Lower Duwamish Waterway Group

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

Lower Duwamish Waterway Remedial Investigation

DATA REPORT:
ROUND 2 SURFACE SEDIMENT SAMPLING FOR CHEMICAL ANALYSES AND TOXICITY TESTING
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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Supporting documentation

The following appendices, which consist of detailed validation reports and scanned versions of original field and laboratory documents may be viewed at http://www.ldwg.org/rifs_docs.htm; the links are found in the Data Report section under the heading **Task 10: Results of Phase 2 fieldwork**. A compact disc version of these materials is available on request.

List of Tables and In-text Figures (GIS figures in separate map folio)

Acronyms

ACRONYM	Definition
2LAET	second lowest apparent effects threshold
%RSD	percent relative standard deviation
ACG	analytical concentration goal
AET	apparent effects threshold
ARI	Analytical Resources, Inc.
Axys	Axys Analytical Services, Ltd
BEHP	bis(2-ethylhexyl) phthalate
CRQL	contract required quantitation limit
CSL	cleanup screening level
DMMP	Dredged Material Management Program
DMR	Dinnel Marine Resources
DO	dissolved oxygen
dw	dry weight
Ecology	Washington State Department of Ecology
EPA	US Environmental Protection Agency
ERA	ecological risk assessment
HHRA	human health risk assessment
ICS	interference check sample
LAET	lowest apparent effects threshold
LCS	laboratory control sample

ACRONYM	Definition
LCSD	laboratory control sample duplicate
LDC	Laboratory Data Consultants
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group
MDL	method detection limit
ML	maximum level
MLLW	mean lower low water
MS	matrix spike
MSD	matrix spike duplicate
NAS	Northwestern Aquatic Sciences
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
ppt	parts per thousand
PSEP	Puget Sound Estuary Program
QAPP	Quality Assurance Project Plan
RI	Remedial Investigation
RL	reporting limit
RPD	relative percent difference
SDG	sample delivery group
SIM	selected ion monitoring
SL	screening level
SMS	Washington State Sediment Management Standards
SOP	standard operating procedure
SQS	sediment quality standards
SRM	standard reference material
SVOC	semivolatile organic compound
TCDD	tetrachlorodibenzo-*p*-dioxin
TEF	toxic equivalency factor
TEQ	toxic equivalent
TOC	total organic carbon
Weston	Weston Solutions, Inc.
Windward	Windward Environmental LLC

1.0 Introduction

This data report presents the results of chemical analyses and toxicity tests conducted with surface sediment samples collected in Round 2 as part of the Phase 2 Remedial Investigation (RI) for the Lower Duwamish Waterway (LDW). The surface sediment Quality Assurance Project Plan (QAPP) (Windward 2005d) presented the design for the sampling and analysis of Round 1 and Round 2 samples, including details on project organization, field data collection, laboratory analyses, and data management.[1] Results of Round 1 are presented in a separate data report (Windward 2005b). As described in the Phase 2 RI work plan (Windward 2004a), the Round 1 and 2 surface sediment data will be used to support the Phase 2 ecological and human health risk assessments (ERA and HHRA) and the Phase 2 RI and Feasibility Study (FS).

Surface sediment samples (0-10 cm) were collected at 84 locations in the LDW during the Round 2 surface sediment sampling event in March 2005. All samples were analyzed for the chemicals listed in the Washington State Sediment Management Standards (SMS). In addition, a subset of samples was analyzed for organochlorine pesticides, dioxins/furans, polychlorinated biphenyl (PCB) congeners, and butyltins. Splits of samples from 21 of the 84 locations were also submitted for laboratory toxicity testing based on an evaluation of preliminary, unvalidated sediment chemical concentrations.

The Round 1 data report (Windward 2005b) did not include results from dioxin/furan and PCB congener analyses of Round 1 samples because of the time required to obtain the results from the laboratory; those results are included in this data report. In addition, this data report presents the results from dioxin/furan, PCB Aroclor, and pentachlorophenol analyses of surface sediment samples collected from nine locations selected to provide information about urban background conditions in the greater Seattle area.

The remainder of this report is organized into the following sections:

- Section 2 – Surface sediment collection methods
- Section 3 – Laboratory methods
- Section 4 – Selection of samples for toxicity testing and additional analyses
- Section 5 – Results
- Section 6 – References

The text of this report is supported by the following appendices:

[1] Sampling was conducted in two rounds because of the limit on the number of sediment samples that could be tested for toxicity at one time.

- Appendix A – data tables
- Appendix B – summary data tables for both Round 1 and Round 2
- Appendix C – protocols for dioxin and furan sediment sampling in the greater Seattle area and table outlining the selection of samples for PCB congener analyses
- Appendix D – data management
- Appendix E – data validation reports
- Appendix F – raw analytical laboratory data
- Appendix G – collection forms and field notes
- Appendix H – chain-of-custody forms

Appendices E through H, which consist of detailed validation reports and scanned original field and laboratory documents for this data report, may be viewed online at http://www.ldwg.org/rifs_docs.htm; the links to these resources are found in the Data Report section of that web page under the heading **Task 10: Results of Phase 2 fieldwork**. These materials are also available on compact disk on request, and will be provided to the US Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology).

2.0 Surface Sediment Collection Methods

This section describes the methods used to collect surface sediment samples in the LDW (Section 2.1) and outside the LDW in the greater Seattle area (Section 2.2). Additional details regarding the surface sediment collection methods are presented in the QAPP (Windward 2005d). Copies of field notes, surface sediment collection forms, and protocol modification forms are presented in Appendix G. Copies of completed chain-of-custody forms used to track sample custody are presented in Appendix H.

2.1 LDW Surface Sediment

This section presents the Round 2 surface sediment sample identification scheme, sample locations, collection methods, and field deviations from the QAPP (Windward 2005d) for samples collected in the LDW.

2.1.1 Sample identification scheme

Each sediment sampling location was assigned a unique alphanumeric location ID number. The first three characters of the location ID were "LDW" to identify the Lower Duwamish Waterway project area. The next characters indicated the type of samples collected. All locations were designated with an "SS" to indicate surface sediment, followed by a number indicating a unique sampling location. For example,

sampling location 2 was identified as LDW-SS2. Four field duplicate samples were identified using the sampling location numbers LDW-SS204 through LDW-SS207.

The Carr Inlet locations where reference samples were collected for toxicity testing had existing location IDs from previous sampling for other projects. For this sampling effort, those existing IDs were preceded with "LDW." For example, the sample collected from existing location SSCR23B was identified as LDW-SSCR23B.

Seven sampling locations previously sampled as part of the benthic invertebrate and clam sampling event in August and September 2004 were resampled in Round 2. These locations were identified using the same sampling identification scheme as described above, with the exception that "SS" was followed by the original location ID (e.g., B2b or C1). For example, sampling location B2b from the 2004 sampling event was identified as LDW-SSB2b in Round 2 sampling.

Sample IDs are similar to location IDs, but include the suffix of "010" to indicate that sediment samples were collected from the 0-10 cm depth range (e.g., LDW-SS2-010). Rinsate blanks were identified by the location identifier followed by the suffix "RB" (e.g., LDW-SS2-RB).

2.1.2 Sampling locations

The rationale for selecting sediment sampling locations is presented in the QAPP (Windward 2005d). Round 2 surface sediment samples were collected from 84 sampling locations from March 7 to 18, 2005 (Table 2-1). Round 2 sampling locations are shown in Figures 2-1a through 2-1c, located in a separate map folio volume. Reference samples for toxicity testing were collected from three locations in Carr Inlet.

Ten locations were added to the Round 2 sampling event in addition to the locations identified in the QAPP. Seven of these locations (LDW-SSB2b, LDW-SSB4a, LDW-SSB5b, LDW-SSB6a, LDW-SSB7a, LDW-SSB9a, and LDW-SSC1) were previously sampled as part of the benthic invertebrate and clam sampling event in August and September 2004 (Windward 2005a). These seven Phase 2 locations were resampled during Round 2, per agreement with EPA and Ecology, because chemical concentrations in sediment collected from these locations during the previous sampling event exceeded at least one SMS sediment quality standard (SQS), but the results of the chemical analyses were not known before the holding times for toxicity testing had expired. Therefore, additional sediment was needed from these locations to conduct toxicity testing. The other three locations (LDW-SS157, LDW-SS158, and LWG-SS159) were added to Round 2 to further investigate the area in the vicinity of Round 1 location LDW-SS115 (see Figure 2-1b), which was identified as a candidate early action area (Windward 2003).

Table 2-1. Round 2 LDW surface sediment sampling locations

Location	Date	Time (PST)	Target Location[A]		Actual Location[A]		Distance from Target (m)	Depth Above (+) or Below (-) MLLW (ft)
			(X)	(Y)	(X)	(Y)		
LDW-SS2	03.16.05	11:20	1266244	211348	1266326	211298	29.3[b]	-14.0
LDW-SS3	03.09.05	11:36	1265842	211235	1265845	211233	1.1	-34.8
LDW-SS6	03.10.05	12:58	1267025	211196	1267028	211197	1.0	-25.6
LDW-SS7	03.09.05	10:47	1266985	211054	1266984	211052	0.7	-30.8
LDW-SS8	03.07.05	15:46	1266544	210832	1266543	210831	0.4	-40.0
LDW-SS9	03.14.05	16:00	1265959	210632	1265959	210631	0.3	5.0
LDW-SS11	03.08.05	11:13	1266643	210208	1266643	210209	0.3	-46.6
LDW-SS16	03.08.05	10:53	1266291	209832	1266290	209832	0.3	-36.4
LDW-SS19[c]	03.08.05	10:01	1266487	209162	1266486	209162	0.3	-34.4
LDW-SS21	03.08.05	09:40	1266683	209140	1266686	209139	1.0	-33.8
LDW-SS24	03.14.05	14:35	1265954	208326	1265896	208303	19.0[b]	0.0
LDW-SS25	03.10.05	17:38	1267292	208141	1267285	208202	18.7[b]	1.8
LDW-SS29	03.14.05	08:36	1266075	206826	1266081	206822	2.2	4.0
LDW-SS30	03.08.05	09:23	1268374	206823	1268374	206824	0.3	-23.3
LDW-SS34	03.14.05	09:24	1266952	206472	1266976	206482	7.9	-5.0
LDW-SS35	03.08.05	11:42	1267924	206395	1267932	206332	19.4[b]	-21.7
LDW-SS39	03.11.05	08:42	1268190	205909	1268190	205909	0.0	-1.6
LDW-SS41	03.08.05	09:05	1267766	205457	1267770	205455	1.4	-26.6
LDW-SS45	03.10.05	10:32	1268041	204842	1268062	204843	6.4	-30.8
LDW-SS46	03.10.05	11:30	1267939	204779	1267940	204779	0.3	-6.7
LDW-SS47	03.10.05	14:09	1267947	204708	1267956	204710	2.8	-5.7
LDW-SS53	03.14.05	09:53	1268070	204302	1268070	204302	0.0	-18.0
LDW-SS59	03.14.05	10:58	1268225	203668	1268225	203668	0.0	-3.0
LDW-SS61	03.10.05	16:34	1268914	203381	1268883	203384	9.5	-11.8
LDW-SS62[d]	03.09.05	18:07	1268491	203360	1268486	203356	2.0	-34.8
LDW-SS65	03.08.05	08:44	1269037	202985	1269038	202983	0.7	-10.8
LDW-SS66	03.09.05	17:45	1268640	202919	1268639	202917	0.7	-32.5
LDW-SS68	03.07.05	14:32	1268713	202359	1268711	202359	0.6	-20.3
LDW-SS69b	03.16.05	12:20	1269228	202313	1269293	202059	79.9[b]	1.8
LDW-SS71	03.14.05	12:20	1269542	201854	1269542[e]	201854[e]	0.0[e]	-5.5
LDW-SS73	03.07.05	09:42	1270712	201648	1270715	201653	1.8	-7.9
LDW-SS74	03.07.05	11:25	1269818	201593	1269820	201594	0.7	-6.6
LDW-SS77	03.14.05	12:57	1270688	201421	1270688[e]	201421[e]	0.0[e]	-4.0
LDW-SS78	03.07.05	10:01	1270342	201335	1270341	201333	0.7	-17.4
LDW-SS81	03.07.05	07:59	1270429	200851	1270430	200851	0.3	-14.1
LDW-SS82[f]	03.07.05	10:23	1270157	200554	1270158	200554	0.3	-7.2
LDW-SS85	03.07.05	08:51	1270587	200137	1270595	200140	2.6	-0.3

Location	Date	Time (PST)	Target Location[A]		Actual Location[A]		Distance from Target (m)	Depth Above (+) or Below (-) MLLW (ft)
			(X)	(Y)	(X)	(Y)		
LDW-SS86	03.10.05	15:29	1270690	200026	1270733	199973	20.8[b]	2.3
LDW-SS90	03.14.05	12:30	1271624	199053	1271623	199052	0.4	2.0
LDW-SS91	03.07.05	11:53	1271681	198982	1271714	198977	10.2[b]	-1.0
LDW-SS93	03.15.05	11:15	1271951	198652	1271945	198681	9.0	na
LDW-SS95	03.09.05	13:15	1272126	198572	1272117	198577	3.1	-7.5
LDW-SS98	03.15.05	08:02	1272828	197929	1272791	197929	11.3[b]	-2.0
LDW-SS100	03.11.05	12:13	1273234	197502	1273212	197513	7.5	2.0
LDW-SS103	03.07.05	12:59	1273558	197257	1273559	197258	0.4	0.0
LDW-SS105	03.08.05	13:30	1274071	196821	1274076	196851	9.3	-3.0
LDW-SS106	03.08.05	13:53	1274278	196614	1274280	196614	0.6	1.6
LDW-SS107	03.14.05	15:38	1274616	196393	1274619	196385	2.6	-1.0
LDW-SS108	03.10.05	14:53	1274974	196037	1274977	196035	1.1	-4.3
LDW-SS122	03.08.05	14:25	1275900	194046	1275903	194048	1.1	2.0
LDW-SS124	03.15.05	12:15	1275921	193500	1275947	193478	10.4[b]	3.0
LDW-SS131[g]	03.08.05	14:50	1276248	192710	1276246	192701	2.8	-3.0
LDW-SS132	03.09.05	17:02	1276751	192578	1276753	192579	0.7	-9.2
LDW-SS133	03.09.05	14:54	1276328	192324	1276328	192323	0.3	-3.3
LDW-SS135	03.15.05	12:45	1276334	192030	1276335	192029	0.4	2.0
LDW-SS136	03.15.05	13:15	1276362	191857	1276373	191852	3.7	2.0
LDW-SS137	03.09.05	16:29	1276936	191788	1276936	191786	0.6	-2.5
LDW-SS138	03.09.05	15:16	1276907	191426	1276907	191427	0.3	1.6
LDW-SS139	03.09.05	15:56	1276492	191380	1276491	191381	0.4	0.3
LDW-SS140	03.08.05	15:08	1276602	191154	1276601	191156	0.7	-6.6
LDW-SS141	03.15.05	08:44	1276569	190661	1276573	190657	1.7	4.0
LDW-SS144	03.15.05	15:00	1278433	190320	1278412	190348	10.7[b]	0.0
LDW-SS145	03.14.05	15:08	1278123	190207	1278129	190195	4.1	-3.0
LDW-SS146	03.09.05	13:05	1277768	190183	1277766	190184	0.7	4.4
LDW-SS147	03.09.05	13:50	1276848	190135	1276847	190135	0.3	4.1
LDW-SS148[h]	03.09.05	14:38	1277573	189995	1277573	189993	0.6	.65
LDW-SS149	03.09.05	16:08	1277148	189961	1277148	189959	0.6	4.3
LDW-SS150	03.09.05	15:34	1277446	189743	1277445	189740	1.0	4.8
LDW-SS151	03.15.05	14:30	1279105	189733	1279105	189733	0.0	-4.0
LDW-SS152	03.15.05	14:07	1279530	189496	1279533	189494	1.1	-3.0
LDW-SS153	03.15.05	13:45	1279741	188993	1279742	188991	0.7	1.0
LDW-SS154	03.15.05	13:15	1279148	187805	1279097	187805	15.5[b]	2.0
LDW-SS155	03.15.05	12:35	1278938	187314	1278873	187293	20.8[b]	2.0
LDW-SS156	03.15.05	11:56	1278650	186699	1278652	186701	0.9	0.0
LDW-SS157	03.16.05	15:00	1276081[i]	194746[i]	1276152	194714	na	1.0
LDW-SS158	03.16.05	13:41	1276149[i]	194729[i]	1276073	194704	na	-6.0

Location	Date	Time (PST)	Target Location[A]		Actual Location[A]		Distance from Target (m)	Depth Above (+) or Below (-) MLLW (ft)
			(X)	(Y)	(X)	(Y)		
LDW-SS159	03.16.05	14:30	1276191	194628	1276191	194628	na	2.0
LDW-SSB2b	03.11.05	10:36	1267396	207052	1267397	207052	0.3	-36.7
LDW-SSB4a	03.14.05	10:25	1267960	203960	1267960	203964	1.2	-1.0
LDW-SSB5b	03.14.05	13:39	1268657	204112	1268661	204114	1.4	-4.5
LDW-SSB6a	03.15.05	14:45	1269735	200928	1269737	200931	1.1	1.0
LDW-SSB7a	03.18.05	10:00	1273379	197419	1273384	197415	2.0	na
LDW-SSB9a	03.15.05	09:23	1277046	190939	1277047	190933	1.9	1.0
LDW-SSC1	03.15.05	15:30	1265982	210338	1265982	210338	0.0	0.0
LDW-SSCR20b[j]	03.12.05	07:30	1102224	736762	1102225	736759	1.0	61.7
LDW-SSCR23b[j]	03.12.05	09:00	1100876	736683	1100878	736684	0.7	47.4
LDW-SSMSMP43b[j]	03.11.05	18:30	1084069	724322	1084070	724326	1.3	45.9

[a] Coordinates given in NAD83 horizontal datum; X-Y coordinates in Washington State Plane N (US survey ft)

[b] These twelve locations could not be sampled within 10 m of the targeted location, as specified in the QAPP (Windward 2005d), for reasons presented in Table 2-2

[c] Field duplicate LDW-SS205-010 was also collected at this location

[d] Field duplicate LDW-SS207-010 was also collected at this location

[e] Accurate GPS readings could not be obtained in the field at this location because of interferences; locations were identified in the field based on aerial photos

[f] Field duplicate LDW-SS204-010 was also collected at this location

[g] Field duplicate LDW-SS206-010 was also collected at this location

[h] Target coordinates at this location differ from Table 3-2 of the QAPP (Windward 2005d) because the coordinates for this location were incorrectly reported in the QAPP, but were corrected prior to sample collection and are correctly identified in this data report

[i] LDW-SS157 and LDW-SS158 were initially intended to reoccupy historical locations 900 and 899, respectively. However, the coordinates originally reported forhistorical locations 900 and 899 were apparently incorrect because location 900 was on land, and location 899 should have been farther south than its coordinates suggested. Therefore, coordinates for these historical locations were approximated based on field notes from the historical sampling; the reconstructed coordinates are presented as target locations in this table. The locations for samples 900 and 899 have also been revised in figures of this report that show these locations. Because exact target coordinates were not provided to the field crew, however, the actual locations of LDW-SS157 and LDW-SS158 differ somewhat from the reconstructed coordinates of historical locations 900 and 899.

[j] Reference area sample for toxicity testing

na – not available

MLLW – mean lower low water

PST – Pacific Standard Time

2.1.3 Sample collection methods

Round 1 sediment samples were collected using standardized procedures from the Puget Sound Estuary Program (PSEP 1997). Surface sediments were collected at each

location using either a 0.1-m^2 single or double van Veen grab sampler, a 0.04-m^2 Young grab sampler,[2] a 0.02-m^2 Ekman grab sampler, or a stainless steel spoon if the sample was collected by hand. In most cases, the van Veen grab sampler was used. The Young grab sampler was used at locations where successful van Veen grab samples could not be collected because sediment bottom conditions (sloped surface, rocky substrate) interfered with the closing of the sampler. The weighted frame of the Young grab sampler allowed the sampler to settle more firmly on the bottom surface so that the jaws could close. An Ekman grab sampler was used where a smaller boat, which could not be equipped with a van Veen grab sampler, was needed for sampling. Exposed sediment was collected during low tide using a pre-cleaned stainless steel spoon at 15 of 42 intertidal locations (LDW-SS9, LDW-SS24, LDW-SS90, LDW-SS100, LDW-SS124, LDW-SS135, LDW-SS136, LDW-SS144, LDW-SS153, LDW-SS154, LDW-SS155, LDW-SS157, LDW-SS159, LDW-SSB6a, and LDW-SSBC1).

Each successful grab sample was evaluated for acceptability in accordance with the QAPP (Windward 2005d). Sediment was collected for sulfide analysis from the first acceptable grab at each location prior to collecting and homogenizing sediment for the remaining chemical and toxicity analyses. At each grab location, one to three acceptable grab samples were collected, depending on the volume of sediments retrieved in the grab sampler and the volume needed for chemical analyses (e.g., extra volume was needed at locations where field duplicates were collected). At all locations, sediment was taken from the 0-10 cm interval and homogenized in a clean, stainless steel bowl or stockpot using either a stainless steel spoon or a drill with stainless steel mixing paddles, until texture and color were homogenous. Homogenized sediment was then split into the appropriate sampling containers for chemical and toxicity analyses. Field duplicate samples were obtained by filling additional separate containers with the same homogenized sample.

Sediment characteristics were noted in the field logbook or in the field collection forms at each sampling location (see Appendix G for copies of field logbooks and field collection forms). Table G-1 in Appendix G presents sediment characteristics, redox potential depth, and penetration depth for each Round 2 surface sediment sample.

2.1.4 Field deviations from the QAPP

Field deviations from the QAPP (Windward 2005d) included modifications to collection methods and sampling locations. These field deviations did not affect the data quality. EPA and Ecology were consulted on deviations that involved a change in study design. The deviations were as follows:

[2] The Young-modified van Veen grab sampler, or "Young grab sampler", consists of a steel conical frame encasing a hinged bucket that splits apart at the center to scoop sediment from a 0.04-m^2 area. Weights on the frame improve the ability of the bucket to penetrate into the sediment.

- Fourteen samples could not be collected at a distance ≤10 m from the target location. Table 2-2 presents the rationale for sampling the revised locations. Representatives from EPA and Ecology were consulted regarding the revision of each location.

Table 2-2. Round 2 locations where actual sampling locations were >10 m from their target sampling locations

LOCATION	DISTANCE FROM TARGET (M)	RATIONALE
LDW-SS2	29.3	Unable to collect sediment at target location, which was near outfall located on rocky rip rap slope; sample was collected approximately 30 m from outfall at a location closest to the target location where the van Veen grab sampler would close and collect acceptable samples
LDW-SS24	19.0	Location was moved closer to shore so sediment could be collected by hand using a stainless steel spoon because rock piles were covering the target location
LDW-SS25	18.7	Location was moved closer to shore to evaluate a human health exposure area
LDW-SS35	19.4	Unable to collect sediment at target location because a barge blocked access; therefore, the sample was collected at the closest open area to the south, which was approximately 19 m from the target location.
LDW-SS69b	79.9	Unable to collect sediment at target location because gravel substrate covered a large area; therefore, the location was moved approximately 80 m upstream near potential source from outfall
LDW-SS86	20.8	Unable to collect sediment at target location because access was blocked by sunken debris; location was moved to the closest accessible area to the south
LDW-SS91	10.2	Low recovery encountered at target location because of rocks; location was moved away from target location until acceptable samples were collected
LDW-SS98	11.3	Unable to collect sediment at target location because access was blocked by sunken debris; location was moved to the closest accessible area to the south
LDW-SS124	10.4	Unable to collect sediment at target location because of rock piles; location was moved to the closest area where sediment could be collected.
LDW-SS144	10.7	Target location was on sediment cap, so location was moved off the cap, as requested by EPA and Ecology
LDW-SS154	15.5	Target location was approached on foot to sample exposed sediment using a stainless steel spoon. However, the target location was covered by water at the time of sampling, so the location was moved closer to shore where exposed sediment could be sampled.
LDW-SS155	20.8	Target location coordinates placed the location on land; location was moved to an intertidal area located as close to the target as possible

- The minimum penetration depth of 11 cm (as defined in the QAPP) was not achieved at three sampling locations (LDW-SS34, LDW-SS151, and LDW-SSB7a) despite efforts involving numerous grabs where low recovery of sediment was consistently observed because of hard-packed native sediment or obstructions such as rocks or wood debris. The penetration depths ranged from 9 to 10 cm at locations LDW-SS34 and LDW-SS151, and from 5 to 10 cm at location LDW-

SSB7a; at these locations, the entire depth of the grab was collected with the exception of a small amount of sediment in contact with the sampler.

- A Young grab sampler was used in place of the 0.1-m^2 van Veen grab sampler at 11 sampling locations (LDW-SS3, LDW-SS25, LDW-SS39, LDW-SS46, LDW-SS47, LDW-SS61, LDW-SS81, LDW-SS95, LDW-SS105, LDW-SS106, and LDW-SS122) because of rocky substrate and sloped sediment surfaces.
- An Ekman grab sampler was used in place of the 0.1-m^2 van Veen grab sampler at two sampling locations (LDW-SS93 and LDW-SSB7a) where a smaller boat, which was not equipped with a van Veen grab sampler, was needed for sampling.
- At location LDW-SS80, the field crew was unable to find the target location using GPS because the 1st Avenue Bridge caused interference with the satellite signals. Instead, the sediment sample was collected approximately 70 ft from the target where accurate GPS readings could be recorded. This sample was subsequently discarded; sediment collected at location LDW-B6a was considered by EPA and Ecology to be more representative of the target LDW-SS80 sampling location.
- At LDW-SS59, two samples were collected, one just following Round 1 and another during Round 2. The Round 1 sample was collected as a precautionary measure because of concerns that maintenance dredging might be conducted by Glacier Northwest in that area prior to Round 2 sampling. It was later determined that the Round 1 sample was not needed (i.e., dredging had already occurred). ARI disposed of the samples from this location collected during Round 1, but Axys was not alerted; therefore, LDW-SS59 was inadvertently analyzed for dioxins and furans. Thus, there are two sets of results for dioxins and furans for LDW-SS59: both sets of results are presented in this report. In addition, although the QAPP did not state that organochlorine pesticides would be analyzed in LDW-SS-59-010, analysis for pesticides was mistakenly added to the chain of custody form for this sample, so ARI analyzed the sample for pesticides.

2.2 GREATER SEATTLE AREA SURFACE SEDIMENT

Surface sediment samples were collected outside the LDW in the greater Seattle area to determine the range of dioxin/furan sediment concentrations in areas associated with urban watersheds that are influenced by general non-point sources of dioxins/furans. Non-point sources to the LDW include a mix of residential, commercial, and industrial-related releases to air, resulting in direct deposition onto the waterway, or deposition onto impervious surfaces within the LDW drainage basin and subsequent transport to the LDW via runoff. Appendix E of the surface sediment QAPP (Windward 2005d) discusses these non-point sources to the LDW in detail, in

addition to the land use mixes in the LDW compared to the other urban areas sampled.

Sampling locations within the greater Seattle area were placed to meet the following criteria:

- Drainage of areas with land use similar to those areas draining to the LDW
- No known industrial point sources of dioxins/furans
- Similar receiving environments (i.e., representing a range of quiescence/disturbance conditions)
- Similar discharge flow characteristics (i.e., a range of discharge frequencies, velocities, and types)

To meet these criteria, 13 urban sampling stations were selected in nine locations, in consultation with EPA and Ecology. Samples were analyzed for dioxins/furans, PCB Aroclors, and grain size. Samples were analyzed for PCBs to address concerns about the potential for co-location of PCBs with dioxin/furans. In addition, the two samples from the Ship Canal (SC-SS1a and SC-SS1b) were analyzed for pentachlorophenol (PCP) because of a concern that PCP can be contaminated with dioxins/furans. A potential source of PCP in Salmon Bay may include wood treatment preservatives used in the marine industry. LDWG will consult with EPA and Ecology regarding how these data will be used to evaluate conditions in the LDW for the Phase 2 RI.

2.2.1 Sample identification scheme

Each sampling location was assigned a unique alphanumeric location ID number. The first two characters of the location ID identify the sampling area: "DRD" for Duwamish River; "EB" for Elliott Bay; "LU" for Lake Union; "LW" for Lake Washington; "PB" for Portage Bay; "SB" for Springbrook Creek; and "SC" for Ship Canal. The next characters indicate the type of samples collected. All locations were designated with an "SS" to indicate surface sediment, followed by a number identifying the specific background location (1 through 9). If more than one composite sample was collected within a sampling area, then each location was designated with a letter suffix (e.g., SC-SS1a and SC-SS1b).

The sample ID was similar to the location ID, but included the suffix of "010" to indicate that sediment samples were collected from the 0-10 cm depth range (e.g., SC-SS1a-010). One field duplicate sample collected from Lake Washington at location LW-SS3 was assigned the sample ID LW-SS6-010.

2.2.2 Sediment sample collection

Thirteen composite surface sediment samples and one composite field duplicate sample were collected from nine sampling areas between January 31 and February 8, 2005 (Table 2-3). These sampling locations are shown in Figures 2-2a through 2-2c (located in separate map folio).

Table 2-3. Surface sediment sampling locations for dioxin/furan analysis outside of the LDW

Location ID	Location Description	Date	Time (PST)	Actual Location[A]	
				X	Y
SC-SS1a	Ship canal, north side of 11th Ave NW	02.01.05	14:48	1261540	244308
SC-SS1b	Ship canal, north side of 11th Ave NW	02.10.05	14:49	1261511	244246
EB-SS2a	Elliott Bay, Pier 91, top NE corner	02.02.05	12:39	1259293	234706
EB-SS2b	Elliott Bay, Pier 91, top NE corner	02.02.05	14:59	1259235	234651
LW-SS3[b]	Lake Washington, NE corner	02.01.05	12:06	1290081	279049
LW-SS4	Lake Washington, offshore Mercer Slough (Bellevue)	02.08.05	09:02	1306029	213961
LW-SS5a	Lake Washington, SW end offshore drain near Renton Municipal Airport	02.08.05	10:57	1297981	185691
LW-SS5b	Lake Washington, SW end offshore drain near Renton Municipal Airport	02.08.05	12:54	1297986	185746
SB-SS6	Springbrook Creek, upstream of pump station	01.31.05	14:15	1292461	176643
DRD-SS7	Duwamish River, upstream of LDW site	02.02.05	10:16	1279749	188931
UB-SS8	Union Bay, Laurelhurst	02.02.05	13:08	1282031	242811
LU-SS9a	Lake Union under 1-5 bridge	01.31.05	10:05	1273423	241958
LU-SS9b	Lake Union under 1-5 bridge	02.01.05	09:15	1273411	241901

[a] Coordinates given in NAD83 horizontal datum; X-Y coordinates in Washington State Plane N (US survey ft); actual location is reported as the centroid of the six individual grab locations

[b] Field duplicate LW-SS6-010 was also collected at this location

PST – Pacific Standard Time

Surface sediments were collected at most locations using either a 0.1-m^2 single van Veen grab or a 0.02-m^2 Ekman grab. At location UB-SS8, a single 0.025-m^2 van Veen hand grab was used, and at location SB-SS6, a stainless steel spoon was used.

Each successful grab sample was evaluated for acceptability in accordance with the QAPP (Windward 2005d). At each location, the composite sample consisted of six acceptable grab samples (see Figures 2-2a through 2-2b). The locations of the six grabs depended on the rationale for selecting the location. Locations SC-SS1a/SC-SS1b, EB-SS2a/EB-SS2b, LW-SS5a/LW-SS5b, and LU-SS9a/LU-SS9b were located near specific outfalls. At these locations, the composite "a" and "b" samples were collected approximately 30-50 ft and 100-120 ft, respectively, away from the outfall, as specified in a supplemental memorandum to the QAPP (Windward 2005c), attached as Appendix C of this data report. Field screening of grain size was completed at all composite "a" locations using a 2-mm sieve, and all grab samples in the "a" composite samples contained less than 50% gravel, as specified in the QAPP. At the five locations without an associated outfall (LW-SS3, LW-SS4, SB-SS6, DRD-SS7, and UB-SS8), the locations of the six grab samples were distributed within the general sampling area.

At all grab locations, sediment was taken from the 0-10 cm interval and homogenized in a clean, stainless steel bowl or stockpot using either a stainless steel spoon or a drill with stainless steel mixing paddles, until texture and color were homogenous.

Homogenized sediment was then split into the appropriate sampling containers for chemical analyses.

Observations were noted in the field logbook or on the field collection forms at each sampling location, including whether an outfall was flowing at the time of sediment collection (at locations where outfalls were located). See Appendix G for copies of field logbooks and field collection forms. Table G-2 in Appendix G summarizes the collected sediment characteristics, redox potential depth, and penetration depth for each of the samples collected from the greater Seattle area.

2.2.3 Field deviations from the QAPP during sampling in the greater Seattle area

Field deviations from the QAPP (Windward 2005d) included modifications to collection methods, grab locations, and designation of sample IDs. These field deviations (listed below) did not affect the data quality. The deviations were as follows:

- Location DR-SS7 was renamed DRD-SS7 because the sampling location ID "DR-SS7" was previously used during the upstream Duwamish River sampling event, as described in the Round 1 surface sediment data report (Windward 2005b).
- A 0.1-m^2 single van Veen grab sampler was used in place of the 0.02-m^2 Ekman grab sampler at the majority of the sampling locations (SC-SS1a, SC-SS1b, EB-SS2a, EB-SS2b, LW-SS3, LW-SS4, LW-SS5a, DRD-SS7, LU-SS9a, and LU-SS9b) because it was more effective at collecting a sufficient volume of sediment than the Ekman grab sampler.
- A single 0.025-m^2 van Veen hand grab sampler was used in place of the 0.02-m^2 Ekman grab sampler at one sampling location (UB-SS8) because the area could only be accessed by foot.
- The locations of the six grabs at each sampling location were intended to follow either a general grid sampling pattern (at locations without associated outfall) or an arc sampling pattern (at locations with an associated outfall) as described in the January 28, 2005 supplemental memorandum to the QAPP (Windward 2005c). Attempts were made in the field to follow the specific grab location design; however, as shown in Figures 2-2a through 2-2d, a strict grid or arc pattern was not achieved at several locations because of logistical constraints or grain-size limitations.

3.0 Laboratory Methods

The methods used to chemically analyze sediment samples and to conduct sediment toxicity testing are described briefly in this section and in detail in the surface sediment QAPP (Windward 2005d). This section also summarizes any laboratory deviations from the QAPP.

3.1 METHODS FOR CHEMICAL ANALYSES

Table 3-1 summarizes the number of sediment samples analyzed for the various chemical analytes in the Round 2 sampling event. Table 3-2 lists the analyses conducted at each location.

Table 3-1. Summary of chemical analyses conducted with surface sediment samples collected during Round 2 and in the greater Seattle area

ANALYSES	NUMBER OF SAMPLES	NUMBER OF FIELD DUPLICATE SAMPLES	TOTAL NUMBER OF SAMPLES
Chemical Analyses of LDW Samples Collected During Round 2			
SMS chemicals (SVOCs, metals, PCBs as Aroclors), total solids, TOC, grain size, ammonia, and sulfides	84	4	88
Dioxins/furans	3[a]	1	4
PCB congeners	15[b]	0	15
Organochlorine pesticides	26	2	28
Butyltins	19	1	20
SVOC-SIM	84	4	88
Chemical Analyses of Samples Collected from the Greater Seattle Area			
Dioxins/furans	13	1	14
PCBs as Aroclors, total solids, TOC	13	1	14
Pentachlorophenol	2[c]	0	2

[a] Eighteen surface sediment samples that were collected during Round 1 were also analyzed for dioxins and furans; results are provided in this report

[b] Eighteen surface sediment samples that were collected during Round 1 were also analyzed for selected PCB congeners (see footnote a to Table 3-3); results are provided in this report

[c] These two samples were analyzed only for pentachlorophenol, not the full SVOC list, using EPA Method 8041 (modified)

Table 3-2. Round 2 surface sediment chemical analyses by location

LOCATION	SMS CHEMICALS	ORGANO-CHLORINE PESTICIDES	DIOXINS/ FURANS	PCB CONGENERS	BUTYLTINS	SVOC GC/MS SIM
LDW-SS2	X	X			X	X
LDW-SS3	X				X	X
LDW-SS6	X			X	X	X
LDW-SS7	X				X	X
LDW-SS8	X				X	X
LDW-SS9	X	X				X
LDW-SS11	X					X
LDW-SS16	X				X	X
LDW-SS19[a]	X			X		X
LDW-SS21	X					X
LDW-SS24	X			X		X

Location	SMS Chemicals	Organo-chlorine Pesticides	Dioxins/ Furans	PCB Congeners	Butyltins	SVOC GC/MS SIM
LDW-SS25	X	X		X		X
LDW-SS29	X					X
LDW-SS30	X					X
LDW-SS34	X				X	X
LDW-SS35	X					X
LDW-SS39	X					X
LDW-SS41	X	X			X	X
LDW-SS45	X				X	X
LDW-SS46	X			X	X	X
LDW-SS47	X				X	X
LDW-SS53	X				X	X
LDW-SS59	X	X	X			X
LDW-SS61	X					X
LDW-SS62[b]	X					X
LDW-SS65	X					X
LDW-SS66	X					X
LDW-SS68	X					X
LDW-SS69b[c]	X	X				X
LDW-SS71	X		X	X		X
LDW-SS73	X	X				X
LDW-SS74	X	X		X	X	X
LDW-SS77	X					X
LDW-SS78	X				X	X
LDW-SS81	X	X				X
LDW-SS82[d]	X	X				X
LDW-SS85	X	X				X
LDW-SS86	X			X		X
LDW-SS90	X					X
LDW-SS91	X					X
LDW-SS93	X	X				X
LDW-SS95	X					X
LDW-SS98	X					X
LDW-SS100	X					X
LDW-SS103	X					X
LDW-SS105	X					X
LDW-SS106	X			X		X
LDW-SS107	X				X	X
LDW-SS108	X	X		X	X	X
LDW-SS122	X					X
LDW-SS124	X				X	X

Location	SMS Chemicals	Organo-chlorine Pesticides	Dioxins/ Furans	PCB Congeners	Butyltins	SVOC GC/MS SIM
LDW-SS131[e]	X	X	X		X	X
LDW-SS132	X					X
LDW-SS133	X	X			X	X
LDW-SS135	X					X
LDW-SS136	X			X		X
LDW-SS137	X					X
LDW-SS138	X					X
LDW-SS139	X					X
LDW-SS140	X	X				X
LDW-SS141	X			X		X
LDW-SS144	X	X				X
LDW-SS145	X					X
LDW-SS146	X					X
LDW-SS147	X					X
LDW-SS148	X					X
LDW-SS149	X			X		X
LDW-SS150	X	X				X
LDW-SS151	X					X
LDW-SS152	X	X				X
LDW-SS153	X					X
LDW-SS154	X					X
LDW-SS155	X	X				X
LDW-SS156	X					X
LDW-SS157	X					X
LDW-SS158	X					X
LDW-SS159	X					X
LDW-SSB2b	X	X		X		X
LDW-SSB4a	X	X				X
LDW-SSB5b	X	X				X
LDW-SSB6a	X	X				X
LDW-SSB7a	X	X				X
LDW-SSB9a	X	X		X		X
LDW-SSC1	X					X

[a] Field duplicate sample LDW-SS205-010 was collected at this location

[b] Field duplicate sample LDW-SS207-010 was collected at this location

[c] The “b” designation was added because this location was sampled twice, per agency request, to relocate the sample further upstream because of difficulties in sampling the initial location. The first location sampled was deemed to be too close to a location sampled during the clam and co-located sediment sampling event.

[d] Field duplicate sample LDW-SS204-010 was collected at this location

[e] Field duplicate sample LDW-SS206-010 was collected at this location

All chemical analyses of the sediment samples were conducted at Analytical Resources, Inc. (ARI), except for the dioxin/furan and PCB congener analyses, which were conducted at Axys Analytical Services, Ltd (Axys). Analytical methods are presented in Table 3-3.

Table 3-3. Chemical analysis methods for surface sediment samples

PARAMETER	LABORATORY	METHOD	REFERENCE
PCBs as Aroclors[a]	ARI	GC/ECD	EPA 8082
PCB congeners[b]	Axys	HRGC/HRMS	EPA 1668
Dioxins and furans	Axys	HRGC/HRMS	EPA 1613B
Organochlorine pesticides[c, d]	ARI	GC/ECD	EPA 8081A
SVOCs (including PAHs)[e]	ARI	GC/MS	EPA 8270C and EPA 8260B[f]
Selected SVOCs[g]	ARI	GC/MS	EPA 8270C-SIM
Mercury	ARI	CVAA	EPA 7471A
Other metals[h]	ARI	ICP-AES and ICP-MS	EPA 6010B and EPA 200.8
TBT, DBT, MBT (as ions)[i]	ARI	GC/FPD	Krone et al. (1989)
Grain size	ARI	sieve/pipette	PSEP (1986)
Pentachlorophenol[j]	ARI	GC/ECD	EPA 8041 (modified)
TOC	ARI	combustion	Plumb (1981)
Total solids	ARI	oven-dried	PSEP (1986)
Total sulfides	ARI	distillation/spectro-photometric	EPA 376.2 (modified)
Ammonia	ARI	automated phenate[k]	EPA 350.1 (modified)

[a] Extracts underwent sulfur cleanup (EPA 3660B) and sulfuric acid cleanup (EPA 3665A)

[b] Sediment samples were analyzed for dioxin-like PCB congeners as defined by the World Health Organization (77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, 189) and six principal PCB congeners (66, 101, 110, 138, 153, 180) identified in LDW sediments based on Phase 1 data

[c] 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

[d] Extracts underwent silica gel cleanup (EPA 3630C) and sulfur cleanup (EPA 3660B)

[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] Method 8260B was used for one sample (LDW-SS3-010) to obtain a lower reporting limit for 1,2,4-trichlorobenzene, although the results were rejected by the data validator because the holding time was exceeded

[g] Selected semivolatile organic compounds (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-nitroso-di-n-propylamine, and pentachlorophenol

[h] SMS metals were analyzed using either the ICP-AES or the ICP-MS method to meet target analytical concentration goals (ACGs), at the laboratory's discretion. Arsenic, antimony, and thallium were analyzed by EPA 200.8 using ICP-MS. Cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, selenium, silver, vanadium, and zinc were analyzed by EPA 6010B using ICP-AES.

[i] Extracts underwent alumina cleanup (EPA 3610B)

[j] Two samples collected from greater Seattle area locations (SC-SS1a and SC-SS1b) were analyzed only for pentachlorophenol and not the full list of SVOCs

[k] Samples were extracted with potassium chloride

CVAA – cold vapor atomic absorption

GC/ECD – gas chromatograph-electron capture detection

GC/FPD – gas chromatograph-flame photometric detection

GC/MS – gas chromatograph-mass spectrometry

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

ICP-MS – inductively coupled plasma mass spectrometry

ICP-AES – inductively coupled plasma atomic emission spectrometry

MBT – monobutyltin; DBT – dibutyltin; TBT – tributyltin

SIM – selected ion monitoring

3.2 METHODS FOR TOXICITY TESTING

Sediment samples were selected for toxicity testing, in consultation with EPA and Ecology, based on an evaluation of preliminary, unvalidated chemical concentrations, as discussed in Section 4.1. Three standard SMS sediment toxicity tests were conducted with sediment samples from each of 21 selected locations in Round 2. These tests were:

- acute 10-day amphipod (*Eohaustorius estuarius*) mortality test
- acute 48-hr bivalve larvae (*Mytilus galloprovincialis*) normal survival
- chronic 20-day juvenile polychaete (*Neanthes arenaceodentata*) survival and growth test

Northwestern Aquatic Sciences (NAS) conducted the amphipod and polychaete tests, and Weston Solutions, Inc. (Weston) conducted the bivalve larvae test. The toxicity tests were conducted in accordance with *Recommended Guidelines for Conducting Laboratory Bioassays on Puget Sound Sediments* (PSEP 1995), with modifications as periodically specified in annual Sediment Management Annual Review Meetings. The toxicity test methods are presented in detail in the surface sediment QAPP (Windward 2005d). The amphipod, polychaete, and bivalve tests were each conducted at the laboratories in one batch, with a start date of April 29, 2005. Table 3-4 lists the samples submitted for toxicity tests.

Table 3-4. Samples submitted for toxicity tests

SAMPLE ID		
LDW-SS2-010	LDW-SS68-010	LDW-SS122-010
LDW-SS6-010	LDW-SS69b-010	LDW-SS144-010
LDW-SS16-010	LDW-SS71-010	LDW-SS148-010
LDW-SS21-010	LDW-SS73-010	LDW-SS157-010
LDW-SS24-010	LDW-SS77-010	LDW-SS158-010
LDW-SS29-010	LDW-SS85-010	LDW-SSB2b-010
LDW-SS39-010	LDW-SS106-010	LDW-SSB6a-010

The rationale for selecting these samples for toxicity testing is presented in Section 4.1.

Prior to the amphipod and polychaete tests, salinity adjustments were performed for seven sediment samples with interstitial salinities less than 20 parts per thousand (ppt) using methods described in the QAPP. Table 3-5 presents interstitial salinity measurements before and after adjustment in these sediment samples.

Table 3-5. Interstitial salinity measurements before and after adjustment

Sample ID	Initial Interstitial Salinity (ppt)	Interstitial Salinity after Adjustment (ppt)	
		Amphipod Test	Polychaete Test
LDW-SS24-010	18.5	27.0	29.0
LDW-SS77-010	16.0	26.5	26.0
LDW-SS122-010	15.5	27.0	26.0
LDW-SS144-010	10.0	25.0	26.0
LDW-SS148-010	15.0	24.0	25.0
LDW-SS157-010	15.5	25.0	26.0
LDW-SSB6a-010	15.5	25.0	26.0

ppt – parts per thousand

The negative control sediment for the amphipod and polychaete tests was collected in the lower Yaquina Bay, Oregon, sieved through a 0.5-mm stainless steel screen, and stored at 4°C in the dark until test initiation. The negative control for the bivalve larvae test was 0.45-µm filtered seawater from San Francisco Bay, collected using the Weston laboratory's flowing seawater system.

The positive control tests were performed concurrently with the sediment toxicity tests. Reference toxicants were cadmium chloride for the amphipod and polychaete tests and copper sulfate for the bivalve larvae tests. The positive control test duration was 4 days for the amphipod and polychaete tests and 48 hours for the bivalve larvae tests. In addition, concurrent positive control tests using ammonium chloride as a reference toxicant were conducted with the three test organisms.

Toxicity testing protocols require that test sediments be matched and tested simultaneously with appropriate reference sediment to account for potential sediment grain-size and total organic carbon (TOC) effects on test organisms (PSEP 1995). Reference sediments are then used in statistical comparisons to determine whether test sediments are toxic. Three reference sediment samples (LDW-SSCR20B-010, LDW-SSCR23B-010, and LDW-SSMSMP43B-010) were collected from the northern end of Carr Inlet on March 11 and 12, 2005 by Biomarine Enterprises. The percent fines of the reference samples LDW-SSCR20B-010, LDW-SSCR23B-010, and LDW-SSMSMP43B-010 were 79.5%, 49.4%, and 6.5%, respectively. Each of the LDW sediment samples was matched with the reference sediment sample with the most similar percent fines, as shown in Table 3-6. These reference samples were also analyzed by ARI for SMS chemicals.

Table 3-6. LDW sediment samples matched with reference sediment samples based on percent fines

LDW Sample		Reference Sample	
Sample ID	Percent Fines	Matched Sample ID	Percent Fines
LDW-SS2-010	42.2	LDW-SSCR23B-010	49.4
LDW-SS6-010	60.8	LDW-SSCR23B-010	49.4
LDW-SS16-010	74.9	LDW-SSCR20B-010	79.5
LDW-SS21-010	45.4	LDW-SSCR23B-010	49.4
LDW-SS24-010	24.8	LDW-SSMSMP43B-010	6.5
LDW-SS29-010	83.1	LDW-SSCR20B-010	79.5
LDW-SS39-010	21.7	LDW-SSMSMP43B-010	6.5
LDW-SS68-010	77.5	LDW-SSCR20B-010	79.5
LDW-SS69b-010	65.0	LDW-SSCR20B-010	79.5
LDW-SS71-010	25.1	LDW-SSMSMP43B-010	6.5
LDW-SS73-010	59.3	LDW-SSCR23B-010	49.4
LDW-SS77-010	17.6	LDW-SSMSMP43B-010	6.5
LDW-SS85-010	12.7	LDW-SSMSMP43B-010	6.5
LDW-SS106-010	19.6	LDW-SSMSMP43B-010	6.5
LDW-SS122-010	45.4	LDW-SSCR23B-010	49.4
LDW-SS144-010	16.3	LDW-SSMSMP43B-010	6.5
LDW-SS148-010	21.6	LDW-SSMSMP43B-010	6.5
LDW-SS157-010	26.0	LDW-SSMSMP43B-010	6.5
LDW-SS158-010	46.8	LDW-SSCR23B-010	49.4
LDW-SSB2b-010	37.6	LDW-SSCR23B-010	49.4
LDW-SSB6a-010	17.7	LDW-SSMSMP43B-010	6.5

The results from the three sediment toxicity tests were evaluated using the SMS rules for marine toxicity tests (Ecology 2003). The performance standards and biological effects criteria (SQS and cleanup screening levels [CSLs] of the SMS) are summarized in Table 3-7. The statistical analyses were conducted using the statistical package included in SedQual Release 5 (Ecology 2004).[3] As shown in Table 3-8, the negative control and reference sediment results from all three tests met the SMS performance standards.

[3] Statistical analyses include Wilk-Shapiro test for normality and Levene's test for equality of variances, followed by the appropriate statistical test for significance (i.e., Student's t-test, approximate t-test, or Mann-Whitney)

Table 3-7. SMS performance standards and biological effects criteria for marine sediment toxicity tests

Toxicity Test	Negative Control	Reference Sediment[A]	Biological Effects Criteria	
			SQS	CSL
Amphipod	<10% mortality	< 25% mortality	mean mortality >25% (absolute) and statistically different from the reference sediment (p ≤0.05)	mean mortality >30% above the mean mortality in the reference sediment and statistically different from the reference sediment (p ≤0.05)
Polychaete	less than 10% mortality; mean individual growth rate ≥0.72 mg/day (test failure if mean individual growth rate <0.38 mg/day)	mean individual growth rate of at least 80% of that of the negative control	mean individual growth rate <70% of that of the reference sediment and statistically different (p ≤0.05)	mean individual growth rate <50% of that of the reference sediment and statistically different (p ≤0.05)
Bivalve larvae	> 70% normal survivorship	no criterion	mean normal survivorship < 85% of that of the reference sediment and statistically different (p ≤0.10)	mean normal survivorship < 70% of that of the reference sediment and statistically different (p ≤0.10)

[a] Ecology may reject results based on unacceptably high variability

Table 3-8. Toxicity test results for the negative control and reference sediments compared to SMS performance standards

Toxicity Test	Negative Control		Reference	
	Test Results	Performance Standards	Test Results	Performance Standards
Amphipod	0.0 ± 0.0% mortality	<10% mortality	% mortality ranged from 2.0 ± 2.7 to 5.0 ± 4.1[b] in three reference samples	<25% mortality
Polychaete	0.0 ± 0.0% mortality; 1.11 ± 0.18 mg/day mean individual growth rate	<10% mortality; mean individual growth rate ≥0.72 mg/day	mean individual growth rate ranged from 97 to 108% of that of the negative control in the three reference samples	mean individual growth rate of at least 80% of that of the negative control
Bivalve larvae	88.6 ± 9.9% normal survivorship	>70% normal survivorship	not applicable	no criterion[a]

[a] Ecology has a guideline for reference sediments of ≥ 65% of the normal development exhibited in the negative control; normal development in the reference sediments ranged from 99 to 101% of that in the negative control (see Appendix F-2)

[b] Mean mortality for this sample was calculated using four replicate results rather than five, because one of the replicates had 100% mortality, and using it would have resulted in unacceptably high variability

3.3 LABORATORY DEVIATIONS FROM THE QAPP

This section discusses laboratory deviations from the QAPP (Windward 2005d) for sediment chemical analyses and for sediment toxicity testing.

3.3.1 Surface sediment chemical analysis

ARI and Axys followed the methods and procedures described in the QAPP, with the following exceptions:

- Antimony, arsenic, and thallium were analyzed by EPA Method 200.8 rather than EPA Method 6020, as specified in the QAPP. Both methods are comparable, using ICP-MS. There is no effect on the overall quality of the data.
- Matrix spike/matrix spike duplicate (MS/MSD) samples were not analyzed for PCB congeners and dioxins and furans. These samples are not required for EPA Method 1668 (congeners) and EPA Method 1613B (dioxins and furans). Although the QAPP listed MS/MSD samples as requiring quality assurance (QA) samples for these analyses, Axys, EPA, and the Lower Duwamish Waterway Group (LDWG) agreed that MS/MSD samples are not required QA samples for these analyses.
- The required standard reference material (SRM) frequency was not met for the PCB congener analyses. Two sediment SRM samples were run for the three sediment SDGs, rather than one SRM run for every 20 samples as stated in the QAPP. No data qualification resulted from the reduced SRM frequency.
- Although the QAPP stated that the SRMs would be analyzed for total sulfides, this analysis was not conducted because there is no SRM available for sulfides in sediment.

3.3.2 Sediment toxicity testing

NAS and Weston followed the methods and procedures described in the QAPP (Windward 2005d), with the exceptions summarized below for the amphipod and polychaete tests. The deviations were all assessed by Dinnel Marine Resources (DMR), the independent QA reviewer. DMR concluded that none of the deviations would affect data quality. The data validation report is provided in Appendix E-2. There were no deviations from the laboratory protocol for the bivalve larvae toxicity test.

Amphipod test

- One beaker in reference sediment SSCR23B-010 had a mortality of 100%. Including this replicate would have caused unacceptably high variability. Thus, the mean mortality for this reference sediment was calculated using only the results for the other four beakers.
- On days 1 through 3, overlying water salinity was below the protocol-specified 28.0 ± 1.0 ppt for LDW-SS24-010, LDW-SS77-010, LDW-SS144-010, LDW-SS148-010, and LDW-SS157-010, with a minimum salinity of 26.5 ppt. All five

sediments had low initial interstitial salinity; the lower overlying water salinity was attributed to the salinity adjustment procedure.

- On days 4 through 10 overlying water salinity was above the protocol-specified 28.0 ± 1.0 ppt for all samples except LDW-SS122-010, LDW-SS144-010, LDW-SS148-010, and LDW-SS157-010, with a maximum salinity of 31.0 ppt. The higher salinities were likely caused by evaporation.
- Temperature and pH measurements were inadvertently omitted one day in LDW-SS6-010

Polychaete test

- Three overlying water salinity measurements for LDW-SS73-010, LDW-SS106-010, and LDW-SSCR20B-010 on day 18 and one for LDW-SSCR20B-010 on day 20 were above the protocol-specified 28.0 ± 2.0 ppt, with a maximum salinity of 30.5 ppt.
- Temperature on day 3 was above the protocol-specified 20.0 ± 1.0°C in several samples, with a maximum temperature of 21.8°C. The room temperature was adjusted.
- Air flow on days 9 and 16 was not operating in some of the beakers. Dissolved oxygen (DO) was measured in the overlying water in a sample of five affected beakers on day 9 and in all affected beakers on day 16 just before aeration was reestablished. The minimum DO concentration on day 9 was 5.2 mg/L, and the minimum on day 16 was 3.5 mg/L. Although the SMS do not specify DO limits, the minimum DO concentration required under PSEP is 60% saturation (4.5 mg/L at 20.0 °C and 28.0 ppt) or 4.0 mg/L under the Dredged Material Management Program (DMMP). Mean survival at test termination in the beakers with the low DO concentrations (97.8 %) was similar to the average survival for all test and reference samples combined (99.0 %). Likewise, the average individual growth rate for the beakers with low DO concentrations (0.88 mg/day/individual) was similar to the average for all test and reference sediments combined (0.87 mg/day/ndividual). Thus, it is unlikely that the transient low DO concentrations on day 16 significantly affected the results of this test.
- Six individuals instead of five were inadvertently added to one of the five LDW-SS122-010 replicate beakers. The growth rate in that one replicate beaker was 0.70 mg/day, compared to a range of 0.76 to 1.06 mg/day for the other four replicate beakers. All five replicates were included in the calculation of mean individual growth rate for LDW-SS122-010, and the mean growth rate for the replicate beaker with six individuals was calculated based on the growth of all six individuals.

4.0 Selection of Sediment Samples for Toxicity Testing and Additional Analyses

This section describes the process for selecting sediment samples for toxicity testing. This section also describes additional laboratory evaluation of chromatograms or additional analyses of sediment samples for which semivolatile organic compound (SVOC) reporting limits (RLs) exceeded the SQS or CSL in the first analysis. The process for selecting Round 1 and Round 2 sediment samples for PCB congener analysis is also described in this section.

4.1 Selection of Samples for Toxicity Testing and Additional SVOC Analyses

Sediment samples for toxicity testing were selected based on a comparison of preliminary, unvalidated surface sediment chemistry data with the SQS and CSL of the SMS and with the screening levels (SLs) and maximum levels (MLs) of the DMMP for 14 chemicals without SQS/CSL values. This review had to be conducted using preliminary, unvalidated data to stay within the maximum holding time for toxicity testing.

A summary of unvalidated chemistry data was delivered to EPA and Ecology on April 19, 2005. LDWG met with EPA and Ecology on April 26, 2005 to discuss these data, and 21 locations were selected for toxicity testing. Evaluation of the preliminary data also resulted in the identification of samples with RLs for certain chemicals that exceeded SMS. Additional laboratory analyses were conducted to attempt to achieve lower RLs for these samples.

The process for deciding whether to conduct toxicity tests or additional analyses is depicted in Figure 4-1. The preliminary, unvalidated data were first compared to the SQS and CSL of the SMS, and to the SLs and MLs of the DMMP. Twenty-five samples had detected chemical concentrations greater than the corresponding SQS or SL concentrations. Of these 25 samples, 20 were selected for toxicity testing; these locations are listed in Table 4-1. The remaining five samples were not tested for toxicity because they were assumed to be toxic based on highly elevated chemical concentrations. In addition to the 20 samples submitted for toxicity testing, Ecology requested that one more sample (LDW-SS29-010) be tested because it was collected from an area with cement kiln dust. Thus, a total of 21 samples were selected for toxicity testing.

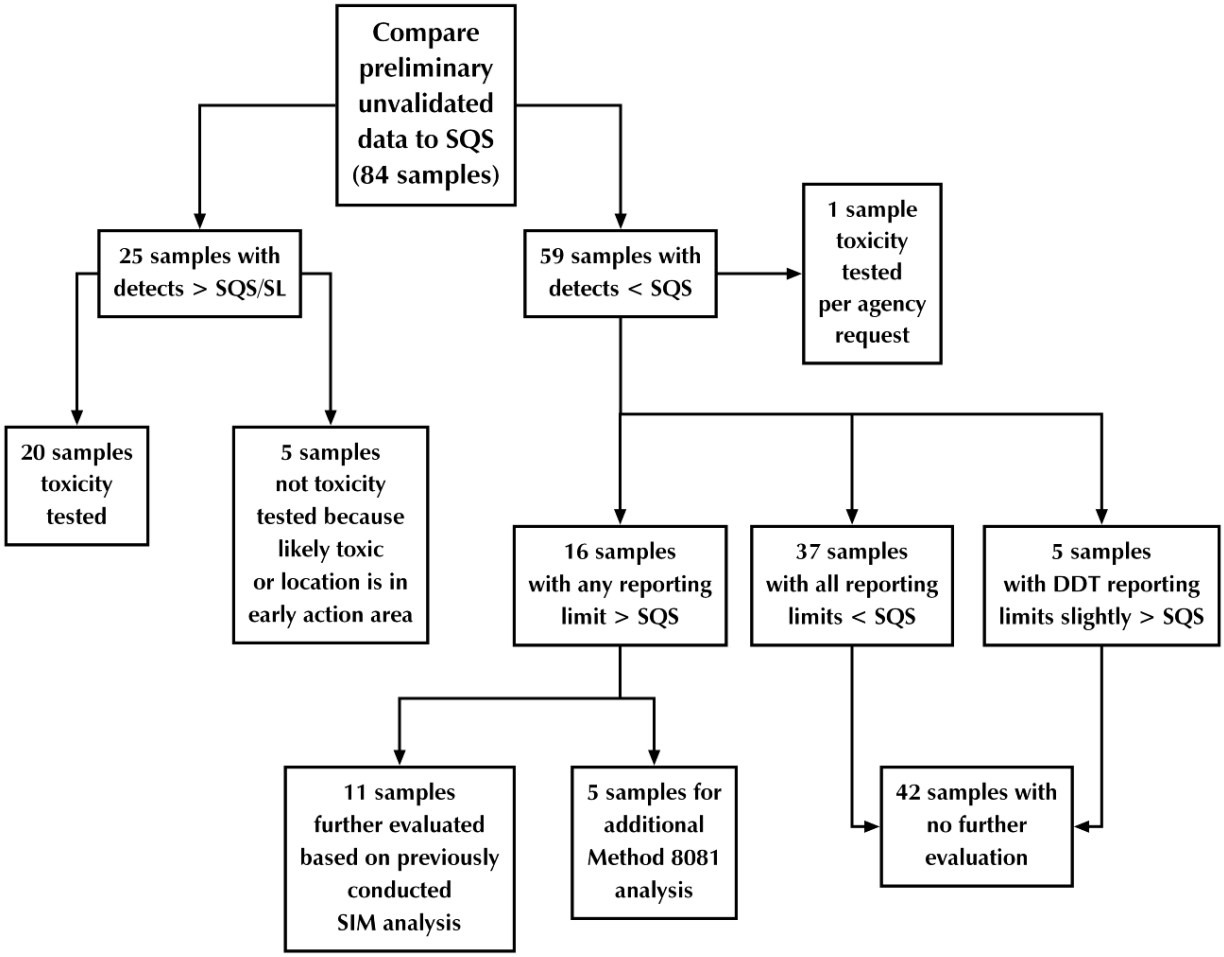

Figure 4-1. Flow chart for decisions regarding toxicity testing and additional SVOC analyses for Round 2 samples

Table 4-1. Action and final status for each sample based on evaluation of preliminary data

Action	Sample Location	Final Number of Chemicals with Concentrations or RLs > SQS/SL and ≤ CSL/ML		Final Number of Chemicals with Concentrations or RLs > CSL/ML	
		Detects	RLs[A]	Detects	RLs[A]
Toxicity testing (21)					
Testing of samples with detected concentrations >SQS/SL or CSL/ML (20)	LDW-SS2	2			
	LDW-SS6	2	1	3	1
	LDW-SS16	1			
	LDW-SS21	1			
	LDW-SS24	1		2	
	LDW-SS39		1	1	1
	LDW-SS68			1	
	LDW-SS69b	1	1		
	LDW-SS71	1			
	LDW-SS73		1	1	
	LDW-SS77	1			
	LDW-SS85	2	2		
	LDW-SS106	1			
	LDW-SS122	1			
	LDW-SS144	1	1		
	LDW-SS148	1			
	LDW-SS157	1		1	
	LDW-SS158	1			
	LDW-SSB2b	1	2		
	LDW-SSB6a	1	1		
Testing of sample with no detected concentrations >SQS/SL or CSL/ML, but tested based on agency request (1)	LDW-SS29				
Laboratory evaluation of RLs and additional analyses (17)					
Laboratory evaluation of existing SIM RLs because they were >SQS/SL (11)	LDW-SS25[b,c]				
	LDW-SS34[d]				
	LDW-SS59[b]		1[e]		
	LDW-SS61[c,d]				
	LDW-SS90[d]				
	LDW-SS98[d]				
	LDW-SS105[d]				
	LDW-SS107[d]				
	LDW-SS124[d]				
	LDW-SS136[d]				
	LDW-SS139[d]				
Laboratory evaluation of existing SIM RLs because they were >SQS/SL plus additional analysis by Method 8081 because hexachlorobenzene RL still exceeded the SQS (5)	LDW-SS3[d]		1[f]		
	LDW-SS53[d]				
	LDW-SS100[d]				
	LDW-SS151[b,c,d]				

Action	Sample Location	Final Number of Chemicals with Concentrations or RLs > SQS/SL and ≤ CSL/ML		Final Number of Chemicals with Concentrations or RLs > CSL/ML	
		Detects	RLs[A]	Detects	RLs[A]
	LDW-SSC1[b]				
No further action (47)					
No action on samples that had detected concentrations >SQS/SL or CSL/ML, because they were assumed to be toxic or were located in areas to be remediated (5)	LDW-SS35	8	1	7	
	LDW-SS46	3		1	
	LDW-SS47	1		2	
	LDW-SS95	6	1	5	
	LDW-SSB4a	2			3
No action on samples that had no detected concentrations or RLs >SQS/SL or CSL/ML for analytes other than DDT (42)	LDW-SS7				
	LDW-SS8				
	LDW-SS9		1[e]		
	LDW-SS11				
	LDW-SS19				
	LDW-SS30				
	LDW-SS41				
	LDW-SS45				
	LDW-SS62				
	LDW-SS65				
	LDW-SS66				
	LDW-SS74		1[e]		
	LDW-SS78				
	LDW-SS81		1[e]		
	LDW-SS82				
	LDW-SS86				
	LDW-SS91				
	LDW-SS93		1[e]		
	LDW-SS103				
	LDW-SS108		1[e]		
	LDW-SS131				
	LDW-SS132				
	LDW-SS133				
	LDW-SS135				
	LDW-SS137				
	LDW-SS138				
	LDW-SS140				
	LDW-SS141				
	LDW-SS145				
	LDW-SS146				
	LDW-SS147				
	LDW-SS149				
	LDW-SS150				
	LDW-SS152				
	LDW-SS153				

Action	Sample Location	Final Number of Chemicals with Concentrations or RLs > SQS/SL and ≤ CSL/ML		Final Number of Chemicals with Concentrations or RLs > CSL/ML	
		Detects	RLs[A]	Detects	RLs[A]
	LDW-SS154				
	LDW-SS155				
	LDW-SS156				
	LDW-SS159				
	LDW-SSB5b				
	LDW-SSB7a				
	LDW-SSB9a				

[a] Reporting limits (RLs) listed for non-detects

[b] Laboratory evaluation based on elevated RL for 1,2,4-trichlorobenzene

[c] Laboratory evaluation based on elevated RL for benzoic acid

[d] Laboratory evaluation based on elevated RL for hexachlorobenzene

[e] The RL for total DDT was > SL and ≤ ML at these locations

[f] The RL for total 1,2,4-trichlorobenzene was > SQS and ≤ CSL at this location

All detected concentrations were below the SQS/SL for 59 samples. Excluding the one sample that was selected for toxicity testing as described above, 41 of the remaining 58 samples had no RLs that exceeded the SQS/SL, with the exception of five samples that had DDT RLs that slightly exceeded the SL for DDT. No further evaluation was conducted on these 41 samples (Table 4-1). The other 17 samples had at least one chemical with an RL exceeding the SQS/SL, so the laboratory conducted an evaluation of the GC/MS chromatograms. For 12 of these 17 samples, the laboratory was able to determine with reasonable certainty that the chemical was not present at a lower RL based on a visual evaluation of the chromatogram and each spectrum of the SIM analysis. The laboratory also monitored the primary and secondary ion signals of the analytes at concentrations below the lowest standard in the initial calibration curve.[4] For 5 of the 17 samples, hexachlorobenzene RLs were still greater than the SQS, so additional chemical analyses were conducted with Method 8081, which resulted in RLs below the SQS. After all analyses were completed on the 17 samples, there were two samples remaining with RLs exceeding the SQS/SL (LDW-SS59-010 for DDT and LDW-SS3-010 for 1,2,4-trichlorobenzene).

4.2 Selection of Samples for PCB Congener and Dioxin/Furan Analyses

In accordance with the QAPP, a subset of sediment samples was selected for analysis of the 12 dioxin-like and six principal PCB congeners. Sample selection was based on a review of the PCB Aroclor results from Rounds 1 and 2, the sandpiper presence and

[4] These lower RLs are identified with a UJ qualifier. None of the qualified RLs are below the MDL.

habitat survey (Windward 2004b), and the human site-access survey (Windward 2005e) to satisfy the following criteria:

- spatial coverage of the LDW (approximately 5 to 6 stations per mile)
- representation of lower, mid, and higher total PCB (Aroclor) concentrations
- representation of areas with differences in PCB Aroclor composition
- location of preferred human use areas and preferred sandpiper foraging habitat

Based on these criteria, 33 locations were selected for PCB congener analysis. These specific locations are identified in Section 5.1.6. Appendix C contains a spreadsheet with the information considered by LDWG, EPA, and Ecology for each location as part of the selection process.

Sampling locations for analysis of dioxins and furans were identified prior to field sampling and were presented in the QAPP, although four of the locations (LDW-SS84, LDW-SS110, LDW-SS121, and LDW-SS144) were only tentatively identified in the QAPP based on the assumption that they would contain the highest concentrations of total PCBs. Following a review of the Round 1 and Round 2 PCB Aroclor results, samples from locations LDW-SS37, LDW-SS84, LDW-SS109, and LDW-SS143 were analyzed for dioxins/furans to represent locations associated with the highest PCB concentrations. These four locations were selected because samples from LDW-SS84 and LDW-SS109 contained the highest concentrations of total PCBs based on the Round 1 and Round 2 PCB Aroclor results. Locations LDW-SS37 and LDW-SS143 were selected because samples from these locations contained the fourth and sixth highest concentrations of total PCBs. They were selected instead of LDW-SS110 and LDW-SS111, which contained the third and fifth highest concentrations of PCBs, because LDW-SS110 and LDW-SS111 are near LDW-SS109.

5.0 Results

This section presents results of chemical analyses and toxicity testing conducted with Round 2 surface sediment samples collected in the LDW (Section 5.1), as well as the results of dioxin/furan, PCB (as Aroclors), and pentachlorophenol analyses of surface sediment samples collected from the greater Seattle area (Section 5.2). Only the final RLs and analytical results (following any re-analyses described in Section 4.1) are presented in tables in this section. The results of the data validation, conducted by Laboratory Data Consultants (LDC), are discussed in Section 5.3 and are presented in full in Appendix E-1. Section 5.4 presents results of the toxicity tests conducted with 21 of the Round 2 surface sediment samples collected from the LDW. Results of the toxicity test data validation, conducted by Dinnel Marine Resources, are discussed in Section 5.5 and are presented in full in Appendix E-2.

Complete data tables and raw laboratory data are presented in Appendices A and F, respectively. A detailed discussion of the approach used to average laboratory

replicates is presented in Appendix D. Methods for calculating concentrations for total PCBs, total polycyclic aromatic hydrocarbons (PAHs), total DDTs, and total chlordane are also presented in Appendix D. The number of significant figures shown for each concentration in all results tables in this section was specified by the analytical laboratory, as described in Appendix D. There was no additional manipulation of significant figures.

5.1 LDW SURFACE SEDIMENT CHEMISTRY RESULTS

All surface sediment samples collected from the LDW were analyzed by ARI for metals, SVOCs (including PAHs), selected SVOCs using selected ion monitoring (SIM), PCBs as Aroclors, grain size, TOC, and percent solids. A subset of these samples was also analyzed by ARI for butyltins and organochlorine pesticides. The results of the analyses are discussed separately below by analyte group. A subset of samples from both Round 1 and Round 2 was also analyzed for dioxins/furans and PCB congeners at Axys. The results from Axys for both sampling rounds are presented in this data report. In this section, the field duplicate results are averaged with the original sample results for each of the four locations where field duplicates were collected. Unaveraged duplicate data are presented in Appendix A.

Tables in this section include summaries of sediment concentrations for 47 chemicals or groups of chemicals compared to the SQS and CSL of the SMS. Concentrations of 14 chemicals not included in the SMS are compared to the SL and ML of the DMMP. If the TOC of a sediment sample is less than 0.5%, the dry weight concentration was compared to the lowest apparent effects threshold (LAET) and second lowest apparent effects threshold (2LAET) (PTI 1988), which are analogous to the SQS and CSL, respectively. Appendix A contains detailed tables containing results for each location in comparison to SMS, DMMP, or apparent effects threshold (AET) values.

Appendix B contains tables summarizing surface sediment chemistry results for all Phase 2 locations (i.e., both Round 1 and Round 2). Figures 5-1a through 5-1c present surface sediment chemistry results represented by SQS or CSL categories for all chemicals in Phase 1 and Phase 2 surface sediment samples.

5.1.1 Metals

Table 5-1 presents a summary of results for the 84 LDW surface sediment samples that were analyzed for metals, including the number of detections, the range of detected concentrations, the mean of detected concentrations, and the range of RLs for chemicals reported as non-detects. Data tables containing metals results for each sample, including field duplicate samples, are presented in Appendix A. Figures 5-2a through 5-2c (located in the map folio) present arsenic results by location. Table 5-1 also presents SQS/SL and CSL/ML values for comparison purposes. Table B-2 in Appendix B presents the same information as Table 5-1, but also includes results from Round 1.

Table 5-1. Summary of metal results in Round 2 LDW surface sediment samples

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[A]		SQS/ SL	CSL/ ML
			Minimum	Maximum	Mean[B]	Minimum	Maximum		
Antimony	mg/kg dw	9/84	0.3	3.6 J	1	0.2	0.5	150	200
Arsenic	mg/kg dw	84/84	2.7	161	17	na	na	57	93
Cadmium	mg/kg dw	39/84	0.3	3.8	0.7	0.2	1	5.1	6.7
Chromium	mg/kg dw	84/84	9.9	174	31	na	na	260	270
Cobalt	mg/kg dw	84/84	3.5	30	8	na	na	nv	nv
Copper	mg/kg dw	84/84	10.3	1,340	92.6	na	na	390	390
Lead	mg/kg dw	84/84	3	573	50	na	na	450	530
Mercury	mg/kg dw	56/84	0.06	1.09	0.2	0.04	0.1	0.41	0.59
Molybdenum	mg/kg dw	82/84	0.7 J	20	2	0.6	0.6	nv	nv
Nickel	mg/kg dw	84/84	6	48	20	na	na	140	370
Selenium	mg/kg dw	0/84	nd	nd	nd	6	30	nv	nv
Silver	mg/kg dw	13/84	0.5	3	1	0.3	2	6.1	6.1
Thallium	mg/kg dw	2/84	0.5	0.6	0.6	0.2	0.5	nv	nv
Vanadium	mg/kg dw	84/84	36.3	87.0	59	na	na	nv	nv
Zinc	mg/kg dw	84/84	30.8	878	150	na	na	410	960

[a] RL range for non-detect samples

[b] Reported mean concentrations are the average of the detected concentrations only; RLs were not included in calculation of the mean concentration

dw – dry weight

na – not applicable

nd – not detected

nv – no value available for this chemical

Eight metals (arsenic, chromium, cobalt, copper, lead, nickel, vanadium, and zinc) were detected in all of the Round 2 surface sediment samples. Selenium was not detected in any of the surface sediment samples. The sample collected at location LDW-SS47 contained the highest concentrations of arsenic (161 mg/kg dry weight [dw]), copper (1,340 mg/kg dw), zinc (878 mg/kg dw), cobalt (30 mg/kg dw), and molybdenum (20 mg/kg dw). The sample collected at location LDW-SS6 contained the highest concentrations of cadmium (3.8 mg/kg dw), lead (573 mg/kg dw), silver (3 mg/kg dw), and thallium (0.6 mg/kg dw).

Table 5-2 presents the number of samples with detected concentrations or RLs (for non-detected results) greater than the SQS/SL or CSL/ML for the 10 metals with SMS or DMMP values. Table B-3 in Appendix B presents the same information as Table 5-2, but also includes results from Round 1. Table A-1 in Appendix A presents the results for each Round 2 sample, including field duplicate samples, and indicates which detected concentrations or RLs exceeded the SQS/SL or CSL/ML. Three metals (arsenic, mercury, and zinc) had a total of eight detected concentrations that exceeded their respective SQS/SL values, but not their CSL/ML values. Four metals (arsenic,

copper, lead, and mercury) had a total of six detected concentrations that exceeded their respective CSL/ML values.

Table 5-2. Number of samples with concentrations within each SQS/SL or CSL/ML category for detected concentrations and reporting limits for metals

Metal	Samples with Detected Concentration			Samples with Reporting Limit when Undetected		
	≤SQS/SL	>SQS/SL ≤CSL/ML	>CSL/ML	≤SQS/SL	>SQS/SL ≤CSL/ML	>CSL/ML
Antimony	9			75		
Arsenic	80	3	1			
Cadmium	39			45		
Chromium	84					
Copper	82		2			
Lead	83		1			
Mercury	53	1	2	28		
Nickel	84					
Silver	13			71		
Zinc	80	4				

5.1.2 Butyltins

Table 5-3 presents a summary of results for the surface sediment samples analyzed for butyltins at 19 locations in the LDW. Data tables containing butyltin results for each sample, including field duplicate samples, are presented in Appendix A. Table B-1 in Appendix B is a summary table similar to Table 5-3, but also includes results from Round 1. Figures 5-3a through 5-3c (located in the map folio) present the tributyltin results by location. Tributyltin was detected in samples collected at 17 of the 19 locations. Dibutyltin and monobutyltin were detected in samples from nine and three locations, respectively. The highest tributyltin and dibutyltin concentrations (shown in Table 5-3) were detected in the sample collected at location LDW-SS46. The next highest tributyltin concentrations of 260 and 230 µg/kg dw were detected in samples collected at locations LDW-SS45 and LDW-SS47, respectively.

Table 5-3. Summary of butyltin results in Round 2 LDW surface sediment samples

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[A]	
			Minimum	Maximum	Mean[B]	Minimum	Maximum
Monobutyltin as ion	µg/kg dw	3/7	3.0 J	16 J	11	3.8	4.1
Dibutyltin as ion	µg/kg dw	9/19	3.6 J	560	90	5.4	5.7
Tributyltin as ion	µg/kg dw	17/19	5.4	3,000	220	3.7	3.8

[a] RL range for non-detect samples

[b] Reported mean concentrations are the average of the detected concentrations only; RLs were not included in calculation of the mean concentration

5.1.3 SVOCs

Table 5-4 presents a summary of results for surface sediment samples from 84 locations in the LDW that were analyzed for SVOCs, including the results from SIM analyses. Table B-1 in Appendix B presents the same information as Table 5-4, but also includes results from Round 1. Data tables containing SVOC results for each sample, including the four field duplicates, are presented in Appendix A.

Table 5-4. Summary of SVOC results in Round 2 LDW surface sediment samples

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[A]	
			Minimum	Maximum	Mean[B]	Minimum	Maximum
PAHs							
2-Chloronaphthalene	µg/kg dw	0/84	nd	nd	nd	19	99
2-Methylnaphthalene	µg/kg dw	8/84	25	3,300	540	19	99
Acenaphthene	µg/kg dw	20/84	16 J	5,200	560	19	99
Acenaphthylene	µg/kg dw	20/84	15 J	240	69	19	99
Anthracene	µg/kg dw	57/84	18 J	10,000	360	19	98
Benzo(a)anthracene	µg/kg dw	75/84	7.3 J	4,000	360	6.4	6.6
Benzo(a)pyrene	µg/kg dw	76/84	7.1	2,100	310	6.4	6.6
Benzo(b)fluoranthene	µg/kg dw	77/84	6.6 J	2,700	440	6.4	6.6
Benzo(g,h,i)perylene	µg/kg dw	58/84	21	1,100	140	19	98
Benzo(k)fluoranthene	µg/kg dw	74/84	16 J	2,700	370	19	20
Total benzofluoranthenes (calc'd)	µg/kg dw	77/84	6.6 J	5,200	790	nc	nc
Chrysene	µg/kg dw	74/84	21	5,700	530	19	20
Dibenzo(a,h)anthracene	µg/kg dw	19/84	12 J	350	70	19	300
Dibenzofuran	µg/kg dw	16/84	10 J	4,000	500	19	99
Fluoranthene	µg/kg dw	77/84	20	17,000	1,100	19	20
Fluorene	µg/kg dw	27/84	22	6,800	500	19	99
Indeno(1,2,3-cd)pyrene	µg/kg dw	75/84	6.5	1,200	150	6.4	6.6
Naphthalene	µg/kg dw	14/84	13 J	5,300	460	19	99
Phenanthrene	µg/kg dw	72/84	20	22,000	790	19	20
Pyrene	µg/kg dw	76/84	21	12,000	820	19	20
Total HPAH (calc'd)	µg/kg dw	78/84	46	48,000 J	4,100	nc	nc
Total LPAH (calc'd)	µg/kg dw	73/84	20	44,000	1,500	nc	nc
Total PAH (calc'd)	µg/kg dw	79/84	46	92,000 J	5,400	nc	nc
Phthalates							
Bis(2-ethylhexyl)phthalate	µg/kg dw	51/84	25	1,600	290	19	840
Butyl benzyl phthalate	µg/kg dw	26/84	10	200	37	6.3	54
Diethyl phthalate	µg/kg dw	17/84	5.7 J	120	16	6.4	42
Dimethyl phthalate	µg/kg dw	12/84	6.6 J	83	24	6.3	54
Di-n-butyl phthalate	µg/kg dw	6/84	21	91	39	19	120
Di-n-octyl phthalate	µg/kg dw	1/84	53	53	53	19	99

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[A]	
			Minimum	Maximum	Mean[B]	Minimum	Maximum
Other SVOCs							
1,2,4-Trichlorobenzene	µg/kg dw	0/84	nd	nd	nd	3.3	27
1,2-Dichlorobenzene	µg/kg dw	1/84	7.3	7.3	7.3	6.3	54
1,3-Dichlorobenzene	µg/kg dw	0/84	nd	nd	nd	19	99
1,4-Dichlorobenzene	µg/kg dw	1/84	9.1	9.1	9.1	6.3	54
2,4,5-Trichlorophenol	µg/kg dw	0/84	nd	nd	nd	96	500
2,4,6-Trichlorophenol	µg/kg dw	0/84	nd	nd	nd	96	500
2,4-Dichlorophenol	µg/kg dw	0/84	nd	nd	nd	96	500
2,4-Dimethylphenol	µg/kg dw	0/84	nd	nd	nd	6.3	27
2,4-Dinitrophenol	µg/kg dw	0/84	nd	nd	nd	190	990
2,4-Dinitrotoluene	µg/kg dw	0/84	nd	nd	nd	96	500
2,6-Dinitrotoluene	µg/kg dw	0/84	nd	nd	nd	96	500
2-Chlorophenol	µg/kg dw	0/84	nd	nd	nd	19	99
2-Methylphenol	µg/kg dw	1/84	32	32	32	6.3	54
2-Nitroaniline	µg/kg dw	0/84	nd	nd	nd	96	500
2-Nitrophenol	µg/kg dw	0/84	nd	nd	nd	96	500
3,3'-Dichlorobenzidine	µg/kg dw	0/84	nd	nd	nd	96	500
3-Nitroaniline	µg/kg dw	0/84	nd	nd	nd	96	500
4,6-Dinitro-o-cresol	µg/kg dw	0/84	nd	nd	nd	190	990
4-Bromophenyl phenyl ether	µg/kg dw	0/84	nd	nd	nd	19	99
4-Chloro-3-methylphenol	µg/kg dw	0/84	nd	nd	nd	96	500
4-Chloroaniline	µg/kg dw	0/84	nd	nd	nd	96	500
4-Chlorophenyl phenyl ether	µg/kg dw	0/84	nd	nd	nd	19	99
4-Methylphenol[C]	µg/kg dw	3/84	20	54	32	19	99
4-Nitroaniline	µg/kg dw	0/84	nd	nd	nd	96	500
4-Nitrophenol	µg/kg dw	0/84	nd	nd	nd	96	500
Aniline	µg/kg dw	0/84	nd	nd	nd	19	99
Benzoic acid	µg/kg dw	15/84	64 J	770	180	63	540
Benzyl alcohol	µg/kg dw	5/84	20	670	180	19	80
Bis(2-chloroethoxy)methane	µg/kg dw	0/84	nd	nd	nd	19	99
Bis(2-chloroethyl)ether	µg/kg dw	0/84	nd	nd	nd	19	99
Bis(2-chloroisopropyl)ether	µg/kg dw	0/84	nd	nd	nd	19	99
Carbazole	µg/kg dw	38/84	20	4,200	210	19	99
Hexachlorobenzene	µg/kg dw	4/84	0.96 J	95 J	25	0.96	54
Hexachlorobutadiene	µg/kg dw	0/84	nd	nd	nd	0.96	54
Hexachlorocyclopentadiene	µg/kg dw	0/84	nd	nd	nd	96	500
Hexachloroethane	µg/kg dw	0/84	nd	nd	nd	19	99
Isophorone	µg/kg dw	0/84	nd	nd	nd	19	99
Nitrobenzene	µg/kg dw	0/84	nd	nd	nd	19	99
N-Nitrosodimethylamine	µg/kg dw	0/84	nd	nd	nd	32	270

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[A]	
			Minimum	Maximum	Mean[B]	Minimum	Maximum
N-Nitroso-di-n-propylamine	µg/kg dw	0/84	nd	nd	nd	32	270
N-Nitrosodiphenylamine	µg/kg dw	11/84	6.6	24	9.4	6.3	54
Pentachlorophenol	µg/kg dw	2/84	76	410	240	32	270
Phenol	µg/kg dw	14/84	21	280 J	120	19	99

[a] RL range for non-detect samples

[b] Reported mean concentrations are the average of the detected concentrations only; RLs were not included in calculation of the mean concentration

[c] Coelutes with 3-methylphenol

nc – not calculated

nd – not detected

All individual PAH compounds were detected in at least one sample, with the exception of 2-chloronaphthalene, which was never detected. The 11 PAHs most frequently detected (each detected in samples from at least 57 locations) were anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene. The remaining eight PAHs were each detected in 20 or fewer samples. The highest concentrations of total LPAHs (44,000 µg/kg dw) and total HPAHs (48,000 µg/kg dw) were detected in the sample collected at LDW-SS95.

All six phthalates were detected in at least one sample. Bis(2-ethylhexyl) phthalate (BEHP), the most frequently detected phthalate compound, was detected in samples collected at 51 of the 84 locations with a maximum concentration of 1,600 µg/kg dw detected in the sample collected at LDW-SS46.

Eleven other SVOCs were infrequently detected in samples from the 84 LDW locations at the following frequencies: 1,2-dichlorobenzene (1/84), 1,4-dichlorobenzene (1/84), 2-methylphenol (1/84), 4-methylphenol (3/84), benzoic acid (15/84), benzyl alcohol (5/84), carbazole (38/84), hexachlorobenzene (3/84), N-nitrosodiphenylamine (11/84), pentachlorophenol (2/84), and phenol (14/84). The remaining 32 SVOCs were not detected in any samples collected from the LDW.

Table 5-5 presents a summary of SVOC results expressed in appropriate units for comparison to SQS/SL and CSL/ML (i.e., organic-carbon normalized for most of the SVOCs and dry weight for the remainder) for those samples with TOC contents more than 0.5%. Table B-2 in Appendix B presents the same information as Table 5-5, but also includes results from Round 1. Tables A-5-1 through A-5-7 in Appendix A present the SVOC results for each sample, including field duplicate samples, and indicate which concentrations exceeded the SQS/SL or CSL/ML.

Four samples had TOC contents of less than 0.5%, so they were not compared to SQS or CSL values that are organic-carbon normalized. Instead, the dry weight concentrations of the chemicals for those samples were compared to the lowest AET

and second-lowest AET values, as presented in Table A-5-8 of Appendix A. Table 5-6 presents the number of samples with detected concentrations or final RLs (for non-detected results) greater than the SQS/SL or CSL/ML for the 40 SVOCs with SMS or DMMP values. Table B-2 in Appendix B presents the same information as Table 5-6, but also includes results from Round 1.

Table 5-5. Summary of SVOC results in Round 2 LDW surface sediment samples in comparison to SQS/SL and CSL/ML

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[A]		SQS/ SL	CSL/ ML
			Minimum	Maximum	Mean[B]	Minimum	Maximum		
PAHs									
2-Methylnaphthalene	mg/kg OC	8/80	0.87	160	26	0.57	6.6	38	64
Acenaphthene	mg/kg OC	20/80	0.57	260	25	0.66	6.6	16	57
Acenaphthylene	mg/kg OC	20/80	1.1	7.8	2.9	0.66	6.6	66	66
Anthracene	mg/kg OC	57/80	0.86	380	15	0.75	6.6	220	1,200
Benzo(a)anthracene	mg/kg OC	75/80	0.46	160	15	0.29	1.3	110	270
Benzo(a)pyrene	mg/kg OC	75/80	0.25	100	14	0.29	1.3	99	210
Benzo(g,h,i)perylene	mg/kg OC	57/80	1.1	30	5.9	0.75	6.6	31	78
Total benzofluoranthenes (calc'd)	mg/kg OC	76/80	0.49 J	250	35	nc	nc	230	450
Chrysene	mg/kg OC	74/80	1.4	220	23	0.88	3.9	110	460
Dibenzo(a,h)anthracene	mg/kg OC	19/80	0.62 J	7.3	2.7	0.66	15	12	33
Dibenzofuran	mg/kg OC	16/80	0.42 J	170	22	0.57	6.6	15	58
Fluoranthene	mg/kg OC	77/80	0.92	850	48	3.0	3.9	160	1,200
Fluorene	mg/kg OC	27/80	1.1	260	22	0.66	6.6	23	79
Indeno(1,2,3-cd)pyrene	mg/kg OC	74/80	0.23	37	6.7	0.29	1.3	34	88
Naphthalene	mg/kg OC	14/80	1.3 J	260	23	0.57	6.6	99	170
Phenanthrene	mg/kg OC	72/80	1.3	830	34	0.88	3.9	100	480
Pyrene	mg/kg OC	76/80	1.1	500	36	2.1	3.9	1,000	1,400
Total HPAH (calc'd)	mg/kg OC	77/80	2.0	2,100	180	nc	nc	960	5,300
Total LPAH (calc'd)	mg/kg OC	73/80	1.3	1,700	66	nc	nc	370	780
Phthalates									
Bis(2-ethylhexyl)phthalate	mg/kg OC	51/80	1.4	81	14	1.6	31	47	78
Butyl benzyl phthalate	mg/kg OC	26/80	0.46	6.5	1.5	0.23	2.3	4.9	64
Diethyl phthalate	mg/kg OC	16/80	0.30	3.1	0.76	0.22	2.3	61	110
Dimethyl phthalate	mg/kg OC	12/80	0.19 J	5.7	1.2	0.21	2.3	53	53
Di-n-butyl phthalate	mg/kg OC	6/80	0.81	3.0	1.9	0.45	6.6	220	1,700

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[A]		SQS/ SL	CSL/ ML
			Minimum	Maximum	Mean[B]	Minimum	Maximum		
Di-n-octyl phthalate	mg/kg OC	1/80	0.88	0.88	0.88	0.57	6.6	58	4,500
Other SVOCs									
1,2,4-Trichlorobenzene	mg/kg OC	0/80	nd	nd	nd	0.19	1.9	0.81	1.8
1,2-Dichlorobenzene	mg/kg OC	1/80	0.35	0.35	0.35	0.19	2.3	2.3	2.3
1,3-Dichlorobenzene	µg/kg dw	0/80	nd	nd	nd	6.3	31	170	nv
1,4-Dichlorobenzene	mg/kg OC	1/80	0.45	0.45	0.45	0.19	2.3	3.1	9
2,4-Dimethylphenol	µg/kg dw	3/80	20	54	32	19	99	29	29
2-Methylphenol	µg/kg dw	15/80	64 J	770	180	63	540	63	63
4-Methylphenol	µg/kg dw	5/80	20	670	180	19	80	670	670
Benzoic acid	µg/kg dw	4/80	0.045 J	3.7 J	0.97	0.036	1.9	650	650
Benzyl alcohol	µg/kg dw	0/80	nd	nd	nd	0.033	1.9	57	73
Hexachlorobenzene	mg/kg OC	4/80	0.045 J	3.7 J	0.97	0.036	1.9	0.38	2.3
Hexachlorobutadiene	mg/kg OC	0/80	nd	nd	nd	0.033	1.9	3.9	6.2
Hexachloroethane	µg/kg dw	2/80	76	410	240	32	270	1,400	14,000
N-Nitrosodiphenylamine	mg/kg OC	11/80	0.23	2.3	0.58	0.19	2.3	11	11

[a] RL range for non-detect samples

[b] Reported mean concentrations are the average of the detected concentrations only; RLs were not included in calculation of the mean concentration

nc – not calculated

nd – not detected

nv – no value available for this chemical

Table 5-6. Number of samples with concentrations within each SQS/SL or CSL/ML category for detected concentrations and reporting limits for SVOCs

SVOC	Samples with Detected Concentration			Samples with Reporting Limit when Undetected[A]		
	≤SQS/SL	>SQS/SL ≤CSL/ML	>CSL/ML	≤SQS/SL	>SQS/SL ≤CSL/ML	>CSL/ML
PAHs						
2-Methylnaphthalene	7		1	76		
Acenaphthene	18		2	64		
Acenaphthylene	20			64		
Anthracene	56	1		27		
Benzo(a)anthracene	73	2		9		
Benzo(a)pyrene	75	1		8		
Benzo(g,h,i)perylene	58			26		
Total benzofluoranthenes (calc'd)	76	1		7		
Chrysene	72	2		10		

SVOC	Samples with Detected Concentration			Samples with Reporting Limit when Undetected [a]		
	≤SQS/SL	>SQS/SL ≤CSL/ML	>CSL/ML	≤SQS/SL	>SQS/SL ≤CSL/ML	>CSL/ML
Dibenzo(a,h)anthracene	19			64	1	
Dibenzofuran	14		2	68		
Fluoranthene	74	3		7		
Fluorene	25		2	57		
Indeno(1,2,3-cd)pyrene	74	1		9		
Naphthalene	13		1	70		
Phenanthrene	70		2	12		
Pyrene	76			8		
Total HPAH (calc'd)	76	2		6[b]		
Total LPAH (calc'd)	71		2	11[c]		
Phthalates						
Bis(2-ethylhexyl)phthalate	49	1	1	33		
Butyl benzyl phthalate	25	1		58		
Diethyl phthalate	17			67		
Dimethyl phthalate	12			72		
Di-n-butyl phthalate	6			78		
Di-n-octyl phthalate	1			83		
Other SVOCs						
1,2,4-Trichlorobenzene				82	1	1
1,2-Dichlorobenzene	1			82		1
1,3-Dichlorobenzene				84		
1,4-Dichlorobenzene	1			83		
2,4-Dimethylphenol				84		
2-Methylphenol	1			83		
4-Methylphenol	3			81		
Benzoic acid	14		1	69		
Benzyl alcohol	3		2	78		1
Hexachlorobenzene	3		1	77	3	
Hexachlorobutadiene				84		
Hexachloroethane				84		
N-Nitrosodiphenylamine	11			73		
Pentachlorophenol	1	1		82		
Phenol	14			70		

[a] All samples with RLs > SQS were either tested for toxicity or will be evaluated in the Phase 2 ERA based on chemical concentrations

[b] The RL for total HPAH was assigned a concentration equal to the highest RL of the HPAH components for a given sample

[c] The RL for total LPAH was assigned a concentration equal to the highest RL of the LPAH components for a given sample

Seven individual PAHs had a total of 11 detected concentrations that exceeded their respective SQS but not their CSL. Six individual PAHs had a total of 10 concentrations that exceeded their respective CSL. The concentrations of total HPAHs exceeded the SQS but not the CSL at two locations (LDW-SS35 and LDW-SS95) and the concentrations of the LPAHs exceeded the CSL at these same two locations. In addition, one individual PAH (dibenzo(a,h)anthracene) was not detected but had an RL exceeding the SQS at location LDW-SS35. The sample from this location was not tested for toxicity because it will be evaluated in the Phase 2 ERA based on chemical concentrations.

BEHP and butyl benzyl phthalate exceeded their SQS but not their CSL in samples collected at LDWSS-46 and LDW-SS157, respectively. Detected concentrations of BEHP exceeded the CSL at one location (LDW-SS6).

One other SVOC, pentachlorophenol, was detected at a concentration exceeding its SQS but not its CSL (at location LDW-SSB4a). Three other SVOCs (benzoic acid, benzyl alcohol, and hexachlorobenzene) had a total of four detected concentrations that exceeded their respective CSL/ML. Four other SVOCs had RLs exceeding their SQS/SL or CSL/ML values; these samples were either tested for toxicity or will be evaluated in the Phase 2 ERA based on chemical concentrations.

5.1.4 PCB Aroclors

Table 5-7 presents a summary of results for the surface sediment samples collected from 84 locations in the LDW that were analyzed for PCB Aroclors. Table B-1 in Appendix B presents a summary of results for both Round 1 and Round 2. Results are presented for both individual Aroclors and total PCBs. Data tables containing results for each sample, including field duplicates, for PCB Aroclors and total PCBs are presented in Appendix A. Table 5-8 presents a summary of organic carbon-normalized results and comparisons with the SQS and CSL for the 80 samples with TOC contents > 0.5%. Table B-2 in Appendix B presents a table with the same information as Table 5-8, but also includes results from Round 1. Figures 5-4a through 5-4c (located in the map folio) present the total PCB results by location.

Table 5-7. Summary of PCB Aroclor results in Round 2 LDW surface sediment samples

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[A]	
			Minimum	Maximum	Mean[B]	Minimum	Maximum
Aroclor-1016	µg/kg dw	0/84	nd	nd	nd	19	110
Aroclor-1221	µg/kg dw	0/84	nd	nd	nd	19	110
Aroclor-1232	µg/kg dw	0/84	nd	nd	nd	19	110
Aroclor-1242	µg/kg dw	16/84	20 J	400	100	19	110
Aroclor-1248	µg/kg dw	15/84	23 J	740	96	19	130
Aroclor-1254	µg/kg dw	63/84	17 J	910	130	19	61
Aroclor-1260	µg/kg dw	60/84	17 J	320	80	19	110

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[A]	
			Minimum	Maximum	Mean[B]	Minimum	Maximum
Total PCBs (calc'd)	µg/kg dw	67/84	17 J	1,920	240	nc	nc

[a] RL range for non-detect samples

[b] Reported mean concentrations are the average of the detected concentrations only; RLs were not included in calculation of the mean concentration

nc – not calculated

nd – not detected

Table 5-8. Summary of PCB Aroclor results in Round 2 LDW surface sediment samples in comparison to SQS and CSL

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[A]		SQS	CSL
			Minimum	Maximum	Mean[B]	Minimum	Maximum		
Total PCBs (calc'd)	mg/kg OC	66/80[c]	0.74 J	180	13	nc	nc	12	65

[a] RL range for non-detect samples

[b] Reported mean concentrations are the average of the detected concentrations only; RLs were not included in calculation of the mean concentration

[c] Only those samples with TOC contents > 0.5% are included. Four of the 84 samples analyzed had TOC contents less than 0.5%; therefore, organic carbon normalization and comparson with the SQS and CSL are not appropriate for those four samples

nc – not calculated

Four of the seven different Aroclors were detected in at least one sediment sample. The most frequently detected Aroclors were 1254 (in samples from 63 of 84 locations) and 1260 (in samples from 60 of 84 locations). The maximum total PCB concentration (1,920 µg/kg dw) was detected at location LDW-SS6. At 17 locations, no PCB Aroclors were detected.

Table 5-9 presents the number of samples with detected concentrations or RLs (for non-detected results) greater than the SQS or CSL. Table B-3 in Appendix B presents a table with the same information as Table 5-9, but also includes results from Round 1. Table A-1 in Appendix A presents the results for each sample, including field duplicate samples, and indicates which concentrations exceeded the SQS or CSL. Total PCBs exceeded the SQS in samples collected at 15 locations and exceeded the CSL in samples collected at one location. RLs for non-detected concentrations were less than the SQS.

Table 5-9. Number of samples with concentrations within each SQS or CSL category for detected concentrations and reporting limits for PCBs

Analyte	Samples with Detected Concentration			Samples with Reporting Limit when Undetected		
	≤SQS	>SQS ≤CSL	>CSL	≤SQS	>SQS ≤CSL	>CSL
Total PCBs	51	15	1	17[a]		

[a] The RL for total PCBs was assigned a concentration equal to the highest RL of the seven individual Aroclors for a given sample

5.1.5 Organochlorine pesticides

Table 5-10 presents a summary of results for surface sediment samples collected from 26 locations in the LDW that were analyzed for organochlorine pesticides. Data tables containing results for each sample, including field duplicates, for pesticides are presented in Appendix A. Table 5-10 also presents comparisons with the SQS/SL and CSL/ML. Table B-1 in Appendix B presents the same information as Table 5-10, but also includes results from Round 1.

Alpha-chlordane and gamma-chlordane were the only pesticides detected in surface sediment samples. Alpha- and gamma-chlordane were detected in only one sample (LDW-SS85-010) at concentrations of 36 and 59 µg/kg dw, respectively.

Table 5-10. Summary of organochlorine pesticide results in Round 2 LDW surface sediment samples

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[A]		SQS/ SL	CSL/ ML
			Minimum	Maximum	Mean[B]	Minimum	Maximum		
2,4'-DDD	µg/kg dw	0/26	nd	nd	nd	1.9	20	nv	nv
2,4'-DDE	µg/kg dw	0/26	nd	nd	nd	1.9	20	nv	nv
2,4'-DDT	µg/kg dw	0/26	nd	nd	nd	1.9	20	nv	nv
4,4'-DDD	µg/kg dw	0/26	nd	nd	nd	1.9	20	nv	nv
4,4'-DDE	µg/kg dw	0/26	nd	nd	nd	1.9	20	nv	nv
4,4'-DDT	µg/kg dw	0/26	nd	nd	nd	1.9	25	nv	nv
Total DDTs (calc'd)	µg/kg dw	0/26	nd	nd	nd	nc	nc	6.9	69
Aldrin	µg/kg dw	0/26	nd	nd	nd	0.96	9.8	10	nv
Dieldrin	µg/kg dw	0/26	nd	nd	nd	1.9	20	10	nv
alpha-BHC	µg/kg dw	0/26	nd	nd	nd	0.96	9.8	nv	nv
beta-BHC	µg/kg dw	0/26	nd	nd	nd	0.96	9.8	nv	nv
delta-BHC	µg/kg dw	0/26	nd	nd	nd	0.96	9.8	nv	nv
gamma-BHC (Lindane)	µg/kg dw	0/26	nd	nd	nd	0.96	9.8	10	nv
alpha-Chlordane	µg/kg dw	1/26	36	36	36	0.96	1.7	10	nv
gamma-Chlordane	µg/kg dw	1/26	59	59	59	0.96	11	nv	nv
Total chlordane (calc'd)	µg/kg dw	1/26	95	95	95	nc	nc	10	nv
alpha-Endosulfan	µg/kg dw	0/26	nd	nd	nd	0.96	9.8	nv	nv
beta-Endosulfan	µg/kg dw	0/26	nd	nd	nd	1.9	20	nv	nv
Endosulfan sulfate	µg/kg dw	0/26	nd	nd	nd	1.9	20	nv	nv
Endrin	µg/kg dw	0/26	nd	nd	nd	1.9	20	nv	nv
Endrin aldehyde	µg/kg dw	0/26	nd	nd	nd	1.9	20	nv	nv
Endrin ketone	µg/kg dw	0/26	nd	nd	nd	1.9	20	nv	nv
Heptachlor	µg/kg dw	0/26	nd	nd	nd	0.96	9.8	10	nv
Heptachlor epoxide	µg/kg dw	0/26	nd	nd	nd	0.96	9.8	nv	nv
Methoxychlor	µg/kg dw	0/26	nd	nd	nd	9.6	98	nv	nv
Mirex	µg/kg dw	0/26	nd	nd	nd	1.9	20	nv	nv
cis-Nonachlor	µg/kg dw	0/26	nd	nd	nd	1.9	20	nv	nv

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[A]		SQS/ SL	CSL/ ML
			Minimum	Maximum	Mean[B]	Minimum	Maximum		
Oxychlordane	µg/kg dw	0/26	nd	nd	nd	1.9	20	nv	nv
Toxaphene	µg/kg dw	0/26	nd	nd	nd	96	980	nv	nv
Trans-Nonachlor	µg/kg dw	0/26	nd	nd	nd	1.9	20	nv	nv

[a] RL range for non-detect samples

[b] Reported mean concentrations are the average of the detected concentrations only; RLs were not included in calculation of the mean concentration

nc – not calculated

nd – not detected

nv – no value available

Table 5-11 presents the number of samples with detected concentrations or RLs (for non-detected results) greater than the SL or ML. Table B-3 in Appendix B presents a table with the same information as Table 5-11, but also includes results from Round 1. Table A-1 in Appendix A presents the results for each sample, including field duplicate samples, and indicates whether any concentrations exceeded the SL or ML. The detected concentrations of alpha-chlordane and gamma-chlordane exceeded the SL in one sediment sample (LDW-SS85-010). This sample was tested for toxicity. Total DDT and dieldrin were not detected in any of these 26 sediment samples, but the total DDT RLs for 12 of these samples exceeded the SL, and the dieldrin RL for 2 of these samples exceeded the SL. The RL for total chlordane exceeded the SL in two sediment samples. These samples with elevated RLs were not tested for toxicity because exceedance of these guidelines will be assessed in the baseline ERA.

Table 5-11. Number of samples with concentrations within each SQS or CSL category for detected concentrations and reporting limits for organochlorine pesticides

Analyte	Samples with Detected Concentration			Samples with Reporting Limit when Undetected		
	≤SL	>SL ≤ML	>ML	≤SL	>SL ≤ML	>ML
Total DDTs (calc'd)				14[a]	12[a]	
Aldrin				26		
Total chlordane (calc'd)		1		23[b]	2[b]	
Dieldrin				24	2	
gamma-BHC (Lindane)				26		
Heptachlor				26		

[a] The RL for total DDTs was assigned a concentration equal to the highest RL of the six DDT isomers for a given sample

[b] The RL for total chlordane was assigned a concentration equal to the highest RL of the chlordane components for a given sample

5.1.6 PCB congeners

Table 5-12 presents a summary of results for the surface sediment samples collected during both Round 1 and Round 2 from 33 locations in the LDW that were analyzed for PCB congeners. Data tables containing results for each sample, including field duplicates, for PCB congeners are presented in Appendix A. Sediment samples were analyzed for 12 co-planar congeners (PCB-077, PCB-081, PCB-105, PCB-114, PCB-118, PCB-123, PCB-126, PCB-156, PCB-157, PCB-167, PCB-169, PCB-189) as well as six principal congeners (PCB-066, PCB-101, PCB-110, PCB-138, PCB-153, PCB-180) in accordance with the QAPP (Windward 2005d). The results for congeners PCB-090 and PCB-129 are also presented in Table 5-12 because these congeners coelute with the principal congeners PCB-101 and PCB-138, respectively.

Table 5-12. Summary of PCB congener results in LDW surface sediment samples

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[A]	
			Minimum	Maximum	Mean[B]	Minimum	Maximum
Coplanar Congeners							
PCB-077	ng/kg dw	33/33	22.0	80,500	5,880	na	na
PCB-081	ng/kg dw	33/33	0.700 J	6,970	377	na	na
PCB-105	ng/kg dw	33/33	164	3,660,000	140,000	na	na
PCB-114	ng/kg dw	33/33	6.52	207,000	7,890	na	na
PCB-118	ng/kg dw	33/33	428	12,000,000	440,000	na	na
PCB-123	ng/kg dw	33/33	9.34	138,000	5,360	na	na
PCB-126	ng/kg dw	33/33	2.17	7,980	375	na	na
PCB-156	ng/kg dw	33/33	64.2 C	1,790,000 C	65,500	na	na
PCB-157	ng/kg dw	33/33	C156	C156	C156	na	na
PCB-167	ng/kg dw	33/33	23.9	515,000	19,100	na	na
PCB-169	ng/kg dw	0/33	nd	nd	nd	0.671	1,700
PCB-189	ng/kg dw	33/33	7.08	65,700	2,820	na	na
Principal Congeners							
PCB-066	ng/kg dw	33/33	167	3,060,000	134,000	na	na
PCB-090	ng/kg dw	33/33	562 C	11,700,000 C	443,000	na	na
PCB-101	ng/kg dw	33/33	C90	C90	C90	na	na
PCB-110	ng/kg dw	33/33	653 C	14,500,000 C	534,000	na	na
PCB-129	ng/kg dw	33/33	728 C	14,000,000 C	521,000	na	na
PCB-138	ng/kg dw	33/33	C129	C129	C129	na	na
PCB-153	ng/kg dw	33/33	555 C	9,090,000 C	353,000	na	na
PCB-180	ng/kg dw	33/33	407 C	1,600,000 CJ	95,700	na	na

[a] RL range for non-detect samples only

[b] Reported mean concentrations are the average of the detected concentrations only; RLs were not included in calculation of the mean concentration.

na – not applicable

nd – not detected

C90 – PCB-090 and PCB-101 coelute; the combined concentration is presented as the concentration of PCB-090

C129 – PCB-129 and PCB-138 coelute; the combined concentration is presented as the concentration of PCB-129

C156 – PCB-156 and PCB-157 co-elute; the combined concentration is presented as the concentration of PCB-156

Data qualifiers: J - estimated concentration C - concentration represents coelution; CJ - estimated coeluted concentration

There are cases in which two or more congeners cannot be separated analytically. In these cases, the congeners are said to be coeluting and the concentration of the combined congeners is reported as one value. The laboratory responsible for the PCB congener analyses (Axys) has the convention of assigning the concentration of the coelution to the coeluting congener with the lowest International Union of Pure and Applied Chemistry (IUPAC) number. For example, PCB-156 and PCB-157 coelute, so the concentration is reported as PCB-156. Thus, Table 5-12 reports the result for PCB-157 as C156 to indicate that it is a component of a coelution. The PCB congener pairs 90/101 and 129/138 also coeluted, and thus PCB-101 and PCB-138 concentrations are reported as C90 and C129, respectively, in Table 5--12.

All of the coplanar and principal PCB congeners (except PCB-169, which was not detected in any of the samples) were detected in all 33 surface sediment samples in which they were analyzed (Table 5-12). The highest concentrations of coplanar and principal PCB congeners were detected in sediment sample LDW-SS109-010.

Toxic equivalents (TEQs) were calculated to represent equivalent concentrations in terms of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) using mammalian toxic equivalency factors (TEFs) for PCB congeners from Van den Berg et al. (1998). For each sample, TEQs were calculated using either zero, half the RL, or the full RL as the selected value for undetected congeners. Results for each sample are presented in Table 5-13, and are shown by location in Figures 5-5a and 5-5b (located in map folio). The differences among the three TEQ values calculated for each sample were small because the only coplanar congener that was reported as undetected in the sediment samples was PCB-169. The coelution between PCB-156 and PCB-157 does not affect the TEQ calculation because both congeners have a TEF of 0.0005.

Table 5-13. Calculated PCB TEQs for LDW surface sediment samples analyzed for PCB congeners

Sample ID	Mammalian PCB TEQ - Zero RL (ng/kg dw)	Mammalian PCB TEQ - Half RL (ng/kg dw)	Mammalian PCB TEQ - Full RL (ng/kg dw)
LDW-SS6-010	45.5	45.9	46.4
LDW-SS14-010	1.20	1.21	1.22
LDW-SS17-010	12.0 J	12.2 J	12.4 J
LDW-SS19-010	7.26 J	7.36 J	7.47 J
LDW-SS24-010	8.96 J	9.04 J	9.12 J
LDW-SS25-010	0.325 J	0.330 J	0.335 J
LDW-SS28-010	6.41 J	6.49 J	6.58 J
LDW-SS37-010	102	103	103

Sample ID	Mammalian PCB TEQ - Zero RL (ng/kg dw)	Mammalian PCB TEQ - Half RL (ng/kg dw)	Mammalian PCB TEQ - Full RL (ng/kg dw)
LDW-SS46-010	14.9 J	15.0 J	15.0 J
LDW-SS56-010	19.5 J	19.6 J	19.8 J
LDW-SS64-010	4.43 J	4.49 J	4.56 J
LDW-SS67-010	0.550 J	0.557 J	0.563 J
LDW-SS71-010	9.61	9.75	9.89
LDW-SS72-010	5.00 J	5.08 J	5.16 J
LDW-SS74-010	4.56 J	4.64 J	4.72 J
LDW-SS83-010	6.17 J	6.27 J	6.37 J
LDW-SS84-010	320	326	332
LDW-SS86-010	0.693 J	0.698 J	0.703 J
LDW-SS92-010	9.76 J	9.83 J	9.91 J
LDW-SS101-010	0.339 J	0.345 J	0.352 J
LDW-SS106-010	6.80 J	6.83 J	6.86 J
LDW-SS108-010	3.12	3.19	3.26
LDW-SS109-010	3,400	3,410	3,410
LDW-SS110-010	337 J	338 J	339 J
LDW-SS120-010	23.4 J	23.5 J	23.6 J
LDW-SS130-010	2.34	2.36	2.37
LDW-SS136-010	0.745	0.754	0.763
LDW-SS141-010	0.481 J	0.484 J	0.488 J
LDW-SS142-010	5.30	5.33	5.36
LDW-SS143-010	44.8 J	44.9 J	45.0 J
LDW-SS149-010	2.45	2.46	2.47
LDW-SSB2b-010	15.6 J	15.8 J	15.9 J
LDW-SSB9a-010	1.31	1.32	1.32

RL – reporting limit

J – estimated concentration

The highest PCB TEQ (3,410 ng/kg dw) was calculated for location LDW-SS109. The next four highest PCB TEQ values were calculated for locations LDW-SS84, LDW-SS37, LDW-SS6, and LDW-SS143 (320, 102, 45.4, and 44.8 ng/kg dw, respectively).

5.1.7 Dioxins and furans

Table 5-14 presents a summary of results for the surface sediment samples collected during both Round 1 and Round 2 from 21 locations in the LDW that were analyzed for dioxins and furans. Data tables containing dioxin and furan results for each sample, including field duplicates and the replicate sample at LDW-SS59, are presented in Appendix A.

Table 5-14. Summary of dioxin and furan results in LDW surface sediment samples

Dioxin/Furan	Unit	Detection Frequency	Detected Concentration			Reporting Limit[A]	
			Minimum	Maximum	Mean[B]	Minimum	Maximum
Dioxins							
2,3,7,8-TCDD	ng/kg dw	20/21	0.0660 J	30.6	3.17	0.560	0.560
1,2,3,7,8-PeCDD	ng/kg dw	21/21	0.100 J	57.1	8.35	na	na
1,2,3,4,7,8-HxCDD	ng/kg dw	21/21	0.193 J	124	15.6	na	na
1,2,3,6,7,8-HxCDD	ng/kg dw	21/21	0.978 J	3,400	240	na	na
1,2,3,7,8,9-HxCDD	ng/kg dw	21/21	0.537 J	315	49.4	na	na
1,2,3,4,6,7,8-HpCDD	ng/kg dw	21/21	25.5	73,700	5,700	na	na
OCDD	ng/kg dw	21/21	203	241,000	35,000	na	na
Furans							
2,3,7,8-TCDF	ng/kg dw	21/21	0.113 J	397	28.7	na	na
1,2,3,7,8-PeCDF	ng/kg dw	21/21	0.0950 J	69.3	10.5	na	na
2,3,4,7,8-PeCDF	ng/kg dw	21/21	0.212 J	230	37	na	na
1,2,3,4,7,8-HxCDF	ng/kg dw	21/21	0.513 J	2,530	285	na	na
1,2,3,6,7,8-HxCDF	ng/kg dw	21/21	0.174 J	365	50.0	na	na
1,2,3,7,8,9-HxCDF	ng/kg dw	19/21	0.0730 J	33.8 J	4.32	0.0590	1.20
2,3,4,6,7,8-HxCDF	ng/kg dw	21/21	0.155 J	302 J	29.7	na	na
1,2,3,4,6,7,8-HpCDF	ng/kg dw	21/21	5.18	40,300	2,500	na	na
1,2,3,4,7,8,9-HpCDF	ng/kg dw	21/21	0.385 J	3,720	254	na	na
OCDF	ng/kg dw	21/21	12.5	93,700	6,440	na	na

[a] RL range for non-detect samples only

[b] Reported mean concentrations are the average of the detected concentrations only; RLs were not included in calculation of the mean concentration.

na – not applicable

Data qualifiers: J - estimated concentration

All of the dioxin congeners were detected in all of the surface sediment samples, except for 2,3,7,8-TCDD, which was not detected in the sample from LDW-SS71. Of the dioxin congeners, 2,3,7,8-TCDD and 1,2,3,7,8-PeCDD concentrations were highest in the sample from LDW-SS84; all of the remaining dioxin congener concentrations were highest in the sample from LDW-SS56.

All of the furan congeners were detected in all of the surface sediment samples, except for 1,2,3,7,8,9-HxCDF, which was not detected in samples from LDW-SS18 and LDW-SS20. Concentrations of 2,3,7,8-TCDF were highest in the sample from LDW-SS37; all of the remaining furan congener concentrations were highest in the sample from LDW-SS56.

TEQs were calculated for each of the sediment samples using the mammalian TEFs for dioxins and furans from Van den Berg et al. (1998). For each sample, TEQs were calculated using either zero, half the RL, or the full RL as the selected value for

undetected congeners. Results are presented in Table 5-15. Results for total PCBs and mammalian PCB TEQS are also shown by location in Table 5-15 for comparative purposes. Figures 5-6a through 5-6c (located in the map folio) present the TEQ values calculated from dioxin/furan concentrations by location. The highest TEQ (2,080 ng/kg dw) was in the sample collected from LDW-SS56. Only four samples had undetected dioxin/furan congeners; differences among the three TEQ values calculated for each sample were small because only one dioxin/furan congener was undetected in these samples.

Table 5-15. Total PCBs and calculated TEQs for dioxins/furans and PCBs in LDW surface sediment samples

Sample ID	Mammalian Dioxin/Furan TEQ (ng/kg dw)			Mammalian PCB TEQ (ng/kg dw)			Total PCBs (µg/kg dw)
	Zero RL	Half RL	Full RL	Zero RL	Half RL	Full RL	
LDW-SS14-010	1.61 J	1.61 J	1.61 J	1.20	1.21	1.22	50 J
LDW-SS18-010	0.875 J	0.878 J	0.881 J	na	na	na	nr
LDW-SS20-010	25.0 J	25.1 J	25.2 J	na	na	na	nr
LDW-SS22-010	21.1 J	21.1 J	21.1 J	na	na	na	250 J
LDW-SS28-010	12.0 J	12.0 J	12.0 J	6.41 J	6.49 J	6.58 J	112
LDW-SS36-010	26.0 J	26.0 J	26.0 J	na	na	na	24
LDW-SS37-010	133 J	133 J	133 J	102	103	103	5,100
LDW-SS43-010	17.3 J	17.3 J	17.3 J	na	na	na	18 J
LDW-SS56-010	2,080 J	2,080 J	2,080 J	19.5 J	19.6 J	19.8 J	750 J
LDW-SS57-010	444 J	444 J	444 J	na	na	na	750
LDW-SS58-010	576 J	576 J	576 J	na	na	na	260
LDW-SS59R1-010[a]	30.6 J	30.6 J	30.6 J	na	na	na	na
LDW-SS59R2-010[b]	46.1 J	46.6 J	47.1 J	na	na	na	53
LDW-SS64-010	9.95 J	9.95 J	9.95 J	4.43 J	4.49 J	4.56 J	127
LDW-SS71-010	13.7 J	14.0 J	14.2 J	9.61	9.75	9.89	460
LDW-SS83-010	32.0 J	32.0 J	32.0 J	6.17 J	6.27 J	6.37 J	97 J
LDW-SS84-010	401 J	401 J	401 J	320	326	332	23,000
LDW-SS109-010	119	119	119	3,400	3,410	3,410	110,000
LDW-SS123-010	4.99 J	4.99 J	4.99 J	na	na	na	134
LDW-SS203-010[c]	5.30 J	5.30 J	5.30 J	na	na	na	162
LDW-SS127-010	13.1 J	13.1 J	13.1 J	na	na	na	58
LDW-SS131-010	8.23 J	8.23 J	8.23 J	na	na	na	21 J
LDW-SS206-010[d]	22.7 J	22.7 J	22.7 J	na	na	na	23
LDW-SS143-010	5.11 J	5.11 J	5.11 J	44.8 J	44.9 J	45.0 J	2,700

[a] Collected during Round 1 (see Section 2.2.3)
[b] Collected during Round 2 (see Section 2.2.3)
[c] Field duplicate sample collected at location LDW-SS123
[d] Field duplicate sample collected at location LDW-SS131

J – estimated concentration
na – not analyzed
nr – not reported - data to be provided separately
RL – reporting limit

5.1.8 Grain size, TOC, and total solids

Table 5-16 presents a summary of grain size, TOC, and total solids results for surface sediment samples collected from 84 locations in the LDW. Table B-1 in Appendix B presents a table with the same information as Table 5-16, but also includes results from Round 1. Data tables containing results for each sample, including field duplicates, are presented in Appendix A.

Percent fines in surface sediment samples ranged from 0.1 to 88.7%, with a mean of 40%. TOC ranged from 0.189 to 5.99%. Four samples (LDW-SS86-010, LDW-SS145-010, LDW-SS152-010, and LDW-SS156-010) had TOC contents of less than 0.5%. The maximum concentration of sulfides was 7,700 mg/kg dw, detected at location LDW-SS78. The maximum ammonia concentration (28.7 mg-N/kg dw) was detected at location LDW-SS133.

Table 5-16. Summary of grain size, TOC, and total solids results in Round 2 LDW surface sediment samples

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[A]	
			Minimum	Maximum	Mean[B]	Minimum	Maximum
Sediment grain size							
Total rocks (calc'd)	% dw	72/84	0.1	54.1	6	0.1	0.1
Total sand (calc'd)	% dw	84/84	11.3	99.7	50	na	na
Total silt (calc'd)	% dw	83/84	0.1	68.9	30	0.1	0.1
Total clay (calc'd)	% dw	80/84	0.7	28.9	10	0.1	0.1
Fines (percent silt+clay)	% dw	83/84	0.1	88.7	40	0.1	0.1
Conventional parameters							
Total organic carbon (TOC)	% dw	84/84	0.189	5.99	1.99	na	na
Total solids	% ww	84/84	38.30	90.83	58.93	na	na
Total sulfides	mg/kg dw	46/84	5.1 J	7,700	400	2.4	46
Total ammonia (as nitrogen)	mg-N/kg dw	80/84	0.18	28.7	7.9	0.10	0.12

[a] RL range for non-detect samples

[b] Reported mean concentrations are the average of the detected concentrations only; RLs were not included in calculation of the mean concentration

na – not applicable

5.1.9 Comparison of non-detect results to analytical concentration goals

Appendix C of the surface sediment QAPP (Windward 2005d) documented the derivation of analytical concentration goals (ACGs) for benthic invertebrates (based on SQS, or SL, where no SQS was available), sandpiper (based on consumption of benthic invertebrates and sediment), and human health (based on both direct exposure [e.g., dermal contact] and indirect exposure [e.g., seafood consumption]). The QAPP also included a comparison of ACGs to method detection limits (MDLs) and RLs. The

laboratory reported non-detect results to the RL. The sample-specific RL is based on the lowest point of the calibration curve associated with each analytical batch of samples, whereas the MDL is statistically derived following EPA methods. Both the RL and MDL will be elevated in cases where the sample extract is diluted. Detected concentrations between the MDL and RL were reported by the laboratory and flagged with a J qualifier to indicate that the reported concentration was an estimate because it falls below the lowest point on the calibration curve.

In this section, ACGs for human health-indirect exposure, human health-direct exposure, and benthic invertebrates are compared to both RLs and MDLs for non-detect results. For the sandpiper-based ACGs, there was only a single chemical, selenium, that had one or more RLs (range of RLs from 6 to 30 mg/kg dw) above the ACG (14.9 mg/kg dw). All selenium MDLs were less than the ACG, ranging from 1.4 to 7.6 mg/kg dw.

Twenty-nine chemicals had at least one sample-specific RL above the applicable ACG for human health-indirect exposure (Table 5-17). Fourteen of these chemicals were never detected. One or more MDLs for 20 of these 29 chemicals also exceeded ACGs. The minimum MDL reported in Table 5-17 was generally lower than the target MDL specified in the QAPP (also listed in Table 5-17); many of the MDLs that were above the ACGs were for chemicals previously identified in the QAPP as those that would likely represent analytical challenges. Five chemicals had RLs above the ACG that were not anticipated in the QAPP; however, all of these ACGs were met by the associated MDLs with the exception of two individual dioxin/furan congeners and one PCB congener.

The chemicals for which there were unanticipated ACG exceedances had RL and MDL ranges that spanned a factor of 5 to 10 as a result of necessary analytical dilutions or the adjustment of extracted sample volume for some samples based on pre-screen results. When sample extracts were diluted because the concentrations for one or more target analytes exceeded the upper end of the calibration curve, RLs from the original undiluted extract were reported for compounds other than the target analytes that required dilution. The analytical laboratory performed the appropriate sample cleanups to achieve the lowest possible RLs.

Table 5-17. Detected and non-detected results, RLs, and MDLs for sediment samples compared to human health ACGs associated with indirect exposure

Chemical	Unit	Number of Detected Results	Range of Detected Results	Number of Non-Detected Results	Range of Non-Detected RLs	Number of RLs > ACG	Range of MDLs for NonDetects	Number of MDLs > ACG	Target MDL	Human Health ACG
Metals										
Arsenic	mg/kg dw	84	2.7 – 161	0	na	0	na	0	0.02	0.006
Cadmium	mg/kg dw	39	0.3 – 3.8	45	0.2 – 1	45	0.046 – 0.24	45	0.02	0.003
Chromium	mg/kg dw	84	9.9 – 174	0	na	0	na	0	0.09	100
Copper	mg/kg dw	84	10.3 – 1,340	0	na	0	na	0	0.04	1.3
Mercury	mg/kg dw	56	0.06 – 1.09	28	0.04 – 0.1	28	0.0024 – 0.0076	0	0.003	0.016
Zinc	mg/kg dw	84	30.8 – 878	0	na	0	na	0	0.29	16
Organometals										
Tributyltin as ion	µg/kg dw	17	5.4 – 3,000	2	3.7 – 3.8	2	2.1 – 2.2	2	2.84	0.28
PAHs										
2-Methylnaphthalene	µg/kg dw	8	25 – 3,300	76	19 – 99	0	11 – 57	0	7.21	1,700
Acenaphthene	µg/kg dw	20	16 – 5,200	64	19 – 99	0	6.7 – 35	0	9.36	540,000
Anthracene	µg/kg dw	57	18 – 10,000	27	19 – 98	0	6.3 – 32	0	8.69	900,000
Benzo(a)anthracene	µg/kg dw	75	7.3 – 4,000	9	6.4 – 6.6	9	0.93 – 0.96	0	8.34	5.2
Benzo(a)pyrene	µg/kg dw	76	7.1 – 2,100	8	6.4 – 6.6	8	1.0 – 1.1	8	7.31	0.76
Benzo(b)fluoranthene	µg/kg dw	77	6.6 – 2,700	7	6.4 – 6.6	7	2.1 – 2.2	0	7.34	4.7
Benzo(k)fluoranthene	µg/kg dw	74	16 – 2,700	10	19 – 20	0	3.9 – 4.0	0	10.4	47
Chrysene	µg/kg dw	74	21 – 5,700	10	19 – 20	0	5.3 – 5.5	0	8.09	480
Dibenzofuran	µg/kg dw	16	10 – 4,000	68	19 – 99	0	12 – 61	0	7.95	560
Fluoranthene	µg/kg dw	77	20 – 17,000	7	19 – 20	0	4.5 – 4.7	0	8.49	2,100
Indeno(1,2,3-cd)pyrene	µg/kg dw	75	6.5 – 1,200	9	6.4 – 6.6	9	1.0 – 1.1	0	8.54	2.9
Naphthalene	µg/kg dw	14	13 – 5,300	70	19 – 99	0	5.4 – 28	0	7.53	4,500
Pyrene	µg/kg dw	76	21 – 12,000	8	19 – 20	0	8.1 – 8.4	0	8.72	8,900
Phthalates										
Bis(2-ethylhexyl)phthalate	µg/kg dw	51	25 – 1,600	33	19 – 840	14	5 – 21	0	10.8	120

Chemical	Unit	Number of Detected Results	Range of Detected Results	Number of Non-Detected Results	Range of Non-Detected RLs	Number of RLs > ACG	Range of MDLs for NonDetects	Number of MDLs > ACG	Target MDL	Human Health ACG
Butyl benzyl phthalate	µg/kg dw	26	10 – 200	58	6.3 – 54	0	3.8 – 32	0	10.3	30,000
Dimethyl phthalate	µg/kg dw	12	6.6 – 83	72	6.3 – 54	0	1.6 – 14	0	12	1,400,000
Di-n-butyl phthalate	µg/kg dw	6	21 – 91	78	19 – 120	0	6.3 – 33	0	13.5	14,000
Di-n-octyl phthalate	µg/kg dw	1	53 – 53	83	19 – 99	0	3.7 – 19	0	11.3	3,000
Other SVOCs										
1,2-Dichlorobenzene	µg/kg dw	1	7.3 – 7.3	83	6.3 – 54	0	1.3 – 11	0	8.76	12,000
1,4-Dichlorobenzene	µg/kg dw	1	9.1 – 9.1	83	6.3 – 54	0	2.1 – 18	0	8.16	73
2,4,5-Trichlorophenol	µg/kg dw	0	na	84	96 – 500	0	3.4 – 17	0	8.34	37,000
2,4-Dichlorophenol	µg/kg dw	0	na	84	96 – 500	0	5.7 – 30	0	7.73	1,100
2-Chlorophenol	µg/kg dw	0	na	84	19 – 99	0	5.7 – 29	0	9.48	1,800
4-Methylphenol	µg/kg dw	3	20 – 54	81	19 – 99	0	4.7 – 24	0	13.5	1,800
Hexachlorobutadiene	µg/kg dw	0	na	84	0.96 – 54	2	0.351 – 23	0	8.28	23
Hexachloroethane	µg/kg dw	0	na	84	19 – 99	0	6.5 – 34	0	7.98	120
Phenol	µg/kg dw	14	21 – 280	70	19 – 99	0	6.4 – 33	0	9.47	210,000
PCB Congeners										
PCB-077	ng/kg dw	33	22.0 – 80,500	0	na	0	na	0	0.39	3,500
PCB-081	ng/kg dw	33	0.700 – 6,970	0	na	0	na	0	0.39	3,500
PCB-105	ng/kg dw	33	164 – 3,660,000	0	na	0	na	0	0.44	3,500
PCB-114	ng/kg dw	33	6.52 – 207,000	0	na	0	na	0	0.46	700
PCB-118	ng/kg dw	33	428 – 12,000,000	0	na	0	na	0	0.37	3,500
PCB-123	ng/kg dw	33	9.34 – 138,000	0	na	0	na	0	0.95	3,500
PCB-126	ng/kg dw	33	2.17 – 7,980	0	na	0	na	0	0.21	3.5
PCB-156	ng/kg dw	33	64.2 – 1,790,000	0	na	0	na	0	0.66	700
PCB-157	ng/kg dw	33	[a]	0	na	0	na	0	[a]	[a]
PCB-167	ng/kg dw	33	23.9 – 515,000	0	na	0	na	0	0.35	35,000
PCB-169	ng/kg dw	0	na	33	0.671 – 1,700	5	1.85 – 929	6	0.44	35
PCB-189	ng/kg dw	33	7.08 – 65,700	0	na	0	na	0	0.34	3,500
PCBs as Aroclors										

Chemical	Unit	Number of Detected Results	Range of Detected Results	Number of Non-Detected Results	Range of Non-Detected RLs	Number of RLs > ACG	Range of MDLs for NonDetects	Number of MDLs > ACG	Target MDL	Human Health ACG
Aroclor-1016	µg/kg dw	0	na	84	19 – 110	84	3.0 – 17	4	0.98	6.1
Aroclor-1221	µg/kg dw	0	na	84	19 – 110	84	3.0 – 17	84	0.98	0.21
Aroclor-1232	µg/kg dw	0	na	84	19 – 110	84	3.0 – 17	84	0.98	0.21
Aroclor-1242	µg/kg dw	16	20 – 400	68	19 – 110	68	3.0 – 17	68	0.98	0.21
Aroclor-1248	µg/kg dw	15	23 – 740	69	19 – 130	69	3.0 – 17	69	0.98	0.21
Aroclor-1254	µg/kg dw	63	17 – 910	21	19 – 61	21	3.0 – 4.8	21	0.98	0.21
Aroclor-1260	µg/kg dw	60	17 – 320	24	19 – 110	24	3.0 – 17	24	0.98	0.21
Total PCB Aroclors	µg/kg dw	67	17 – 1,920	17	19 – 20	17	3.0 – 17	17	0.98	0.21
Pesticides										
4,4'-DDD	µg/kg dw	0	na	26	1.9 – 20	1	0.306 – 3.15	0	0.32	8.3
4,4'-DDE	µg/kg dw	0	na	26	1.9 – 20	9	0.159 – 1.63	0	0.166	2.6
4,4'-DDT	µg/kg dw	0	na	26	1.9 – 25	26	0.269 – 2.77	2	0.284	0.92
Total DDT	µg/kg dw	0	na	26	1.9-25	26	0.306 – 3.15	2	0.32	0.92
Aldrin	µg/kg dw	0	na	26	0.96 – 9.8	26	0.052 – 0.531	3	0.054	0.063
Dieldrin	µg/kg dw	0	na	26	1.9 – 20	26	0.047 – 0.482	26	0.049	0.033
beta-BHC	µg/kg dw	0	na	26	0.96 – 9.8	26	0.043 – 0.444	0	0.045	0.63
gamma-BHC	µg/kg dw	0	na	26	0.96 – 9.8	26	0.135 – 1.39	1	0.141	0.83
Total chlordane	µg/kg dw	1	95 – 95	25	1.9 – 5.6	25	0.921 – 1.64	0	0.964	1.7
Endrin	µg/kg dw	0	na	26	1.9 – 20	0	0.048 – 0.492	0	0.24	27
Heptachlor	µg/kg dw	0	na	26	0.96 – 9.8	26	0.026 – 0.355	2	0.027	0.25
Methoxychlor	µg/kg dw	0	na	26	9.6 – 98	0	0.388 – 5.46	0	0.402	440
Dioxins and Furans										
2,3,7,8-TCDD	ng/kg dw	20	0.0660 – 30.6	1	0.560 – 0.560	1	0.976 – 0.976	1	0.059	0.35
1,2,3,7,8-PeCDD	ng/kg dw	21	0.100 – 57.1	0	na	0	na	0	0.153	0.35
1,2,3,4,7,8-HxCDD	ng/kg dw	21	0.193 – 124	0	na	0	na	0	0.172	0.7
1,2,3,6,7,8-HxCDD	ng/kg dw	21	0.978 – 3,400	0	na	0	na	0	0.118	3.5
1,2,3,7,8,9-HxCDD	ng/kg dw	21	0.537 – 315	0	na	0	na	0	0.172	3.5
1,2,3,4,6,7,8-HpCDD	ng/kg dw	21	25.5 – 73,700	0	na	0	na	0	0.169	3.5

Chemical	Unit	Number of Detected Results	Range of Detected Results	Number of Non-Detected Results	Range of Non-Detected RLs	Number of RLs > ACG	Range of MDLs for NonDetects	Number of MDLs > ACG	Target MDL	Human Health ACG
OCDD	ng/kg dw	21	203 – 241,000	0	na	0	na	0	0.518	3.5
2,3,7,8-TCDF	ng/kg dw	21	0.113 – 397	0	na	0	na	0	0.077	3.5
1,2,3,7,8-PeCDF	ng/kg dw	21	0.095 – 69.3	0	na	0	na	0	0.132	3.5
2,3,4,7,8-PeCDF	ng/kg dw	21	0.212 – 230	0	na	0	na	0	0.143	3.5
1,2,3,4,7,8-HxCDF	ng/kg dw	21	0.513 – 2,530	0	na	0	na	0	0.148	3.5
1,2,3,6,7,8-HxCDF	ng/kg dw	21	0.174 – 365	0	na	0	na	0	0.154	7
1,2,3,7,8,9-HxCDF	ng/kg dw	19	0.073 – 33.8	2	0.0590 – 1.20	0	4.77 – 36.8	1	0.148	35
2,3,4,6,7,8-HxCDF	ng/kg dw	21	0.155 – 302	0	na	0	na	0	0.09	35
1,2,3,4,6,7,8-HpCDF	ng/kg dw	21	5.18 – 40,300	0	na	0	na	0	0.183	35
1,2,3,4,7,8,9-HpCDF	ng/kg dw	21	0.385 – 3,720	0	na	0	na	0	0.081	3,500
OCDF	ng/kg dw	21	12.5 – 93,700	0	na	0	na	0	0.381	3,500

[a] PCB-157 coelutes with PCB-156; the combined concentrations are presented for PCB-156

na – not applicable

The purpose of developing ACGs for analyses of sediment samples on the basis of human seafood consumption (i.e., through the use of assumptions of chemical transfer from sediment to seafood tissue) was to provide an additional method to evaluate the possibility that these chemicals could accumulate in tissue at concentrations of concern. The fish, crab, and clam tissue data collected for this project provide the most relevant data for this evaluation (Windward 2005b). Other than two SVOCs (hexachlorobutadiene and N-nitrosodimethylamine) and toxaphene, all the chemicals listed in Table 5-17 with at least one RL above applicable ACGs were either detected in fish, crab, and clam tissue samples or the chemical contributes to a group sum (i.e., total PCBs as Aroclors) that was detected in fish, crab, and clam tissue samples. Only two of the hexachlorobutadiene RLs and one of the toxaphene RLs exceeded the ACG, and none of the MDLs for either chemical exceeded the ACG. For N-nitrosodimethylamine, all RLs and most MDLs were above the ACG. This chemical is very difficult to quantify in tissue or sediment. Based on the comparisons presented above, there appears to be a very low likelihood that the non-detect results for the chemicals listed in Table 5-15 would be associated with unacceptable uncertainty that is not already accounted for in the existing fish, crab, and clam tissue data collected in 2004. The uncertainty associated with risk estimates for the chemicals exceeding ACGs will be discussed in the baseline HHRA. For other chemicals, there will be relatively low uncertainty for risk estimates associated with the non-detect results.

Table 5-18 shows that RLs for five chemicals exceeded applicable ACGs developed for the protection of human health through direct exposure. All MDLs were below the ACGs, with the exception of most MDLs for N-nitrosodimethylamine and one MDL for an individual PCB congener. N-nitrosodimethylamine is known to be difficult to quantify in sediment. In the baseline HHRA, risk estimates will be made for dioxin-like PCB congeners by evaluating TEQs, rather than individual congener concentrations. However, because TEQs are calculated rather than quantitated by the laboratory, ACGs for individual congener concentrations are presented to facilitate comparison with RLs for those congeners.

Table 5-18. Detected and non-detected results, RLs, and MDLs for sediment samples compared to human health ACGs associated with direct exposure

Chemical	Unit	Number of Detected Results	Range of Detected Results	Number of Non-Detected Results	Range of Non-Detected RLs	Number of RLs > ACG	Range of MDLs	Number of MDLs > ACG	Target MDL	Human Health ACG
Metals										
Antimony	mg/kg dw	9	0.3 – 3.6	75	0.2 – 0.5	0	0.012 – 0.029	0	0.005	3.1
Arsenic	mg/kg dw	84	2.7 – 161	0	na	0	na	0	0.02	0.39
Cadmium	mg/kg dw	39	0.3 – 3.8	45	0.2 – 1	0	0.046 – 0.24	0	0.02	3.7
Chromium	mg/kg dw	84	9.9 – 174	0	na	0	na	0	0.09	210
Cobalt	mg/kg dw	84	3.5 – 30	0	na	0	na	0	0.03	900
Copper	mg/kg dw	84	10.3 – 1,340	0	na	0	na	0	0.04	310
Lead	mg/kg dw	84	3 – 573	0	na	0	na	0	0.12	40
Mercury	mg/kg dw	56	0.06 – 1.09	28	0.04 – 0.1	0	0.0024 – 0.0076	0	0.003	2.3
Molybdenum	mg/kg dw	82	0.7 – 20	2	0.6 – 0.6	0	0.074 – 0.075	0	0.06	39
Nickel	mg/kg dw	84	6 – 48	0	na	0	na	0	0.38	160
Selenium	mg/kg dw	0	na	84	6 – 30	0	1.4 – 7.6	0	0.3	39
Silver	mg/kg dw	13	0.5 – 3	71	0.3 – 2	0	0.046 – 0.24	0	0.03	39
Thallium	mg/kg dw	2	0.5 – 0.6	82	0.2 – 0.5	0	0.0064 – 0.016	0	0.003	0.52
Vanadium	mg/kg dw	84	36.3 – 87	0	na	0	na	0	0.03	55
Zinc	mg/kg dw	84	30.8 – 878	0	na	0	na	0	0.29	2,300
Organometals										
Tributyltin as ion	µg/kg dw	17	5.4 – 3,000	2	3.7 – 3.8	0	2.1 – 2.2	0	2.84	1,800
PAHs										
2-Chloronaphthalene	µg/kg dw	0	na	84	19 – 99	0	6.9 – 36	0	8.32	490,000
Acenaphthene	µg/kg dw	20	16 – 5,200	64	19 – 99	0	6.7 – 35	0	9.36	370,000
Anthracene	µg/kg dw	57	18 – 10,000	27	19 – 98	0	6.3 – 32	0	8.69	2,200,000
Benzo(a)anthracene	µg/kg dw	75	7.3 – 4,000	9	6.4 – 6.6	0	0.93 – 0.96	0	8.34	620
Benzo(a)pyrene	µg/kg dw	76	7.1 – 2,100	8	6.4 – 6.6	0	1.0 – 1.1	0	7.31	62

Chemical	Unit	Number of Detected Results	Range of Detected Results	Number of Non-Detected Results	Range of Non-Detected RLs	Number of RLs > ACG	Range of MDLs	Number of MDLs > ACG	Target MDL	Human Health ACG
Benzo(b)fluoranthene	µg/kg dw	77	6.6 – 2,700	7	6.4 – 6.6	0	2.1 – 2.2	0	7.34	620
Benzo(k)fluoranthene	µg/kg dw	74	16 – 2,700	10	19 – 20	0	3.9 – 4.0	0	10.4	6,200
Chrysene	µg/kg dw	74	21 – 5,700	10	19 – 20	0	5.3 – 5.5	0	8.09	62,000
Dibenzo(a,h)anthracene	µg/kg dw	19	12 – 350	65	19 – 300	9	3.7 – 58	0	8.35	62
Dibenzofuran	µg/kg dw	16	10 – 4,000	68	19 – 99	0	12 – 61	0	7.95	29,000
Fluoranthene	µg/kg dw	77	20 – 17,000	7	19 – 20	0	4.5 – 4.7	0	8.49	230,000
Fluorene	µg/kg dw	27	22 – 6,800	57	19 – 99	0	6.1 – 32	0	9.17	270,000
Indeno(1,2,3-cd)pyrene	µg/kg dw	75	6.5 – 1,200	9	6.4 – 6.6	0	1.0 – 1.1	0	8.54	620
Naphthalene	µg/kg dw	14	13 – 5,300	70	19 – 99	0	5.4 – 28	0	7.53	5,600
Pyrene	µg/kg dw	76	21 – 12,000	8	19 – 20	0	8.1 – 8.4	0	8.72	230,000
Phthalates										
Bis(2-ethylhexyl)phthalate	µg/kg dw	51	25 – 1,600	33	19 – 840	0	5.0 – 21	0	10.8	35,000
Butyl benzyl phthalate	µg/kg dw	26	10 – 200	58	6.3 – 54	0	3.8 – 32	0	10.3	1,200,000
Diethyl phthalate	µg/kg dw	17	5.7 – 120	67	6.4 – 42	0	4.3 – 28	0	135	4,900,000
Dimethyl phthalate	µg/kg dw	12	6.6 – 83	72	6.3 – 54	0	1.6 – 14	0	12	100,000,000
Di-n-butyl phthalate	µg/kg dw	6	21 – 91	78	19 – 120	0	6.3 – 33	0	13.5	610,000
Di-n-octyl phthalate	µg/kg dw	1	53 – 53	83	19 – 99	0	3.7 – 19	0	11.3	240,000
Other SVOCs										
1,2,4-Trichlorobenzene	µg/kg dw	0	na	84	3.3 – 42	0	0.61 – 13	0	5.88	65,000
1,2-Dichlorobenzene	µg/kg dw	1	7.3 – 7.3	83	6.3 – 54	0	1.3 – 11	0	8.76	370,000
1,3-Dichlorobenzene	µg/kg dw	0	na	84	19 – 99	0	6.8 – 35	0	7.55	1,600
1,4-Dichlorobenzene	µg/kg dw	1	9.1 – 9.1	83	6.3 – 54	0	2.1 – 18	0	8.16	3,400
2,4,5-Trichlorophenol	µg/kg dw	0	na	84	96 – 500	0	3.4 – 17	0	8.34	610,000
2,4,6-Trichlorophenol	µg/kg dw	0	na	84	96 – 500	0	4.0 – 21	0	10	610
2,4-Dichlorophenol	µg/kg dw	0	na	84	96 – 500	0	5.7 – 30	0	7.73	18,000
2,4-Dimethylphenol	µg/kg dw	0	na	84	6.3 – 31	0	3.7 – 31	0	10.52	120,000
2,4-Dinitrophenol	µg/kg dw	0	na	84	190 – 990	0	65 – 340	0	104.2	12,000

Chemical	Unit	Number of Detected Results	Range of Detected Results	Number of Non-Detected Results	Range of Non-Detected RLs	Number of RLs > ACG	Range of MDLs	Number of MDLs > ACG	Target MDL	Human Health ACG
2,4-Dinitrotoluene	µg/kg dw	0	na	84	96 – 500	0	3.7 – 19	0	8.97	12,000
2,6-Dinitrotoluene	µg/kg dw	0	na	84	96 – 500	0	6.4 – 33	0	10.73	6,100
2-Chlorophenol	µg/kg dw	0	na	84	19 – 99	0	5.7 – 29	0	9.48	6,300
2-Methylphenol	µg/kg dw	1	32 – 32	83	6.3 – 54	0	3.2 – 27	0	13.8	310,000
3,3'-Dichlorobenzidine	µg/kg dw	0	na	84	96 – 500	0	23 – 120	0	61.7	1,100
4-Chloroaniline	µg/kg dw	0	na	84	96 – 500	0	27 – 140	0	25.7	24,000
4-Methylphenol	µg/kg dw	3	20 – 54	81	19 – 99	0	4.7 – 24	0	13.5	31,000
Aniline	µg/kg dw	0	na	84	19 – 99	0	4.8 – 25	0	9.12	85,000
Benzoic acid	µg/kg dw	15	64 – 770	69	63 – 540	0	50 – 420	0	105	100,000,000
Benzyl alcohol	µg/kg dw	5	20 – 670	79	19 – 80	0	15 – 68	0	41	1,800,000
bis(2-chloroethyl)ether	µg/kg dw	0	na	84	19 – 99	0	5.7 – 30	0	9.93	210
bis(2-chloroisopropyl)ether	µg/kg dw	0	na	84	19 – 99	0	9.3 – 48	0	9.96	2,900
Hexachlorobenzene	µg/kg dw	4	0.96 – 95	80	0.96 – 54	0	0.032 – 16	0	9.28	300
Hexachlorobutadiene	µg/kg dw	0	na	84	0.96 – 54	0	0.351 – 23	0	8.28	6,200
Hexachloroethane	µg/kg dw	0	na	84	19 – 99	0	6.5 – 34	0	7.98	35,000
Isophorone	µg/kg dw	0	na	84	19 – 99	0	8.1 – 42	0	7.38	510,000
Nitrobenzene	µg/kg dw	0	na	84	19 – 99	0	15 – 79	0	15.9	2,000
N-Nitrosodimethylamine	µg/kg dw	0	na	84	32 – 270	84	8.9 – 190	81	9.12	9.5
N-Nitroso-di-n-propylamine	µg/kg dw	0	na	84	32 – 270	8	2.5 – 21	0	10.2	69
N-Nitrosodiphenylamine	µg/kg dw	11	6.6 – 24	73	6.3 – 54	0	2.9 – 24	0	10.7	99,000
Pentachlorophenol	µg/kg dw	2	76 – 410	82	32 – 270	0	12 – 110	0	37.1	3,000
Phenol	µg/kg dw	14	21 – 280	70	19 – 99	0	6.4 – 33	0	9.47	3,700,000
PCB Congeners										
PCB-077	ng/kg dw	33	22.0 – 80,500	0	na	0	na	0	0.39	39,000
PCB-081	ng/kg dw	33	0.700-6,970	0	na	0	na	0	0.39	39,000
PCB-105	ng/kg dw	33	164 – 3,660,000	0	na	0	na	0	0.44	39,000
PCB-114	ng/kg dw	33	6.52 – 207,000	0	na	0	na	0	0.46	7,800

Chemical	Unit	Number of Detected Results	Range of Detected Results	Number of Non-Detected Results	Range of Non-Detected RLs	Number of RLs > ACG	Range of MDLs	Number of MDLs > ACG	Target MDL	Human Health ACG
PCB-118	ng/kg dw	33	428 – 12,000,000	0	na	0	na	0	0.37	39,000
PCB-123	ng/kg dw	33	9.34 – 138,000	0	na	0	na	0	0.95	39,000
PCB-126	ng/kg dw	33	2.17 – 7,980	0	na	0	na	0	0.21	39
PCB-156	ng/kg dw	33	64.2 – 1,790,000	0	na	0	na	0	0.66	7,800
PCB-157	ng/kg dw	33	C156	0	na	0	na	0	0.66	7,800
PCB-167	ng/kg dw	33	23.9 – 515,000	0	na	0	na	0	0.35	390,000
PCB-169	ng/kg dw	0	na	33	0.671 – 1,700	2	1.85 – 929	1	0.44	390
PCB-189	ng/kg dw	33	7.08 – 65,700	0	na	0	na	0	0.34	39,000
PCBs as Aroclors										
Aroclor-1016	µg/kg dw	0	na	84	19 – 110	0	3.0 – 17	0	0.98	390
Aroclor-1221	µg/kg dw	0	na	84	19 – 110	0	3.0 – 17	0	0.98	220
Aroclor-1232	µg/kg dw	0	na	84	19 – 110	0	3.0 – 17	0	0.98	220
Aroclor-1242	µg/kg dw	16	20 – 400	68	19 – 110	0	3.0 – 17	0	0.98	220
Aroclor-1248	µg/kg dw	15	23 – 740	69	19 – 130	0	3.0 – 17	0	0.98	220
Aroclor-1254	µg/kg dw	63	17 – 910	21	19 – 61	0	3.0 – 4.8	0	0.98	220
Aroclor-1260	µg/kg dw	60	17 – 320	24	19 – 110	0	3.0 – 17	0	0.98	220
Total PCB Aroclors	µg/kg dw	67	17 – 1,920	17	19 – 20	0	3.0 – 17	0	0.98	220
Pesticides										
4,4'-DDD	µg/kg dw	0	na	26	1.9 – 20	0	0.306-3.15	0	0.32	2,400
4,4'-DDE	µg/kg dw	0	na	26	1.9 – 20	0	0.159 – 1.63	0	0.166	1,700
4,4'-DDT	µg/kg dw	0	na	26	1.9 – 25	0	0.269 – 2.77	0	0.284	1,700
Total DDT	µg/kg dw	0	na	26	1.9 – 25	0	0.306 – 3.15	0	0.32	1,700
Aldrin	µg/kg dw	0	na	26	0.96 – 9.8	0	0.052 – 0.531	0	0.054	29
Dieldrin	µg/kg dw	0	na	26	1.9 – 20	0	0.047 – 0.482	0	0.049	30
alpha-BHC	µg/kg dw	0	na	26	0.96 – 9.8	0	0.204 – 2.1	0	0.214	90
beta-BHC	µg/kg dw	0	na	26	0.96 – 9.8	0	0.043 – 0.444	0	0.045	320
gamma-BHC	µg/kg dw	0	na	26	0.96 – 9.8	0	0.135 – 1.39	0	0.141	440

Chemical	Unit	Number of Detected Results	Range of Detected Results	Number of Non-Detected Results	Range of Non-Detected RLs	Number of RLs > ACG	Range of MDLs	Number of MDLs > ACG	Target MDL	Human Health ACG
Total chlordane	µg/kg dw	1	95 – 95	25	1.9 – 5.6	0	0.921 – 1.64	0	0.964	1,600
Endrin	µg/kg dw	0	na	26	1.9 – 20	0	0.048 – 0.492	0	0.24	1,800
Heptachlor	µg/kg dw	0	na	26	0.96 – 9.8	0	0.026 – 0.355	0	0.027	110
Heptachlor epoxide	µg/kg dw	0	na	26	0.96 – 9.8	0	0.117 – 1.2	0	0.122	53
Methoxychlor	µg/kg dw	0	na	26	9.6 – 98	0	0.388 – 5.46	0	0.402	31,000
Mirex	µg/kg dw	0	na	26	1.9 – 20	0	0.378 – 3.89	0	1.22	270
Toxaphene	µg/kg dw	0	na	26	96 – 980	1	2.83 – 29.1	0	29.7	440
Dioxins and Furans										
2,3,7,8-TCDD	ng/kg dw	20	0.0660 – 30.6	1	0.560 – 0.560	0	0.976 – 0.976	0	0.059	3.9
1,2,3,7,8-PeCDD	ng/kg dw	21	0.100 – 57.1	0	na	0	na	0	0.153	3.9
1,2,3,4,7,8-HxCDD	ng/kg dw	21	0.193 – 124	0	na	0	na	0	0.172	7.8
1,2,3,6,7,8-HxCDD	ng/kg dw	21	0.978 – 3,400	0	na	0	na	0	0.118	39
1,2,3,7,8,9-HxCDD	ng/kg dw	21	0.537 – 315	0	na	0	na	0	0.172	39
1,2,3,4,6,7,8-HpCDD	ng/kg dw	21	25.5 – 73,700	0	na	0	na	0	0.169	39
OCDD	ng/kg dw	21	203 – 241,000	0	na	0	na	0	0.518	39
2,3,7,8-TCDF	ng/kg dw	21	0.113 – 397	0	na	0	na	0	0.077	39
1,2,3,7,8-PeCDF	ng/kg dw	21	0.0950 – 69.3	0	na	0	na	0	0.132	39
2,3,4,7,8-PeCDF	ng/kg dw	21	0.212 – 230	0	na	0	na	0	0.143	39
1,2,3,4,7,8-HxCDF	ng/kg dw	21	0.513 – 2,530	0	na	0	na	0	0.148	39
1,2,3,6,7,8-HxCDF	ng/kg dw	21	0.174 – 365	0	na	0	na	0	0.154	78
1,2,3,7,8,9-HxCDF	ng/kg dw	19	0.0730 – 33.8	2	0.059 – 1.2	0	4.77 – 36.8	0	0.148	390
2,3,4,6,7,8-HxCDF	ng/kg dw	21	0.155 – 302	0	na	0	na	0	0.09	390
1,2,3,4,6,7,8-HpCDF	ng/kg dw	21	5.18 – 40,300	0	na	0	na	0	0.183	390
1,2,3,4,7,8,9-HpCDF	ng/kg dw	21	0.385 – 3,720	0	na	0	na	0	0.081	39,000
OCDF	ng/kg dw	21	12.5 – 93,700	0	na	0	na	0	0.381	39,000

na – not applicable

Table 5-19 lists 14 chemicals with RLs above applicable ACGs for benthic invertebrates. Seven of these chemicals had MDLs above their respective ACG. Eight chemicals had RLs above the ACG that were not anticipated in the QAPP; however, these ACGs were met by the associated MDLs for all but four chemicals in only four individual samples. The unanticipated RLs that exceeded the ACGs were elevated because of an analytical dilution for that sample. For chemicals with SQS expressed on an organic-carbon-normalized basis, a lower-than-average OC content of 0.5% was assumed in the ACG derivation to convert the SQS to its dry weight equivalent. This decision to use a low TOC content for the calculation was made to ensure that RLs would be sufficiently low for samples with such low TOC content. In actuality, only four samples had TOC concentrations below 0.5%, and the mean TOC concentration from the Round 2 sediment samples was 1.99%. The more relevant comparison for non-detect results is to normalize (if appropriate for that chemical) to the actual TOC content for that sample and compare to the SQS. A summary of these comparisons is presented in Table 5-6 for SVOCs. As discussed in Section 4.1, all samples with RLs > SQS were either tested for toxicity or will be evaluated in the Phase 2 ERA based on chemical data.

Table 5-19. Detected and non-detected results, RLs, and MDLs for sediment samples compared to benthic invertebrate ACGs

Chemical	Unit	Number of Detected Results	Range of Detected Results	Number of Non-Detected Results	Range of RLs	Number of RLs > ACG	Range of MDLs	Number of MDLs > ACG	Target MDL	Benthic Invertebrate ACG
Metals										
Antimony	mg/kg dw	9	0.3 – 3.6	75	0.2 – 0.5	0	0.012 – 0.029	0	0.005	150
Arsenic	mg/kg dw	84	2.7 – 161	0	na	0	na	0	0.02	57
Cadmium	mg/kg dw	39	0.3 – 3.8	45	0.2 – 1	0	0.046 – 0.24	0	0.02	5.1
Chromium	mg/kg dw	84	9.9 – 174	0	na	0	na	0	0.09	260
Copper	mg/kg dw	84	10.3 – 1,340	0	na	0	na	0	0.04	390
Lead	mg/kg dw	84	3 – 573	0	na	0	na	0	0.12	450
Mercury	mg/kg dw	56	0.06 – 1.09	28	0.04 – 0.1	0	0.0024 – 0.0076	0	0.003	0.41
Nickel	mg/kg dw	84	6 – 48	0	na	0	na	0	0.38	140
Silver	mg/kg dw	13	0.5 – 3	71	0.3 – 2	0	0.046 – 0.24	0	0.03	6.1
Zinc	mg/kg dw	84	30.8 – 878	0	na	0	na	0	0.29	410
Organometals										
Tributyltin as ion	µg/kg dw	17	5.4 – 3,000	2	3.7 – 3.8	0	2.1 – 2.2	0	2.84	8.5
PAHs										
2-Methylnaphthalene	µg/kg dw	8	25 – 3,300	76	19 – 99	0	11 – 57	0	7.21	190
Acenaphthene	µg/kg dw	20	16 – 5,200	64	19 – 99	7	6.7 – 35	0	9.36	80
Acenaphthylene	µg/kg dw	20	15 – 240	64	19 – 99	0	6.7 – 35	0	9.09	330
Anthracene	µg/kg dw	57	18 – 10,000	27	19 – 98	0	6.3 – 32	0	8.69	1,100
Benzo(a)anthracene	µg/kg dw	75	7.3 – 4,000	9	6.4 – 6.6	0	0.93 – 0.96	0	8.34	550
Benzo(a)pyrene	µg/kg dw	76	7.1 – 2,100	8	6.4 – 6.6	0	1.0 – 1.1	0	7.31	500
Benzo(g,h,i)perylene	µg/kg dw	58	21 – 1,100	26	19 – 98	0	4.7 – 24	0	8.04	160
Chrysene	µg/kg dw	74	21 – 5,700	10	19 – 20	0	5.3 – 5.5	0	8.09	500
Dibenzo(a,h)anthracene	µg/kg dw	19	12 – 350	65	19 – 300	9	3.7 – 58	0	8.35	60
Dibenzofuran	µg/kg dw	16	10 – 4,000	68	19 – 99	8	12 – 61	0	7.95	75
Fluoranthene	µg/kg dw	77	20 – 17,000	7	19 – 20	0	4.5 – 4.7	0	8.49	800
Fluorene	µg/kg dw	27	22 – 6,800	57	19 – 99	0	6.1 – 32	0	9.17	120
Indeno(1,2,3-cd)pyrene	µg/kg dw	75	6.5 – 1,200	9	6.4 – 6.6	0	1.0 – 1.1	0	8.54	170
Naphthalene	µg/kg dw	14	13 – 5,300	70	19 – 99	0	5.4 – 28	0	7.53	500
Phenanthrene	µg/kg dw	72	20 – 22,000	12	19 – 20	0	5.8 – 6.0	0	8.63	500
Pyrene	µg/kg dw	76	21 – 12,000	8	19 – 20	0	8.1 – 8.4	0	8.72	5,000
Total LPAH	µg/kg dw	73	20 – 44,000	11	19 – 20	0	11 – 11	0	9.36	1,900
Total HPAH	µg/kg dw	78	46 – 48,000	6	19 – 20	0	8.1 – 8.4	0	10.4	4,800

Chemical	Unit	Number Of Detected Results	Range Of Detected Results	Number Of Non-Detected Results	Range Of RLs	Number Of RLs > ACG	Range Of MDLs	Number Of MDLs > ACG	Target MDL	Benthic Invertebrate ACG
Total Benzofluoranthenes	µg/kg dw	77	6.6 – 5,200	7	19 – 20	0	3.9 – 4.0	0	10.4	1,200
Phthalates										
Bis(2-ethylhexyl)phthalate	µg/kg dw	51	25 – 1,600	33	19 – 840	6	5.0 – 21	0	10.8	240
Butyl benzyl phthalate	µg/kg dw	26	10 – 200	58	6.3 – 54	3	3.8 – 32	1	10.3	25
Diethyl phthalate	µg/kg dw	17	5.7 – 120	67	6.4 – 42	0	4.3 – 28	0	135	310
Dimethyl phthalate	µg/kg dw	12	6.6 – 83	72	6.3 – 54	0	1.6 – 14	0	12	270
Di-n-butyl phthalate	µg/kg dw	6	21 – 91	78	19 – 120	0	6.3 – 33	0	13.5	1,100
Di-n-octyl phthalate	µg/kg dw	1	53 – 53	83	19 – 99	0	3.7 – 19	0	11.3	290
Other SVOCs										
1,2,4-Trichlorobenzene	µg/kg dw	0	na	84	3.3 – 27	81	0.61 – 13	6	5.88	4.1
1,2-Dichlorobenzene	µg/kg dw	1	7.3 – 7.3	83	6.3 – 54	10	1.3 – 11	0	8.76	12
1,3-Dichlorobenzene	µg/kg dw	0	na	84	19 – 99	0	6.8 – 35	0	7.55	170
1,4-Dichlorobenzene	µg/kg dw	1	9.1 – 9.1	83	6.3 – 54	7	2.1 – 18	1	8.16	16
2,4-Dimethylphenol	µg/kg dw	0	na	84	6.3 – 31	1	3.7 – 31	1	10.52	29
2-Methylphenol	µg/kg dw	1	32 – 32	83	6.3 – 54	0	3.2 – 27	0	13.8	63
4-Methylphenol	µg/kg dw	3	20 – 54	81	19 – 99	0	4.7 – 24	0	13.5	670
Benzoic acid	µg/kg dw	15	64 – 770	69	63 – 540	0	50 – 420	0	105	650
Benzyl alcohol	µg/kg dw	5	20 – 670	79	19 – 80	1	15 – 68	1	41	57
Hexachlorobenzene	µg/kg dw	4	0.96 – 95	80	0.96 – 54	53	0.032 – 16	10	9.28	1.9
Hexachlorobutadiene	µg/kg dw	0	na	84	0.96 – 54	2	0.351 – 23	1	8.28	20
Hexachloroethane	µg/kg dw	0	na	84	19 – 99	0	6.5 – 34	0	7.98	1,400
N-Nitrosodiphenylamine	µg/kg dw	11	6.6 – 24	73	6.3 – 54	0	2.9 – 24	0	10.7	55
Pentachlorophenol	µg/kg dw	2	76 – 410	82	32 – 270	0	12 – 110	0	37.1	360
Phenol	µg/kg dw	14	21 – 280	70	19 – 99	0	6.4 – 33	0	9.47	420
PCBs as Aroclors										
Total PCB Aroclor	µg/kg dw	67	17 – 1,920	17	19 – 20	0	3.0 – 17	0	0.98	60
Pesticides										
Aldrin	µg/kg dw	0	na	26	0.96 – 9.8	0	0.052 – 0.531	0	0.054	10
Dieldrin	µg/kg dw	0	na	26	1.9 – 20	2	0.047 – 0.482	0	0.049	10
gamma-BHC	µg/kg dw	0	na	26	0.96 – 9.8	0	0.135 – 1.39	0	0.141	10
alpha-Chlordane	µg/kg dw	1	36 – 36	25	0.96 – 1.7	0	0.138 – 0.283	0	0.144	10
Heptachlor	µg/kg dw	0	na	26	0.96 – 9.8	0	0.026 – 0.355	0	0.027	10
Total DDT	µg/kg dw	0	na	26	1.9 – 25	12	0.306 – 3.15	0	0.32	6.9

5.2 GREATER SEATTLE AREA DIOXIN/FURAN SEDIMENT RESULTS

Surface sediment samples were collected from 13 locations in nine areas within the greater Seattle area. These samples were analyzed for dioxins/furans, PCB Aroclors, TOC, and grain size. In addition, the two samples collected in the ship canal were also analyzed for pentachlorophenol. The results of these analyses are discussed in the following sections.

5.2.1 Dioxins and furans

Table 5-20 presents a summary of the dioxin/furan results. Data tables containing results for each sample, including field duplicates, for dioxins and furans are presented in Appendix A.

Table 5-20. Summary of dioxin and furan results in surface sediment samples collected from the greater Seattle area

Dioxin/Furan	Unit	Detection Frequency	Detected Concentration			Reporting Limit[A]	
			Minimum	Maximum	Mean[B]	Minimum	Maximum
Dioxins							
2,3,7,8-TCDD	ng/kg dw	13/13	0.125 J	3.01 J	0.936	na	na
1,2,3,7,8-PeCDD	ng/kg dw	13/13	0.481 J	11.8 J	4.12	na	na
1,2,3,4,7,8-HxCDD	ng/kg dw	13/13	0.768 J	35.5	9.03	na	na
1,2,3,6,7,8-HxCDD	ng/kg dw	13/13	1.99 J	86.7	27.7	na	na
1,2,3,7,8,9-HxCDD	ng/kg dw	13/13	1.86 J	88.4	22.8	na	na
1,2,3,4,6,7,8-HpCDD	ng/kg dw	13/13	41.7	8,740	1,190	na	na
OCDD	ng/kg dw	13/13	316	208,000	20,000	na	na
Furans							
2,3,7,8-TCDF	ng/kg dw	13/13	0.254 J	12.6	3.09	na	na
1,2,3,7,8-PeCDF	ng/kg dw	13/13	0.265 J	6.88 J	2.25	na	na
2,3,4,7,8-PeCDF	ng/kg dw	13/13	0.360 J	10.1 J	3.03	na	na
1,2,3,4,7,8-HxCDF	ng/kg dw	13/13	0.864 J	18.0 J	6.63	na	na
1,2,3,6,7,8-HxCDF	ng/kg dw	13/13	0.627 J	16.3 J	5.20	na	na
1,2,3,7,8,9-HxCDF	ng/kg dw	8/13	0.0630 J	0.858 J	0.450	0.380	0.590
2,3,4,6,7,8-HxCDF	ng/kg dw	13/13	0.521 J	13.5 J	4.44	na	na
1,2,3,4,6,7,8-HpCDF	ng/kg dw	13/13	7.31 J	259	93	na	na
1,2,3,4,7,8,9-HpCDF	ng/kg dw	13/13	0.625 J	15.5 J	6.48	na	na
OCDF	ng/kg dw	13/13	19.1 J	714 J	270	na	na

[a] RL range for non-detect samples only

[b] Reported mean concentrations are the average of the detected concentrations only; RLs were not included in calculation of the mean concentration.

na – not applicable

Data qualifiers: J - estimated concentration

All of the dioxin congeners were detected in all of the surface sediment samples. Of the dioxin congeners, 2,3,7,8-TCDD and 1,2,3,7,8-PeCDD concentrations were highest in the sample from UB-SS8; all of the remaining dioxin congener concentrations were highest in the sample from SC-SS1a.

All of the furan congeners were detected in all of the surface sediment samples, except for 1,2,3,7,8,9-HxCDF, which was not detected in five samples. Concentrations of all of the furan congeners were highest in the sample from SC-SS1b with the following four exceptions: concentrations of 1,2,3,4,7,8-HxCDF, 1,2,3,4,7,8,9-HpCDF, and OCDF were highest in SC-SS1a and the concentration of 1,2,3,7,8,9-HxCDF was highest in UB-SS8.

TEQs were calculated for each of the sediment samples using the mammalian TEFs for dioxins and furans from Van den Berg et al. (1998). For each sample, TEQs were calculated using either zero, half the RL, or the full RL as the selected value for undetected congeners. Results are presented in Table 5-21 and are shown by location in Figure 5-7. The highest TEQ of 147 ng/kg dw was in the sample collected from SC-SS1a. Five samples had undetected congeners; differences among the three TEQ values calculated for each sample were small because only one congener was undetected in each sample.

Table 5-21. Calculated dioxin/furan TEQs in surface sediment samples collected from the greater Seattle area

Sample ID	Mammalian dioxin/furan TEQ - Zero RL (ng/kg dw)	Mammalian dioxin/furan TEQ - Half RL (ng/kg dw)	Mammalian dioxin/furan TEQ - Full RL (ng/kg dw)
SC-SS1a-010	147 J	147 J	147 J
SC-SS1b-010	61.0 J	61.0 J	61.0 J
EB-SS2a-010	13.3 J	13.4 J	13.4 J
EB-SS2b-010	18.5 J	18.5 J	18.5 J
LW-SS3-010	13.4 J	13.4 J	13.4 J
LW-SS6-010[a]	12.5 J	12.6 J	12.6 J
LW-SS4-010	14.5 J	14.6 J	14.6 J
LW-SS5a-010	14.0 J	14.0 J	14.0 J
LW-SS5b-010	14.3 J	14.3 J	14.3 J
SB-SS6-010	2.23 J	2.23 J	2.23 J
DRD-SS7-010	2.67 J	2.67 J	2.67 J
UB-SS8-010	53.1 J	53.1 J	53.1 J
LU-SS9a-010	5.40 J	5.40 J	5.40 J
LU-SS9b-010	25.7 J	25.7 J	25.7 J

[a] Field duplicate sample collected at location LW-SS3

RL – reporting limit

J – estimated concentration; U – not detected at reporting limit; UJ – not detected at estimated reporting limit shown

na – not analyzed

Tables A-4-3 and A-4-4 in Appendix A present concentrations of total PCBs and pentachlorophenol, along with the calculated TEQ values, for each sample.

5.2.2 PCB Aroclors and pentachlorophenol

Table 5-22 presents a summary PCB Aroclor and pentachlorophenol results for surface sediment samples collected from the greater Seattle area. Results are presented for both individual Aroclors and total PCBs. Data tables containing results for each sample for PCB Aroclors and total PCBs are presented in Appendix A. Table 5-23 presents a comparison of organic carbon-normalized PCB results and dry weight pentachlorophenol results to the SQS and CSL. Table 5-23 also presents a comparison of dry weight PCB results for samples with TOC contents greater than 10 percent to the LAET or 2LAET (PTI 1988). All but two of the samples collected from the greater Seattle area were from fresh water, but the SQS/LAET and CSL/2LAET apply only to marine sediments. However, results are compared to SQS/LAET and CSL/2LAET in this report for informational purposes.

Table 5-22. Summary of PCB Aroclor and pentachlorophenol results in surface sediment samples collected from the greater Seattle area

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[A]	
			Minimum	Maximum	Mean[B]	Minimum	Maximum
Aroclor-1016	µg/kg dw	0/13	nd	nd	nd	19	20
Aroclor-1221	µg/kg dw	0/13	nd	nd	nd	19	20
Aroclor-1232	µg/kg dw	0/13	nd	nd	nd	19	20
Aroclor-1242	µg/kg dw	0/13	nd	nd	nd	19	20
Aroclor-1248	µg/kg dw	2/13	65 J	100	83	19	20
Aroclor-1254	µg/kg dw	5/13	37	160	78	19	20
Aroclor-1260	µg/kg dw	1/13	73 J	73 J	73	19	78
Total PCBs (calc'd)	µg/kg dw	5/13	37	260	130	nc	nc
Pentachlorophenol	µg/kg dw	0/2	nd	nd	nd	7.8	21

[a] RL range for non-detect samples

[b] Reported mean concentrations are the average of the detected concentrations only; RLs were not included in calculation of the mean concentration

nc – not calculated

nd – not detected

Table 5-23. Summary of PCB Aroclor and pentachlorophenol results in surface sediment samples collected from the greater Seattle area in comparison to SQS/LAET and CSL/2LAET

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[A]		SQS/ LAET	CSL/ 2LAET
			Minimum	Maximum	Mean[B]	Minimum	Maximum		
Total PCBs (calc'd)	mg/kg OC	4/10[c]	0.54	10 J	3.4	nc	nc	12[d]	65[d]
Total PCBs (calc'd)	µg/kg dw	1/3[e]	260	260	260	20	20	130[f]	1,000[f]
Pentachlorophenol	µg/kg dw	0/2	nd	nd	nd	7.8	21	360[d]	690[d]

The SQS/LAET and CSL/2LAET apply only to marine sediments. All but two of the 13 samples collected from the greater Seattle area (EB-SS2a and EBSS2b) were from freshwater locations; results are compared to SQS/ LAET and CSL/2LAET in this report for informational purposes.

[a] RL range for non-detect samples

[b] Reported mean concentrations are the average of the detected concentrations only; RLs were not included in calculation of the mean concentration.

[c] Detection frequency for the 10 samples that had TOC contents ≤ 10%

[d] SQS or CSL

[e] Detection frequency for the three samples that had TOC contents > 10%

[r] LAET or 2LAET

nc – not calculated

nd – not detected

Three of the seven different Aroclors were detected in at least one sediment sample. Aroclor 1254 was the most frequently detected Aroclor. The maximum total PCB concentration (260 µg/kg dw) was detected in the sediment sample collected at location SC-SS1a. In eight of the sediment samples, no PCB Aroclors were detected. Pentachlorophenol was not detected in either of the two sediment samples (SC-SS1a-010 and SC-SS1b-010) in which it was analyzed.

Table 5-24 presents the number of samples with detected concentrations or RLs (for non-detected results) greater than the SQS or CSL. Table A-1 in Appendix A presents the results for each sample and indicates which concentrations exceeded the SQS or CSL. None of the total PCB or pentachlorophenol concentrations exceeded the SQS.

Table 5-24. Number of samples with concentrations within each SQS/SL or CSL/ML category for detected concentrations and reporting limits for PCBs

Analyte	Samples with Detected Concentration			Samples with Reporting Limit when Undetected		
	≤SQS	>SQS ≤CSL	>CSL	≤SQS	>SQS ≤CSL	>CSL
Total PCBs	5			8		
Pentachlorophenol				2		

[a] The RL for total PCBs was assigned a concentration equal to the highest RL of the seven Aroclors for a given sample

5.2.3 Total organic carbon and total solids

Table 5-25 presents a summary of TOC and total solids results for surface sediment samples collected from the greater Seattle area. TOC ranged from 1.27% dw in SB-SS6 to 16.4% dw in LW-SS4. Total solids ranged from 14.6 to 81.90% ww.

Table 5-25. Summary of TOC and total solids results in surface sediment samples collected from the greater Seattle area

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[A]	
			Minimum	Maximum	Mean[B]	Minimum	Maximum
Total organic carbon (TOC)	% dw	13/13	1.27	16.4	6.61	na	na
Total solids	% ww	13/13	14.60	81.90 J	46.45	na	na

[a] RL range for non-detect samples

[b] Reported mean concentrations are the average of the detected concentrations only; RLs were not included in calculation of the mean concentration

na – not applicable

Grain size was not analyzed in the laboratory, but was qualitatively evaluated in the field at locations associated with outfalls (SC-SS1, EB-SS2, LW-SS5, UB-SS8, and LU-SS9). Samples were only collected in areas where gravel content was less than 50%, to ensure that the samples were collected outside of the scour zone. Only three samples contained gravel (LU-SS9a-010, EB-SS2a-010, and EB-SS2b-010). The gravel content was less than 10% in sample LU-SS9a-010, and less than 5 % in samples EB-SS2a-010 and EB-SS2b-010.

5.3 Chemical Data Validation Results

Independent data validation of all results of chemical analyses was conducted by LDC. The complete data validation report is provided in Appendix E-1. The following sections summarize the results of the validation, but do not list every sample affected by a qualification in this summary. Detailed information regarding every qualified sample is available in Appendix E-1.

5.3.1 Overall data quality

The 84 surface sediment samples submitted to ARI were analyzed in 12 sample delivery groups (SDGs). LDC conducted a full validation on two ARI SDGs (HP42 and HP76). All sample results that were not selected for full validation underwent a summary validation. The summary validation included a subsequent review of calibration, internal standard, and ICP interference check sample summary forms. Table 5-26 provides a summary of the number of samples in each ARI SDG, the analyses performed, and the level of data validation.

The 33 surface sediment samples submitted to Axys for PCB congener analysis were analyzed in three SDGs, and the 38 samples submitted for dioxin and furan analysis were analyzed in four SDGs (Table 5-26). LDC conducted a full validation on all of the PCB congener and dioxin and furan results.

The majority of the data did not require qualification, or were qualified with a J, indicating an estimated value. Thirteen non-detected results for monobutyltin were rejected as a result of the validation review.

Based on the information reviewed, the overall data quality was considered acceptable for use in the RI, as qualified. The results of the validation are summarized below by analyte group.

Table 5-26. Numbers of sediment samples and level of data validation performed for each SDG

SDG	Lab	Validation Level	SVOCs	SVOC-SIM	Pesticides	PCB Aroclors	Metals and Mercury	Butyltins	PCP	Conventionals[A]	PCB Congeners	Dioxins/ Furans
HV42	ARI	full	10	9	2	9	8	6	0	8	0	0
HV76	ARI	full	10	10	4	10	10	0	0	10	0	0
HR49	ARI	summary	0	0	0	10	0	0	1	10[b]	0	0
HS56	ARI	summary	0	0	0	4	0	0	4	4[b]	0	0
HU85	ARI	summary	10	10	5	11	10	3	0	10	0	0
HV37	ARI	summary	19	16	2	17	16	3	0	16	0	0
HV00	ARI	summary	15	15	5	15	15	4	0	15	0	0
HV38	ARI	summary	3	3	1	4	3	0	0	3	0	0
HV58	ARI	summary	14	13	3	12	12	3	0	12	0	0
HV72	ARI	summary	6	6	2	6	6	1	0	9[c]	0	0
HW06	ARI	summary	8	9	2	9	7	1	0	7	0	0
HW16	ARI	summary	1	1	1	1	1	0	0	1	0	0
HZ55	ARI	summary	5	0	0	0	0	0	0	0	0	0
DPWG16148	Axys	full	0	0	0	0	0	0	0	0	14	0
DPWG16165	Axys	full	0	0	0	0	0	0	0	0	13	0
DPWG16336	Axys	full	0	0	0	0	0	0	0	0	6	0
DPWG15547	Axys	full	0	0	0	0	0	0	0	0	0	13
DPWG15584	Axys	full	0	0	0	0	0	0	0	0	0	15
DPWG16036	Axys	full	0	0	0	0	0	0	0	0	0	5
DPWG16057	Axys	full	0	0	0	0	0	0	0	0	0	5

[a] Includes ammonia, sulfides, total solids, TOC, and grain size

[b] Analyzed for total solids and TOC only

[c] Six samples were analyzed for all conventional parameters; three samples were analyzed for sulfides and grain size only

5.3.2 Sample transport and holding times

All analyses of the surface sediment samples were conducted within the maximum holding times, with the following exceptions. Sulfides were analyzed for samples LDW-SS35-010 and LDW-SSMSMP43B-010 outside of the 7-day holding time by three and one day(s) respectively, resulting in J-qualification of the results. Total solids results for 10 samples in SDG HR49 and one sample from SDG HW06 were also J-qualified because of holding time exceedances, ranging from three to seven days. The chain-of-custody documents were reviewed for documentation of cooler temperatures. All cooler temperatures met validation criteria.

5.3.3 Field blank results

Rinsate blanks were submitted for each of the analyses. No analytes were detected in any of the rinsate blank samples.

5.3.4 Analytical results

This section presents the data validation results separately for each of the following analytes or groups of analytes: metals (including mercury), SVOCs, SVOCs by SIM, PCBs (as Aroclors) and pesticides, pentachlorophenol, PCB congeners, and dioxins and furans.

5.3.4.1 Metals (including mercury)

Calibration

The initial calibration was performed and the frequency and analysis criteria of the initial calibration verification and continuing calibration verification were met.

Blanks

Zinc was detected in one method blank. Samples were not qualified because concentrations were either not detected or were greater than five times the blank concentration.

Interference check sample analysis

The frequency of analysis criteria was met for interference check samples (ICS) analyzed for all metals, except mercury. The ICS results were within quality control (QC) limits, except for selenium associated with three samples in SDGs HV42 and HV76. As a result, the three nondetected results associated with the ICS were J-qualified. In addition, the molybdenum result in an ICS associated with two samples in SDG HV76 was outside of QC limits. Consequently, these detected results were J-qualified.

Matrix spike

All matrix spike (MS) results were within QC limits, with the following exceptions. The percent recovery reported for antimony in all nine MS samples ranged from 1.6 to 8.1%, resulting in J-qualification of detected and non-detected antimony results.

Although the results were not rejected because the post-digestion spike recoveries for antimony were greater than 75%, the systematic low recoveries may be indicative of an overall low bias in both the detected results and nondetected results for antimony. The MS recovery was below QC limits for chromium in SDG HV58 and for mercury in SDG HW06; thus, the associated detected results were J-qualified. The MS recovery was above QC limits for copper in SDG HW06 and SDG HV58 and for zinc in SDG HV58; associated detected results were J-qualified.

Laboratory control samples and standard reference material

All percent recoveries for laboratory control samples (LCS) were within QC limits. SRM samples were analyzed at the required frequencies and all results were within QC limits.

Sample result verification

All sample result verifications met validation criteria.

5.3.4.2 Butyltins

Calibration

Initial calibration was performed as required by the method. Calibration verification was performed and all aspects of the calibration were within QC limits.

Blanks

No butyltin compounds were detected in the method blanks.

Surrogate Recovery

All surrogate recoveries were within QC limits.

Matrix spike

All MS/MSD results were within QC limits, with the following exceptions. The MSDs associated with SDGs HV00 and HV42 were outside of QC limits for precision and accuracy for tributyltin. The MS/MSD percent recoveries for dibutyltin were outside QC limits in SDG HV42 and HU85. The associated detected results were J-qualified. The monobutyltin MS/MSD recoveries were biased low in SDGs HU85, HV58, and HV42, resulting in the rejection of nondetected results, and the J-qualification of detected results.

Laboratory control samples and standard reference material

All LCS results were within QC limits, with the following exceptions. The LCS recoveries associated with SDGs HU85, HV00, HV37, HV42, HV72, HV58, and HW06 were below QC limits for monobutyltin. These percent recoveries ranged from 4.6-10.0%, resulting in the J-qualification of detected results and the rejection of associated non-detected results. SRM samples were analyzed at the required frequencies and all results were within QC limits.

5.3.4.3 SVOCs (including PAHs)

Calibration

The initial calibration was conducted correctly. All response factors and system performance check compounds were adequate. The percent relative standard deviations (%RSDs) for all analytes were within QC limits, with the exception of 4,6-dinitro-2-methylphenol, resulting in J-qualification of non-detected results in SDGs HV42 and HV76. Continuing calibration verifications were conducted at the required frequencies. The only compounds with percent deviations higher than 25% in the continuing calibration relative to the initial calibration were hexachloro-cyclopentadiene, 2,4-dinitrophenol, 4-nitrophenol, and nitrobenzene. Non-detected results for these analytes for some samples in SDGs HV42 and HV76 were J-qualified. The initial calibration verification was also above QC limits for 4,6-dinitro-2-methylphenol, associated with SDG HV42.

Blanks

Four SVOCs were detected in three method blanks. Sample concentrations were compared to concentrations detected in the method blanks. Detected concentrations that were less than ten times the blank concentration for phthalates, which are common laboratory contaminants, or less than five times the blank concentration for phenol were qualified as non-detected with elevated RLs, as shown in Table 5-27. The elevated RLs resulting from blank contamination are below the ACGs, so reanalysis was not performed.

Table 5-27. Sample results qualified because of method blank contamination

Compound	Associated SDG	Number of Samples	Lowest Modified Final Concentration (µg/kg dw)	Highest Modified Final Concentration (µg/kg dw)
Bis(2-ethylhexyl)phthalate	HV00, HV37, HV38	28	24 U	840 U
Di-n-butylphthalate	HV00, HV38	2	21 U	120 U
Diethylphthalate	HV37	3	26 U	100 U
Phenol	HV58	7	34 U	84 U

Surrogate recovery

Surrogates were added to all samples and blanks as required by the method. All surrogate recoveries were within QC limits, with the exception of LDW-SS95-010, which exhibited low surrogate recovery for all eight surrogates. This sample was re-extracted and all surrogates from the re-extracted analysis were within QC limits.

Matrix spike

All MS/MSD results were within QC limits, with the following exceptions. The phenol recovery was low in the MSD for SDG HU85 and benzo(g,h,i)perylene recoveries were below QC limits in both the MS and the MSD associated with SDG HV58. Associated detected and non-detected results were J-qualified.

Laboratory control samples and standard reference material

LCS results were reviewed and percent recovery results were within QC limits. SRM samples were analyzed at required frequencies and all results were within QC limits.

Internal standards

All internal standard areas and retention times were within QC limits except for perylene-d12 in two samples in SDG HV42, where the internal standard was below the QC limit. Consequently, results for six PAH compounds (benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, and benzo(g,h,i)perylene) were J-qualified as estimated in two samples.

Compound quantification

All compound identification and quantification parameters were within validation criteria. When detected concentrations exceeded the calibration range of the instrument, extracts were diluted and reanalyzed to obtain results within the calibrated range.

5.3.4.4 SVOCs by selected ion monitoring (SIM)

Calibration

Initial and continuing calibrations were conducted as required by the method. The initial calibration %RSDs were less than or equal to 30% for all compounds, with one exception. Benzoic acid results for SDGs HV42 and HV76 were J-qualified based on a %RSD of 39.2%. All of the continuing calibration percent differences were less than 25%, except for benzoic acid and N-nitrosodimethylamine results associated with SDGs HV42 and HV76; detected and non-detected results for those compounds were J-qualified.

Blanks

Two method blanks associated with SDGs HV42, HV76, and HW06 contained diethylphthalate. Sample concentrations were compared to the concentrations detected in the method blanks. Detected concentrations that were less than ten times the blank concentration were qualified as non-detected with elevated RLs as a result of blank contamination. Detected diethylphthalate concentrations in one sample in SDG HV42, six samples in SDG HV76, and two samples in SDG HW06 were qualified as not detected because of blank contamination.

Surrogate recovery

All surrogate recoveries were above the QC limits of 40%, except for low percent recoveries for two surrogates in LDW-SS106-010 (34.8 and 36.4%), eight surrogates in LDW-SS61-010 (22.4 – 35.2%), and two surrogates in LDW-SS155-010 (34.7 and 37.9%). As a result, only the SIM analytes associated with these surrogate compounds for these samples were J-qualified. The exception is LDW-SS61-010, which was re-extracted with passing surrogates. The SIM results were reported from the re-extraction for this sample.

Matrix spike

All MS/MSD results were within QC limits, with the following exceptions. The MSD recovery for pentachlorophenol was slightly below the lower limit of 40% at 39.2% associated with sample LDW-SS145-010 (SDG HV58). The MS recoveries for N-nitroso-di-n-propylamine were below the lower limit of 40% at 34.7% and 31.2%, respectively, for samples LDW-SS86-010 (SDG HV42) and LDW-SS151-010 (SDG HV76). Associated non-detected results were J-qualified on the original field samples only.

Laboratory control samples and standard reference materials

LCS results were reviewed and results were within QC limits. SRM samples were analyzed at required frequencies and results were within QC limits.

Internal standards

All internal standard areas and retention times were within QC limits.

Compound quantification

All compound identification and quantification parameters were within validation criteria**.** When detected concentrations exceeded the calibration range of the instrument, extracts were diluted and reanalyzed to obtain results within the calibrated range.

5.3.4.5 PCBs (as Aroclors) and pesticides

Calibration

Initial and continuing calibrations were conducted as required by the methods. The %RSDs were less than or equal to 20% for all compounds, and retention times of all compounds were within QC limits. The percent differences calculated for the continuing calibrations were within QC limits.

Blanks

PCBs and pesticides were not detected in any of the method blanks.

Surrogate recovery

Surrogates were added to all samples and blanks as required by the method. Surrogate recoveries were within QC limits in all but one sample (UB-SS8-010), which had a reported recovery below the QC limit of 50% for tetrachloro-m-xylene. The undetected results for PCB Aroclors were J-qualified for this sample.

Internal Standards

The laboratory used internal standards for quantification in both methods EPA 8082 and EPA 8081A. All internal standard areas and retention times were within QC limits.

Matrix spike

All MS/MSD results for pesticides were within QC limits, with the exception of hexachlorobenzene in LDW-SSB7a-010 (SDG HQ16) which had a 330% recovery, compared to the upper limit of 150%. The associated detected result was J-qualified. All MS/MSD results for PCBs were within QC limits.

Laboratory control samples and standard reference material

The laboratory control sample/laboratory control sample duplicate (LCS/LCSD) results for the PCB analyses were within QC limits. For pesticides, the LCS results were within QC limits for all analyses, except for the recoveries of endrin aldehyde associated with SDGs HU85, HV37, HV00, HV42, HV38, HV58, HW06, HW16, HV72, and HV76. The results for these compounds were J-qualified. SRM samples were analyzed at the required frequencies and all results were within QC limits.

Compound quantification

All pesticide and PCB compound identification and quantification parameters were within validation criteria. When detected concentrations exceeded the calibration range of the instrument, extracts were diluted and reanalyzed to obtain results within the calibrated range. Quantitation limits for several pesticides were elevated because of Aroclor interferences.

Analyst experience in pattern recognition of the individual Aroclors was used in interpreting the PCB results. When samples contained more than one Aroclor, a higher level of analyst expertise and review was necessary to ensure the correct identification and quantification. The detected concentrations of alpha- and gamma-chlordane in sample LDW-SS85-010 were closely evaluated by the laboratory, and the identifications were verified using their best technical judgment within the limitations of this method.

Five samples were identified in which the results for detected Aroclors and pesticides from the two analytical columns exceeded the relative percent difference (RPD) QC limit of 40%. These samples are identified in Table 5-28. All of the detected results for these specific parameters and samples were J-qualified. When comparing the results from the two analytical columns, the greater of the two values was reported, with the exception of alpha-chlordane in sample LDW-SS85-010, where it was determined that Aroclor interference elevated the result on one column.

Table 5-28. Pesticide and Aroclor results with RPD greater than 40%

SAMPLE ID	PARAMETER	RPD
LDW-SS85-010	alpha-Chlordane	61
LDW-SS11-010	Aroclor 1260	43
LDW-SS71-010	Aroclor 1242	42
LDW-SS158-010	Aroclor 1242	42
SC-SS1b-010	Aroclor 1248	41
	Aroclor 1260	48

RPD – relative percent difference

5.3.4.6 Pentachlorophenol

This section presents data validation results for the two samples (SC-SS1a-010 and SC-SS1b-010) analyzed for pentachlorophenol using EPA Method 8041. Data quality for all other pentachlorophenol results, which were analyzed with SVOCs using EPA Method 8270, is discussed in Section 5.4.4.3.

Calibration

Initial calibration was performed as required by the method. Calibration verification was performed, and all aspects of the calibration were within QC limits.

Blanks

Pentachlorophenol was not detected in the method blanks.

Surrogate Recovery

All surrogate recoveries were within QC limits.

Matrix spike

All MS/MSD results were within QC limits.

Laboratory control samples

LCS results were reviewed, and all results were within QC limits.

Compound quantification

All compound quantitation and contract required quantitation limits (CRQLs) were within validation criteria.

5.3.4.7 PCB congeners

Calibration

All criteria for the initial calibration and continuing calibration were met.

Blanks

Two method blanks associated with SDGs DPWG16148 and DPWG16165 contained PCB congeners. Detected sample concentrations were more than five times the blank concentrations, so qualification of the results was not required.

Laboratory Duplicates

Laboratory duplicate results were reviewed and the RPDs between the results were within QC limits for all samples.

Compound Quantification

All compound quantification and CRQLs were within validation criteria, except for two samples from SDG DPWG16148. The internal standards in these samples were not reported because the samples were diluted to 150 times the original sample volume. The internal standards were quantified from the undiluted sample, and the congener results obtained from the dilution were J-qualified as a result (Table 5-29).

Table 5-29. Samples and PCB congener results J-qualified because of internal standard dilution

SAMPLE ID	QUALIFIED PCB CONGENERS
LDW-SS-120-010	PCB90, PCB105, PCB110, PCB118, PCB129, PCB153, PCB189
LDW-SS-B2b-010	PCB66, PCB90, PCB105, PCB110, PCB118, PCB129, PCB153, PCB180, PCB189

Laboratory control samples and standard reference material

LCS results were reviewed, and all results were within QC limits. SRM samples were analyzed for SDG DPWG16148 and all results were within QC limits.

5.3.4.8 Dioxins and furans

Calibration

All criteria for the initial calibration and continuing calibration were met.

Blanks

Dioxins and furans were detected in all four method blanks associated with the four SDGs. Sample concentrations were compared to the concentrations detected in the method blanks and sample concentrations were either not detected or the detected concentrations were greater than five times the blank concentration, with the exception of the 2,3,7,8-TCDD concentrations in two samples from SDG DPWG16036. The detected concentrations in these samples were qualified as nondetected with elevated RLs because of the presence of this compound in the method blank (Table 5-30).

Table 5-30. Sample results qualified because of method blank contamination

SAMPLE	COMPOUND	REPORTED CONCENTRATION (ng/kg dw)	MODIFIED FINAL CONCENTRATION (ng/kg dw)
LDW-SS71-010	2,3,7,8-TCDD	0.560	0.560 U
LDW-SS59R2-010	2,3,7,8-TCDD	1.04	1.04 U

Laboratory Duplicates

Duplicate sample analyses were reviewed and the RPDs between the results were within QC limits for all samples except one sample in SDG DPWG16057 and one sample in SDG DPWG15547. Consequently, the result for 1,2,3,6,7,8-HxCDD was J-qualified for LDW-SS59-010 and the results for 1,2,3,4,6,7,8-HpCDD and OCDD were J-qualified for LDW-SS14-010.

Compound Quantification

All compound quantification and CRQLs were within validation criteria.

Laboratory control samples and standard reference material

LCS results were reviewed and the recoveries were all within QC limits.

SRM results were within QC limits, with the following exceptions. All of the SRM results for 1,2,3,7,8,9-HxCDF were less than 10% of the certified values in all four SDGs. The associated results were J-qualified because the LCS recoveries were not within applicable QC limits. In addition, the results for 2,3,4,6,7,8-HxCDF were more than the certified values in two SRM samples associated with SDGs DPWG15547 and DPWG15584. As a result, the detected results for this compound were J-qualified.

5.3.4.9 Total solids, ammonia as nitrogen, sulfides, grain size and total organic carbon

Calibration

All criteria for the initial calibration of each method were met.

Blanks

Method blanks were reviewed for applicable analyses. Analytes were not detected in the method blanks, with the exception of ammonia in the blanks associated with HU85 and HV00. Sample concentrations were either not detected or were more than five times the blank concentrations, requiring no qualification.

Matrix spike

MS/MSD results were reviewed for each analysis as applicable. Percent recoveries and RPDs were within QC limits for all analyses except sulfide. Percent recoveries of sulfide were less than the lower QC limit of 75% in MS samples associated with seven SDGs (HV37, HV42, HV00, HV42, HV38, HW06, and HW16). The sulfide recoveries ranged from 50.6-73.5%. All of the detected and non-detected results in the five SDGs were J- qualified to reflect a potential negative bias in the result.

Laboratory control samples and standard reference material

LCS results were reviewed for each analysis, and all results were within QC limits. SRM samples were analyzed for all parameters except sulfide. All results were within QC limits.

Compound quantification

All compound quantitation and CRQLs were within validation criteria.

5.4 SEDIMENT TOXICITY TESTING RESULTS

This section presents the results of the sediment toxicity tests performed with amphipods (*Eohaustorius estuarius*), polychaetes (*Neanthes arenaceodentata*), and bivalve larvae (*Mytilus galloprovincialis*). The complete laboratory toxicity test reports are presented in Appendix F-2, and raw data summaries from the laboratories are presented in Appendix F-3.

5.4.1 Amphipod test

Mean mortality results in the 10-day sediment toxicity test with *Eohaustorius estuarius* are presented in Table 5-31. The mean mortality in the test sediment samples ranged from 1% in LDW-SS85-010 and LDW-SS144-010 to 47% in LDW-SS6-010.

Table 5-31. Percent mean mortality in amphipod sediment toxicity tests and SMS biological effects criteria results

SAMPLE ID	REFERENCE SEDIMENT MATCH	PERCENT MEAN MORTALITY ± SD	EXCEEDANCE OF SMS BIOLOGICAL EFFECT CRITERION[A]
Negative control	na	0.0 ± 0.0	na
LDW-SSMSMP43B-010 (ref)	na	2.0 ± 2.7[b]	na
LDW-SSCR20B-010 (ref)	na	2.0 ± 2.7[b]	na
LDW-SSCR23B-010 (ref)	na	5.0 ± 4.1[b]	na
LDW-SS2-010	LDW-SSCR23B-010	39.0 ± 16.0	CSL
LDW-SS6-010	LDW-SSCR23B-010	47.0 ± 21.7	CSL
LDW-SS16-010	LDW-SSCR20B-010	16.0 ± 10.2	no exceedances
LDW-SS21-010	LDW-SSCR23B-010	37.0 ± 23.6	CSL
LDW-SS24-010	LDW-SSMSMP43B-010	7.0 ± 4.5	no exceedances
LDW-SS29-010	LDW-SSCR20B-010	12.0 ± 7.6	no exceedances
LDW-SS39-010	LDW-SSMSMP43B-010	29.0 ± 11.4	SQS
LDW-SS68-010	LDW-SSCR20B-010	12.0 ± 9.1	no exceedances
LDW-SS69b-010	LDW-SSCR20B-010	37.0 ± 15.7	CSL
LDW-SS71-010	LDW-SSMSMP43B-010	5.0 ± 6.1	no exceedances
LDW-SS73-010	LDW-SSCR23B-010	12.0 ± 9.1	no exceedances
LDW-SS77-010	LDW-SSMSMP43B-010	16.0 ± 9.6	no exceedances
LDW-SS85-010	LDW-SSMSMP43B-010	1.0 ± 2.2	no exceedances
LDW-SS106-010	LDW-SSMSMP43B-010	6.0 ± 4.2	no exceedances
LDW-SS122-010	LDW-SSCR23B-010	7.0 ± 4.5	no exceedances
LDW-SS144-010	LDW-SSMSMP43B-010	1.0 ± 2.2	no exceedances
LDW-SS148-010	LDW-SSMSMP43B-010	6.0 ± 6.5	no exceedances
LDW-SS157-010	LDW-SSMSMP43B-010	8.0 ± 7.6	no exceedances
LDW-SS158-010	LDW-SSCR23B-010	12.0 ± 4.5	no exceedances

Sample ID	Reference Sediment Match	Percent Mean Mortality ± SD	Exceedance of SMS Biological Effect Criterion[A]
LDW-SSB2b-010	LDW-SSCR23B-010	25.0 ± 12.2	no exceedances
LDW-SSB6a-010	LDW-SSMSMP43B-010	2.0 ± 4.5	no exceedances

na - not applicable

SD - standard deviation

SQS - mean mortality > 25% (absolute), and statistically different from the reference sediment ($p \leq 0.05$)

CSL - mean mortality > 30% above the mean mortality in the reference sediment and statistically different from the reference sediment ($p \leq 0.05$)

[a] Statistical analyses in SedQual Release 5 include Wilk-Shapiro test for normality and Levene's test for equality of variances, followed by the appropriate statistical test for significance (i.e., Student's t-test, approximate t-test, or Mann-Whitney)

[b] The three reference sediments met the SMS performance standard of < 25% mortality, as presented in Table 3-7. Mean mortality for SSCR23B was calculated using four replicate results rather than five, because one of the replicates had 100% mortality, and using it would have resulted in unacceptably high variability.

The mean mortality in the negative control was 0% and the mean mortality in the three reference sediments was 2, 2, and 5%. The negative control and reference sediments met the performance standards of less than 10% and 25% mortality, respectively (Table 3-6).

The lethal concentration (50%) (LC50) value from the positive control test was within the laboratory warning limits of two standard deviations of the control chart mean of previous LC50 values, indicating that the test organisms were similar in sensitivity to those previously tested at the laboratory.

Results were compared to SMS biological effects criteria for the amphipod toxicity test (Table 3-6); one test sediment sample was classified as an SQS exceedance and four test sediment samples were classified as CSL exceedances using the statistical package included in SEDQUAL Release 5 (Table 5-31).

Water quality results for the amphipod toxicity test are summarized in Table 5-32. All water quality parameters were within protocol-specified ranges, except the salinity measurements listed in Section 3.3.2. The water quality results are presented in detail in Appendices E-2 and E-3.

Table 5-32. Water quality measurements for the amphipod sediment toxicity tests

Parameter	Mean ± SD	Minimum	Maximum
Overlying water			
Temperature (°C)	15.2 ± 0.3	14.2	15.9
Dissolved oxygen (mg/L)	7.9 ± 0.2	6.5	8.4
Salinity (ppt)	28.4 ± 0.9	26.5	31.0
pH	8.0 ± 0.1	7.6	8.7

PARAMETER	MEAN ± SD	MINIMUM	MAXIMUM
Interstitial water			
Salinity (ppt)	28.5 ± 1.6	24.0	31.0
pH	7.5 ± 0.4	6.8	8.2

SD - standard deviation

Sulfides and ammonia results for the amphipod test are summarized in Table 5-33. Positive control tests for ammonia were conducted concurrently with the sediment toxicity tests. The LC50 value was 163 mg/L total ammonia-N. All ammonia concentrations in the water overlying the test sediment samples were well below the LC50 concentration.

Table 5-33. Sulfides and ammonia measurements for the amphipod sediment toxicity tests

PARAMETER	MINIMUM	MAXIMUM
Overlying water		
Dissolved sulfides (mg/L)	<0.02	<0.02
Total ammonia-N (mg/L)	<0.1	19.3
Un-ionized ammonia (mg/L)	<0.001	0.402
Interstitial water		
Dissolved sulfides (mg/L)	<0.1	37.3
Total ammonia-N (mg/L)	0.7	37.2
Un-ionized ammonia (mg/L)	0.002	1.513

5.4.2 Polychaete test

Mortality and growth rate results for the 20-day sediment toxicity test with the polychaete *Neanthes arenaceodentata* are presented in Table 5-34. A mortality rate of 4% was observed in four of 21 test sediments (LDW-SS6-010, LDW-SS16-010, LDW-SS77-010, and LDW-SS157-010) and two of the reference sediments (LDW-SSCR23B-010 and LDW-SSMSMP43B-010). No mortality was observed in the other polychaete test samples. The mean individual growth rate ranged from 0.72 mg/day in LDW-SS144-010 to 1.02 mg/day in LDW-SSB2b-010.

Table 5-34. Mean mortality and individual growth rate in polychaete sediment toxicity tests and SMS biological effects criteria results

SAMPLE ID	REFERENCE SEDIMENT MATCH	MEAN MORTALITY ± SD	MEAN INDIVIDUAL GROWTH RATE (MG/DAY) ± SD	EXCEEDANCE OF SMS BIOLOGICAL EFFECTS CRITERION[A]
Batch 1				
Negative control	na	0.0 ± 0.0	1.11 ± 0.18	na
LDW-SSMSMP43B-010 (ref)	na	4.0 ± 8.9	1.20 ± 0.19	na
LDW-SSCR20B-010 (ref)	na	0.0 ± 0.0	1.09 ± 0.22	na
LDW-SSCR23B-010 (ref)	na	4.0 ± 8.9	1.08 ± 0.12	na
LDW-SS2-010	LDW-SSCR23B-010	0.0 ± 0.0	0.76 ± 0.20	no exceedances

Sample ID	Reference Sediment Match	Mean Mortality ± SD	Mean Individual Growth Rate (mg/day) ± SD	Exceedance of SMS Biological Effects Criterion[A]
LDW-SS6-010	LDW-SSCR23B-010	4.0 ± 8.9	0.81 ± 0.04	no exceedances
LDW-SS16-010	LDW-SSCR20B-010	4.0 ± 8.9	0.96 ± 0.13	no exceedances
LDW-SS21-010	LDW-SSCR23B-010	0.0 ± 0.0	0.99 ± 0.10	no exceedances
LDW-SS24-010	LDW-SSMSMP43B-010	0.0 ± 0.0	0.77 ± 0.17	SQS
LDW-SS29-010	LDW-SSCR20B-010	0.0 ± 0.0	0.90 ± 0.08	no exceedances
LDW-SS39-010	LDW-SSMSMP43B-010	0.0 ± 0.0	0.76 ± 0.12	SQS
LDW-SS68-010	LDW-SSCR20B-010	0.0 ± 0.0	0.85 ± 0.10	no exceedances
LDW-SS69b-010	LDW-SSCR20B-010	0.0 ± 0.0	0.85 ± 0.29	no exceedances
LDW-SS71-010	LDW-SSMSMP43B-010	0.0 ± 0.0	0.92 ± 0.16	no exceedances
LDW-SS73-010	LDW-SSCR23B-010	0.0 ± 0.0	0.86 ± 0.11	no exceedances
LDW-SS77-010	LDW-SSMSMP43B-010	4.0 ± 8.9	0.95 ± 0.12	no exceedances
LDW-SS85-010	LDW-SSMSMP43B-010	0.0 ± 0.0	0.87 ± 0.18	no exceedances
LDW-SS106-010	LDW-SSMSMP43B-010	0.0 ± 0.0	0.91 ± 0.11	no exceedances
LDW-SS122-010	LDW-SSCR23B-010	0.0 ± 0.0[b]	0.83 ± 0.14[b]	no exceedances
LDW-SS144-010	LDW-SSMSMP43B-010	0.0 ± 0.0	0.72 ± 0.11	SQS
LDW-SS148-010	LDW-SSMSMP43B-010	0.0 ± 0.0	0.78 ± 0.08	SQS
LDW-SS157-010	LDW-SSMSMP43B-010	4.0 ± 8.9	0.78 ± 0.14	SQS
LDW-SS158-010	LDW-SSCR23B-010	0.0 ± 0.0	0.81 ± 0.10	no exceedances
LDW-SSB2b-010	LDW-SSCR23B-010	0.0 ± 0.0	1.02 ± 0.10	no exceedances
LDW-SSB6a-010	LDW-SSMSMP43B-010	0.0 ± 0.0	0.82 ± 0.14	SQS

na - not applicable

SD - standard deviation

SQS - mean individual growth rate <70% of that of the reference sediment and statistically different ($p \leq 0.05$)

[a] Statistical analyses in SedQual Release 5 include Wilk-Shapiro test for normality and Levene's test for equality of variances, followed by the appropriate statistical test for significance (i.e., Student's t-test, approximate t-test, or Mann-Whitney)

[b] One extra polychaete was inadvertently added to one of the replicate beakers. The mean growth rate for the replicate beaker with six individuals was calculated based on the growth of all six individuals; the mean individual growth rate for that replicate beaker (0.70 mg/day) appears to approximate the growth rates in the other four replicate beakers (0.76 - 1.06 mg/day).

The mean individual growth rate in the negative control was 1.11 mg/day, and the mean individual growth rate in the three reference sediments ranged from 1.08 to 1.20 mg/day. The negative control met the performance criteria of less than 10% mortality (0%) and a mean individual target growth rate of at least 0.72 mg/day (Table 3-6).

The three reference sediments met the performance criterion of an individual growth rate of at least 80% of the negative control (Table 3-6).

The LC50 value from the positive control test was within the laboratory warning limits of two standard deviations of the control chart mean of previous LC50 values, indicating that the test organisms were of similar sensitivity to those previously tested at the laboratory.

Based on a comparison to SMS biological effects criteria for polychaete toxicity tests, six test sediment samples were classified as SQS exceedances and no samples exceeded the CSL. There are no SMS standards for mortality in the polychaete toxicity test.

Water quality results for the 20-day polychaete toxicity test are summarized in Table 5-35. All water quality parameters were within protocol-specified ranges, except the salinity and temperature measurements listed in Section 3.3.2. The water quality results are presented in detail in Appendices E-2 and E-3.

Table 5-35. Water quality measurements for the polychaete sediment toxicity tests

PARAMETER	MEAN ± SD	MINIMUM	MAXIMUM
Overlying water			
Temperature (°C)	20.5 ± 0.4	19.5	21.8
Dissolved oxygen (mg/L)	6.6 ± 0.8	3.5	7.3
Salinity (ppt)	28.4 ± 1.1	26.0	30.5
pH	8.0 ± 0.2	7.0	8.6
Interstitial water			
Salinity (ppt)	28.5 ± 1.8	25.0	32.0
pH	7.4 ± 0.5	5.8	8.1

SD - standard deviation

The sulfides and ammonia results for the polychaete test are summarized in Table 5-36. A positive control test for ammonia was conducted concurrently with the sediment toxicity test. The LC50 value was 226 mg/L total ammonia-N. All ammonia concentrations in the water overlying the test sediment samples were well below the LC50 concentrations.

Table 5-36. Sulfides and ammonia measurements for the polychaete sediment toxicity tests

PARAMETER	MINIMUM	MAXIMUM
Overlying water		
Dissolved sulfides (mg/L)	<0.02	<0.02
Total ammonia-N (mg/L)	<0.1	8.6
Un-ionized ammonia (mg/L)	<0.002	0.443
Interstitial water		
Dissolved sulfides (mg/L)	<0.1	25.8
Total ammonia-N (mg/L)	1.2	64.7
Un-ionized ammonia (mg/L)	0.001	1.685

5.4.3 Bivalve larvae test

Results for the 48-hr sediment toxicity test with *Mytilus galloprovincialis* are presented in Table 5-37. The mean normal survivorship in the test sediment samples ranged from 10.1% in LDW-SS77-010 to 83.4% in LDW-SS39-010.

Table 5-37. Percent mean normal survivorship and percent mean effective mortality in the bivalve larvae sediment toxicity tests and SMS biological effects criteria results

Sample ID	Reference Sediment Match	Percent Mean Normal Survivorship ± SD[A]	Percent Mean Effective Mortality ± SD[B]	Exceedance of SMS Biological Effect Criterion[C]
Negative control	na	88.6 ± 9.9	11.4 ± 9.9	na
LDW-SSMSMP43B-010 (ref)	na	69.7 ± 7.6	30.3 ± 7.6	na
LDW-SSCR20B-010 (ref)	na	75.9 ± 5.8	24.1 ± 5.8	na
LDW-SSCR23B-010 (ref)	na	75.2 ± 9.2	24.8 ± 9.2	na
LDW-SS2-010	LDW-SSCR23B-010	31.8 ± 15.1	68.2 ± 15.1	CSL
LDW-SS6-010	LDW-SSCR23B-010	23.6 ± 16.3	76.4 ± 16.3	CSL
LDW-SS16-010	LDW-SSCR20B-010	64.3 ± 3.2	35.7 ± 3.2	SQS
LDW-SS21-010	LDW-SSCR23B-010	72.9 ± 3.6	27.1 ± 3.6	no exceedances
LDW-SS24-010	LDW-SSMSMP43B-010	18.3 ± 3.3	81.7 ± 3.3	CSL
LDW-SS29-010	LDW-SSCR20B-010	64.7 ± 6.8	35.3 ± 6.8	no exceedances
LDW-SS39-010	LDW-SSMSMP43B-010	83.4 ± 10.1	16.6 ± 10.1	no exceedances
LDW-SS68-010	LDW-SSCR20B-010	71.6 ± 12.5	28.4 ± 12.5	no exceedances
LDW-SS69b-010	LDW-SSCR20B-010	59.0 ± 13.6	41.0 ± 13.6	SQS
LDW-SS71-010	LDW-SSMSMP43B-010	61.8 ± 8.7	38.2 ± 8.7	no exceedances
LDW-SS73-010	LDW-SSCR23B-010	56.8 ± 13.3	43.2 ± 13.3	SQS
LDW-SS77-010	LDW-SSMSMP43B-010	10.1 ± 4.0	89.9 ± 4.0	CSL
LDW-SS85-010	LDW-SSMSMP43B-010	86.8 ± 5.3	13.2 ± 5.3	no exceedances
LDW-SS106-010	LDW-SSMSMP43B-010	61.4 ± 8.8	38.6 ± 8.8	no exceedances
LDW-SS122-010	LDW-SSCR23B-010	68.5 ± 14.9	31.5 ± 14.9	no exceedances
LDW-SS144-010	LDW-SSMSMP43B-010	66.4 ± 12.1	33.6 ± 12.1	no exceedances
LDW-SS148-010	LDW-SSMSMP43B-010	29.9 ± 6.6	70.1 ± 6.6	CSL
LDW-SS157-010	LDW-SSMSMP43B-010	71.6 ± 8.5	28.4 ± 8.5	no exceedances
LDW-SS158-010	LDW-SSCR23B-010	67.5 ± 6.5	32.5 ± 6.5	no exceedances
LDW-SSB2b-010	LDW-SSCR23B-010	42.1 ± 20.0	57.9 ± 20.0	CSL
LDW-SSB6a-010	LDW-SSMSMP43B-010	60.1 ± 13.3	39.9 ± 13.3	no exceedances

[a] Percent mean normal survivorship was calculated by the toxicity testing laboratory by dividing the number of normal survivors in each test sample by the initial stocking density according to PSEP (1995). However, percent normal survivorship can also be calculated by dividing the number of normal survivors in each test sample by the number of survivors in the negative (seawater) control, as is done, for example, for the purposes of dredged material evaluation and disposal (USACE et al. 2000). Calculating normal survivorship in this way would result in slightly higher percent survivorship values, but would not change any of the SMS exceedance results.

[b] Effective mortality as reported by the laboratory is a combination of larval mortality and abnormality, and is the complement of normal survivorship (i.e., 100% - effective mortality% = normal survivorship%), which is the metric used in the SQS and CSL biological effects criteria of the SMS

[c] Statistical analyses in SedQual Release 5 include the Wilk-Shapiro test for normality and Levene's test for equality of variances, followed by the appropriate statistical test for significance (i.e., Student's t-test, approximate t-test, or Mann-Whitney)

na - not applicable

SD - standard deviation

SQS - mean normal survivorship < 85% of that of the reference sediment, and statistically different ($p \leq 0.10$)

CSL - mean normal survivorship < 70% of that of the reference sediment, and statistically different ($p \leq 0.10$)

The mean normal survivorship in the negative control was 88.6%, and the mean normal survivorship in the three reference sediments ranged from 69.7 to 75.9%. The negative control met the performance standard of >70% mean normal survivorship (Table 3-6). There is no performance standard for reference sediments in the bivalve larvae test, although Ecology has guidance stating that normal development in the reference sample must be ≥ 65% of the normal development in the negative (seawater) control (Gries 2005). Normal development in the reference sediments ranged from 99 to 101% of that of the negative (seawater) control (see Appendix F-2).

The effect concentration (50%) (EC50) value from the positive control test was within the laboratory warning limits of one standard deviation of the control chart mean of previous EC50 values, indicating that the test organisms were of similar sensitivity to those previously tested at the laboratory.

Based on a comparison to SMS biological effects criteria for the bivalve larvae toxicity test, three test sediment samples were classified as SQS exceedances and six test sediment samples as CSL exceedances (Table 5-37).

Water quality results for the 48-hr bivalve larvae toxicity test are summarized in Table 5-38. All water quality parameters were within protocol-specified ranges. The water quality results are presented in detail in Appendices E-2 and E-3.

Table 5-38. Water quality measurements for the bivalve larvae sediment toxicity tests

PARAMETER	MEAN ± SD	MINIMUM	MAXIMUM
Temperature (°C)	16.4 ± 0.3	15.9	17.0
Dissolved oxygen (mg/L)	7.4 ± 0.5	6.6	8.7
Salinity (ppt)	28.0 ± 0.0	28.0	28.0
pH	7.7 ± 0.13	7.3	7.9

SD - standard deviation

The sulfides and ammonia results for the 48-hr bivalve larvae toxicity test are summarized in Table 5-39. A positive control test for ammonia was conducted concurrently with the sediment toxicity test. The EC50 value was 6.4 mg/L total ammonia-N. All ammonia concentrations in the water overlying the test sediment samples were well below the EC50 concentration.

Table 5-39. Sulfides and ammonia measurements for overlying water in the bivalve larvae sediment toxicity tests

Parameter	Minimum	Maximum
Dissolved sulfides (mg/L)	0.000	0.190
Total ammonia-N (mg/L)	<0.1	<0.50

5.5 Summary of Toxicity Test Results

Table 5-40 presents results for all 21 test sediments relative to SMS biological effects criteria for the three toxicity tests. Figures 5-8a through 5-8c (located in the map folio) present these results graphically. Eight test sediments exceeded the biological effects criteria for one toxicity test and six test sediments exceeded the criteria for two toxicity tests. An exceedance of the SQS in two toxicity tests at one location is considered a CSL exceedance for that location. Overall, there were four sediments that exceeded the SQS and nine sediments that exceeded the CSL.

Table 5-40. Summary of SMS biological effects criteria exceedances for the three toxicity tests

Sample ID	Individual Test Exceedances			Overall Exceedance
	Amphipod Test	Polychaete Test	Bivalve Larvae Test	
LDW-SS2-010	CSL	no exceedances	CSL	CSL
LDW-SS6-010	CSL	no exceedances	CSL	CSL
LDW-SS16-010	no exceedances	no exceedances	SQS	SQS
LDW-SS21-010	CSL	no exceedances	no exceedances	CSL
LDW-SS24-010	no exceedances	SQS	CSL	CSL
LDW-SS29-010	no exceedances	no exceedances	no exceedances	no exceedance
LDW-SS39-010	SQS	SQS	no exceedances	CSL
LDW-SS68-010	no exceedances	no exceedances	no exceedances	no exceedance
LDW-SS69b-010	CSL	no exceedances	SQS	CSL
LDW-SS71-010	no exceedances	no exceedances	no exceedances	no exceedance
LDW-SS73-010	no exceedances	no exceedances	SQS	SQS
LDW-SS77-010	no exceedances	no exceedances	CSL	CSL
LDW-SS85-010	no exceedances	no exceedances	no exceedances	no exceedance
LDW-SS106-010	no exceedances	no exceedances	no exceedances	no exceedance
LDW-SS122-010	no exceedances	no exceedances	no exceedances	no exceedance
LDW-SS144-010	no exceedances	SQS	no exceedances	SQS
LDW-SS148-010	no exceedances	SQS	CSL	CSL
LDW-SS157-010	no exceedances	SQS	no exceedances	SQS
LDW-SS158-010	no exceedances	no exceedances	no exceedances	no exceedance
LDW-SSB2b-010	no exceedances	no exceedances	CSL	CSL
LDW-SSB6a-010	no exceedances	SQS	no exceedances	SQS

5.6 TOXICITY TEST DATA VALIDATION RESULTS

Independent data validation of all results was conducted by DMR. The data validation process was performed as described in the QAPP, Section 5.1.2 (Windward 2005d) and the validation reports for the Round 2 sediment toxicity testing conducted by the two laboratories are presented in Appendix E-2.

The toxicity test data validation process included the following tasks:

- on-site laboratory visit to evaluate testing facilities and procedures
- an initial evaluation of all data for completeness, correct data entries, and accurate transcription to electronic formats
- a validation report of overall data quality and usability

A review of standard operating procedures (SOPs) was conducted before initiation of Round 1 testing. As discussed in the Round 1 data report, DMR found the SOPs from both laboratories to be in excellent condition, and only minor changes were needed to the bivalve SOP other than the additional project-specific provisions requested by Windward Environmental.

An on-site visit to Weston's Tiburon toxicity test laboratory occurred before initiation of the bivalve larvae tests to evaluate equipment and personnel qualifications. No test-in-progress audits of the bivalve larvae tests were conducted because of the travel distance involved and the very short duration of the bivalve larvae tests (48 hours). Weston's toxicity test laboratory, equipment, and credentials of the testing personnel all appeared to be in order. No modifications to the laboratory or equipment were required. An unannounced test-in-progress audit was conducted at the NAS laboratory when both the Round 2 amphipod and polychaete tests were in progress. Auditors concluded that all PSEP (1995) and project-specific protocol provisions were being followed without any apparent deviations, as discussed in the DMR validation report (Appendix E-2). The only water quality deviation noted by DMR during the audit was a slightly elevated temperature in several polychaete samples (see Section 3.3.2). Completed test-in-progress audit checklists are included in Appendix E-2.

All raw data forms and electronic database files generated by both laboratories were reviewed for completeness and fidelity of transcription to electronic formats. A 100% check was made of all data entered into each laboratory's internal electronic database. All errors, omissions, clarifications, or changes needed to the draft reports were documented and communicated to the laboratories. All needed corrections to the data reports were made by the laboratories and subsequently verified by DMR. Minor deviations to the methods and procedures were found during this validation process (see Section 3.3.2); DMR concluded that these deviations had no effect on the data quality.

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