments are collected upstream of Slip 6, the salinity of the homogenized sediment will be measured and reported to the toxicity test laboratories if it is less than 20 ppt.

reference sites will be archived in case chemical analyses are needed at a later date. Charlie Eaton (Biomarine Enterprises) will collect the reference sediment samples using the extensive database he has compiled on specific coordinates associated with these grain size ranges. TOC content will also be matched to the test sediments as closely as possible (PSEP 1995). Each reference sediment sample will be tested for toxicity using the same three test organisms. The appropriate reference sediment for each LDW test sediment sample will be determined after reviewing the results of TOC and grain-size analyses for those samples.

Ammonia and sulfides unrelated to anthropogenic chemicals may cause toxic effects in amphipods (DMMP 2001) and polychaetes (DMMP 2004). False positive toxicity results caused by increased concentrations of ammonia and total sulfides confound the interpretation of the toxicity tests. Thus, positive control tests for ammonia will be conducted. Positive controls with sulfides cannot be conducted because sulfides will not remain soluble in an aerobic water-only test. In addition, ammonia and total sulfides will be analyzed in sediment porewater from a separate beaker at the beginning of each test, and in overlying water at the start and end of each test.

3.4.2.2 Data quality indicators

DQIs for sediment toxicity tests, shown in Table 3-10, are based on guidelines given in:

- *Recommended Guidelines for Conducting Laboratory Bioassays on Puget Sound Sediments* (PSEP 1995)
- *Standard test method for measuring the toxicity of sediment-associated contaminants with estuarine and marine invertebrates*(ASTM 2003c)
- *Standard Test Method for Conducting Static Acute Toxicity Tests Starting with Embryos of Four Species of Saltwater Bivalve Molluscs* (ASTM 2003b)
- *Standard Test Method for Conducting Acute, Chronic, and Life-cycle Aquatic Toxicity Tests with Polychaetous Annelids* (ASTM 2003a)

Compliance with these indicators will be confirmed by the toxicity testing laboratory and by the toxicity testing data validator.

Table 3-10. Data quality indicators for sediment toxicity testing

TOXICITY TEST	DATA QUALITY INDICATOR
Acute 10-day amphipod mortality test with *Eohaustorius estuarius*	Mean mortality in the negative control ≤ 10%, individual replicate mortality should not exceed 20% Mean mortality in reference sediments ≤ 25% All organisms in a test must be from the same source The mean of the daily test temperature must be within ± 1°C of 15°C Test conducted under continuous light Dissolved oxygen, pH, and salinity within the acceptable ranges established by the protocol All test chambers should be identical and should contain the same amount of sediment and overlying water The LC50 for a positive control test should be within the mean LC50 ±2 standard deviations of the control chart
Acute 48-hr bivalve larvae combined mortality and abnormality test with *Mytilus galloprovincialis*	Mean effective mortality (combined mortality and abnormal development) in the negative control ≤ 30% Mean number of normal developed larvae in the reference sediment divided by the mean number of normal developed larvae in the negative control should be ≥ 65% All organisms in a test must be from the same source The mean of the daily test temperature must be within ± 1°C of 15°C Test conducted under a light cycle of 14 hr light to 10 hr dark Dissolved oxygen, pH, salinity within the acceptable ranges established by the protocol All test chambers should be identical and should contain the same amount of sediment and overlying water The EC50 for a positive control test should be within the mean EC50 ±2 standard deviations of the control chart
Chronic 20-day juvenile polychaete survival and growth test with *Neanthes arenaceodentata*	Mean juvenile polychaete weight must be between 0.5 and 1.0 mg at test initiation. Test initiation with a mean polychaete weight less than 0.25 mg is considered a QA/QC failure Mean mortality in the negative control must be ≤ 10% A target performance growth rate has been set at 0.72 mg/individual/day by the SMS program. A growth rate below 0.38 mg/individual/day is considered a QA/QC failure All organisms in a test must be from the same source The mean of the daily test temperature must be within ± 1°C of 20°C Test conducted under continuous light Dissolved oxygen, pH, salinity within the acceptable ranges established by the protocol All test chambers should be identical and should contain the same amount of sediment and overlying water The EC50 for a positive control test should be within the mean EC50 ±2 standard deviations of the control chart

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 duplicate samples will be collected to evaluate variability attributable to sample homogenization and subsequent sample handling. Field duplicate samples will be collected from the same homogenized material as the original sample and analyzed as a separate sample; this type of field QA /QC sample is also referred to as a field split sample (PSEP 1997). A minimum of one field duplicate will be analyzed for each 20 samples. In addition, rinsate blanks will be collected from sampling equipment at a rate of 1 per 20 samples.

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 Sediment toxicity testing quality control criteria

All three sediment toxicity tests will incorporate standard QA/QC procedures to ensure that the test results are valid. Standard QA/QC procedures include the use of a negative control, a positive control, reference sediment samples, and measurement of water quality during testing.

The negative control will be a test using a clean, inert material and the same diluent seawater used in testing sediment toxicity. For the amphipod and polychaete tests, the negative control will be sand collected from Yaquina Bay. Yaquina Bay has been used successfully as a negative control, and is the sediment collection site for the amphipods used in the test. For the bivalve larvae test, the negative control seawater will be either ambient seawater from San Francisco Bay flowing into the MEC laboratory or seawater collected from Bodega Bay.[17]

For the positive control, a reference toxicant will be used to establish the relative sensitivity of the test organism. The positive control for sediment tests is typically conducted with diluent seawater and without sediment. Reference toxicants are often used in positive controls. Copper sulfate will be used as the reference toxicant in the bivalve tests. Cadmium chloride will be used as the reference toxicant for the amphipod and juvenile polychaete tests. In addition to the positive controls with reference toxicants, positive controls using ammonia (water exposure only) will also be performed for each test species.

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[17] It is standard practice for MEC to use seawater from San Francisco Bay or Bodega Bay for negative controls; these waters are chemically analyzed on a regular basis.

Reference sediment will also be included with each toxicity test series. Reference sediments provide toxicity data that can be used to separate toxicant effects from unrelated effects, such as those of sediment grain size. They are also used in statistical comparisons to determine whether test sediments are toxic. Sediment samples selected to be the test reference sediment should be collected from an area documented to be free from chemical contamination and should represent the range of important natural, physical, and chemical characteristics of the test sediments, specifically, sediment grain size and TOC. Sediments to be used as reference sediment for the three bioassays will be collected from Carr Inlet (PSEP 1995).

Bioassays require that proper water quality conditions be maintained to ensure survival of the organisms and to ensure that undue stress unrelated to test sediments is not exerted on the organisms. Salinity, dissolved oxygen (DO), pH, ammonia, total sulfides, and temperature will be regularly measured during testing. Temperature, salinity, DO, and pH will be measured daily for the amphipod mortality and larval development tests. Temperature will be measured daily for the polychaete growth test, whereas salinity, DO, and pH water quality variables will be measured every three days.

Interstitial porewater will be analyzed for ammonia and total sulfides at test initiation for both the amphipod and polychaete tests.[18] Ammonia and total sulfides will be measured in overlying water in all three tests at test initiation (after salinity adjustment) and test termination.

Toxicity test samples will be retested within the holding time if the negative control fails to meet the performance criteria. If a toxicity test fails and the holding time has expired, the decision to resample and retest sediments will be made in consultation with EPA and Ecology. Similarly, if the independent data validator recommends retesting based on data quality concerns, the decision to retest will be made in consultation with EPA and Ecology.

3.5.3 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, 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 analysis of certified reference materials, calibration checks, laboratory reagent blanks, and spiked samples.

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[18] This analysis is not applicable to the bivalve larvae test because of the small amount of sediment used in the test.

3.5.3.1 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. The laboratories determine MDLs using standard procedures outlined in 40CFR136, where seven 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 a factor of 3.14. The laboratory must submit an initial demonstration of MDLs to EPA prior to sample collection.

3.5.3.2 Sample delivery group

Project- and/or method-specific quality control measures such as matrix spikes and matrix spike duplicates will be analyzed per SDG or sample 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 holding times specific to each analytical method will be met for each sample in the SDG.

3.5.3.3 Laboratory quality control criteria

The analyst will review results of QC analyses (described below) from each sample group immediately after a sample group 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 sample group, 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 group of samples.

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 standard, two different vendors) for 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 3-9.

Table 3-11. Quality control sample analysis summary

Analysis Type	Initial Calibration	Continuing Calibration	Laboratory Control Samples	Field Duplicates	Matrix Replicates	Matrix Spikes	Matrix Spike Duplicates	Method Blanks	Standard Reference Material	Surrogate Spikes
PCB Aroclors	prior to analysis	every 10-20 analyses or 12 hrs	1 per 20 samples	1 per 20 samples	none	1 per batch or SDG	1 per batch or SDG	each batch or SDG	1 per 20 samples	each sample[a]
PCB congeners and dioxins/ furans	prior to analysis	every 10-20 analyses or 12 hrs	1 per 20 samples	none	none	1 per batch or SDG (LCS)	na	each batch or SDG	1 per 20 samples	each sample
Organo-chlorine pesticides[b]	prior to analysis	every 10-20 analyses or 12 hrs	1 per 20 samples	1 per 20 samples	none	1 per batch or SDG	1 per batch or SDG	each batch or SDG	1 per 20 samples	each sample
Mercury	prior to analysis	every 10 samples	1 per 20 samples	1 per 20 samples	1 per 20 samples	1 per batch or SDG	1 per batch or SDG	each batch or SDG	1 per 20 samples	na
Other metals	prior to analysis	every 10 samples	1 per 20 samples	1 per 20 samples	1 per 20 sample	1 per batch or SDG	na	each batch or SDG	1 per 20 samples	na
SVOCs, including PAHs	prior to analysis	every 10-20 analyses or 12 hours	1 per 20 samples	1 per 20 samples	none	1 per batch or SDG	1 per batch or SDG	each batch or SDG	1 per 20 samples	each sample
SVOCs-SIM	prior to analysis	every 10-20 analyses or 12 hours	1 per 20 samples	1 per 20 samples	none	1 per batch or SDG	1 per batch or SDG	each batch or SDG	1 per 20 samples	each sample
TBT	prior to analysis	every 10 samples	1 per 20 samples	1 per 20 samples	none	1 per batch or SDG	1 per batch or SDG	each batch or SDG	1 per 20 samples	each sample
Grain size	na	na	na	1 per 20 samples	1 per 20 samples	na	na	na	na	na
TOC	daily	every 10 samples	na	1 per 20 samples	1 per 20 samples	1 per 20 samples	na	each batch or SDG	na	na
Percent solids	na	na	na	1 per 20 samples	1 per 20 samples	na	na	na	na	na
Total sulfides	prior to analysis	every 10 samples	1 per 20 samples	1 per 20 samples	1 per 20 samples	1 per 20 samples	na	each batch or SDG	1 per 20 samples	na
Ammonia	prior to analysis	every 10 samples	1 per 20 samples	1 per 20 samples	1 per 20 samples	1 per 20 samples	na	each batch or SDG	1 per 20 samples	na

[a] 2,3,6,7-tetrachlorometa-xylene and decachlorobiphenyl will be used as surrogates for all Aroclor analyses

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

LCS – laboratory control standard

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 as a separate sample, assuming sufficient sample matrix is available. For metals and conventional measurements, a minimum of one matrix replicate will be analyzed for every 20 samples.

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. A minimum of one matrix spike and matrix spike duplicate will be analyzed for each sample group or for every 20 samples, whichever is more frequent, 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.

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 analysis (EPA 1613) and PCB congener analysis (EPA 1668A).

Laboratory Control Samples

Laboratory control samples (LCS) are analyzed as a measure of the accuracy of the analyses. 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. 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.

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 instrumentation 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 10-20 samples for 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 7 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.

3.10 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. After sampling is completed, all data from field forms will be entered into a Microsoft Excel® spreadsheet. A QC check will be done within 24 hours to ensure that 100% of the data were properly transferred from the field forms to the spreadsheet. This spreadsheet will be kept on the Windward network drive, which is backed up daily. Field forms will be archived in the Windward library. All photographs will be transferred to a CD each day.

Both analytical and toxicity laboratories are expected to submit data in an electronic format, as described in Section 2.6.2, Tables 2-2 and 2-3. 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 or 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 and toxicity 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 and toxicity 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 3-9). 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, reextraction) will be submitted with the data package using a corrective action form.

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 for each sampling round, as described in Section 2.6.4.

5.0 Data Validation and Usability

5.1 DATA VALIDATION

5.1.1 Chemical data

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 will be conducted by Laboratory Data Consultants, Inc. (or a suitable alternative) for the analytical chemistry data.

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
- 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. Quality assurance 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 3-8, 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 and PCB congener data will undergo full validation following Region 10 guidance for validation of dioxin and furan data (EPA 1996) and Method 1668 (EPA 1995).

5.1.2 Toxicity testing data

Independent third-party data review and summary validation will be conducted by Paul Dinnel of Dinnel Marine Resources for the toxicity test data. Tasks to be conducted for validation of the toxicity test data include:

- prior to test initiation, ensuring that all laboratory test protocols are in accordance with PSEP protocols, up-to-date, and include any modifications to the protocol of current SMS-approved toxicity tests that have recently been published based on the annual Sediment Management Annual Review Meetings
- possibly conducting test audits during sediment testing, which may involve several audit visits if tests are run in multiple batches
- identifying any problems or deviations from established protocols or standard operating procedures
- reviewing all toxicity and QA data from the testing laboratory for each batch of tests; noting any data gaps or items that were out of compliance with protocols; noting time period for out-of-compliance events and corrective actions taken; and providing guidance regarding the severity of any out-of-compliance items
- recommending re-testing if necessary
- preparing QA reports for the testing laboratory for each test and a final QA report covering all laboratory and data audits.

All discrepancies and requests for additional, corrected data will be discussed with the laboratories prior to issuing the formal data validation report. All contacts with the laboratories will be documented in a communication report. Review procedures used and findings made during data validation will be documented on worksheets. The data validator will prepare a data validation report that will summarize QC results, qualifiers, and possible data limitations. Only validated data with appropriate qualifiers will be released for general use.

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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7.0 Oversize Figures

Figures 2-2a – 2-2e. Surface sediment locations for the Phase 2 RI, historical surface sediment chemistry data, and related data

Figure 3-1. Surface sediment chemistry sampling locations for organochlorine pesticide analyses

Figure 3-2. Surface sediment chemistry sampling locations for dioxins/furans analyses

Figure 3-3. Surface sediment chemistry sampling locations for TBT analyses

Figure 3-4. Surface sediment chemistry sampling locations for SVOC-SIM analyses