EAST WATERWAY OPERABLE UNIT
SUPPLEMENTAL REMEDIAL INVESTIGATION/ FEASIBILITY STUDY
DATA REPORT: SURFACE SEDIMENT SAMPLING FOR CHEMICAL ANALYSES AND TOXICITY TESTING

FINAL

For submittal to:

The US Environmental Protection Agency
Region 10
Seattle, WA

September 2010

Prepared by:

Windward environmental LLC
200 West Mercer Street • Suite 401
Seattle, Washington • 98119

Table of Contents

Tables

Figures

Maps

Acronyms

Acronym	Definition
ACG	analytical concentration goal
AET	apparent effects threshold
Anchor	Anchor Environmental LLC
ARI	Analytical Resources, Inc.
AP	Analytical Perspectives
BEHP	bis(2-ethylhexyl) phthalate
BHC	benzene hexachloride
C-qualifier	PCB congener co-elution, concentration represents combined result for co-eluting congeners
CCV	continuing calibration verification
CFR	Code of Federal Regulations
COC	chain of custody
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CSL	cleanup screening level
CVAA	cold vapor atomic absorption
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DL	detection limit
DMMP	Dredged Material Management Program
dw	dry weight
EC50	concentration that causes a non-lethal effect in 50% of an exposed population
Ecology	Washington State Department of Ecology
EPA	US Environmental Protection Agency
EW	East Waterway
GC/ECD	gas chromatography/electron capture detection
GC/MS	gas chromatography/mass spectrometry

Acronym	Definition
GPS	global positioning system
HPAH	high-molecular-weight polycyclic aromatic hydrocarbon
HpCDD	heptachlorodibenzo-*p*-dioxin
HpCDF	heptachlorodibenzofuran
HRGC/HRMS	high-resolution gas chromatography/high-resolution mass spectrometry
HxCDD	hexachlorodibenzo-*p*-dioxin
HxCDF	hexachlorodibenzofuran
ICP-AES	inductively coupled plasma-atomic emission spectrometry
ICP-MS	inductively coupled plasma-mass spectrometry
ICS	interference check sample
ID	identification
J-qualifier	estimated concentration
LC50	concentration that is lethal to 50% of an exposed population
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LPAH	low-molecular-weight polycyclic aromatic hydrocarbon
M-qualified	calculated concentration
MDL	method detection limit
MIS	multi-increment sampling
ML	maximum level
MS	matrix spike
MSD	matrix spike duplicate
N-qualified	tentative identification
NAD83	North American Datum of 1983
OC	organic carbon
OCDD	octachlorodibenzo-*p*-dioxin
OCDF	octachlorodibenzofuran
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCP	pentachlorophenol
PDM	post-dredge monitoring
PeCDD	pentachlorodibenzo-*p*-dioxin
PeCDF	pentachlorodibenzofuran
ppt	parts per thousand

Acronym	Definition
PSEP	Puget Sound Estuary Program
QAPP	quality assurance project plan
QC	quality control
RL	reporting limit
RPD	relative percent difference
SD	standard deviation
SDG	sample delivery group
SIM	selected ion monitoring
SL	screening level
SMS	Washington State Sediment Management Standards
SQS	sediment quality standards
SRI	supplemental remedial investigation
SRI/FS	supplemental remedial investigation/feasibility study
SRM	standard reference material
SVOC	semivolatile organic compound
T-30	Terminal 30
TBT	tributyltin
TCDD	tetrachlorodibenzo-*p*-dioxin
TCDF	tetrachlorodibenzofuran
TEQ	toxic equivalent
TOC	total organic carbon
U-qualifier	not detected at given concentration
Windward	Windward Environmental LLC
ww	wet weight
Y-qualifier	elevated reporting limit due to analytical interferences

1 Introduction

This data report presents the results of chemical analyses and toxicity tests conducted with surface sediment samples collected from the East Waterway (EW) as part of the supplemental remedial investigation and feasibility study (SRI/FS). The surface sediment quality assurance project plan (QAPP) (Windward 2009b), the intertidal multi-increment sampling (MIS) QAPP (Windward 2009a), and the Terminal 30 (T-30) post-dredge monitoring (PDM) plan (Windward and Anchor 2008) provided the detailed sampling designs and sampling and analytical protocols for the surface sediment data provided in this data report. The results of the SRI surface sediment investigation and the T-30 PDM program are presented together, because both sampling events were requested by the US Environmental Protection Agency (EPA) under the EW Comprehensive Environmental Response, Compensation, and Liability Act order, and the combined dataset will be used for the EW SRI.

Data collected in this study will be used to evaluate risk to humans and ecological receptors from surface sediment exposure in the EW human health and ecological risk assessments. The data will also be used in the SRI to describe the nature and extent of contamination.

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

- Section 2, Surface Sediment Collection Methods
- Section 3, Laboratory Methods
- Section 4, Results
- Section 5, References

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

- Appendix A, Chemistry Data Tables
- Appendix B, Data Management
- Appendix C, Data Validation Reports
- Appendix D, Laboratory Reports
- Appendix E, Collection Forms and Field Notes
- Appendix F, Chain-of-Custody Forms

Appendices C through F, which consist of detailed validation reports and scanned original field and laboratory documents, are provided on the attached CD.

2 Surface Sediment Collection Methods

This section presents the surface sediment sample identification (ID) scheme, sampling locations, summary of collection methods, and field deviations from the QAPPs (Windward 2009a, b; Windward and Anchor 2008) for surface sediment samples collected in the EW. Copies of field notes, surface sediment collection forms, and protocol modification forms are presented in Appendix E. Copies of completed chain of custody (COC) forms used to track sample custody are presented in Appendix F.

2.1 Sample Identification Scheme

The surface sediment sample ID schemes for samples collected according to the surface sediment QAPP (Windward 2009b), referred to as Rounds 1 and 2 below; surface sediment samples collected as part of the T-30 PDM; and subtidal composite samples and intertidal MIS samples (Windward 2009b) are presented in the following subsections.

2.1.1 Surface sediment Rounds 1 and 2

Each surface sediment sampling location has been assigned a unique alphanumeric location ID number. The first characters of the location ID are "EW" to identify the EW project area. The project area designation is followed by "09" to identify the year in which the sample was collected. The next characters are "SS" to indicate the type of sample collected (i.e., surface sediment), followed by a consecutive number identifying the specific location within the EW (e.g., EW09-SS-001).

The sample ID is similar to the location ID but includes the suffix of "010" to indicate that sediment sample is from the 0-to-10-cm depth interval. For example, the sediment sample collected at location EW09-SS-001 is identified as EW09-SS-001-010. Field duplicates are identified using location numbers starting with 300.

Rinsate blanks have been assigned the same characters as those for the sampling locations, followed by the identifier "RB." For example, the rinsate blank collected at EW09-SS-001 is identified as EW09-SS-001-RB.

2.1.2 Terminal 30 post-dredge monitoring

Each surface sediment sampling location has been assigned a unique alphanumeric location ID number. The first characters of the location ID are "T30" to identify the Terminal 30 PDM event. The next two characters designate the sampling year, and the last two characters are consecutive numbers that identify the sampling location. For example, the sample collected at location 1 in 2009 is identified as T30-09-01. Field duplicate samples have been assigned a unique sampling location number starting with 101 (e.g., T30-09-101). Rinsate blanks have been assigned the same characters as those used for the sample identifiers, followed by the identifier "RB." For example, the rinsate blank collected for sample T30-09-01 is identified as T30-09-01-RB.

2.1.3 Subtidal composite samples

Grab samples were composited for 13 subtidal areas. The sample ID for these samples is similar to that of the location ID but includes "CS," to identify that it is a subtidal composite sample, followed by the area from which the subtidal composite sample was derived. Finally, a suffix of "010" indicates that the sediment sample is from the 0-to-10-cm depth interval. For example, the subtidal composite sediment sample created for Area 1 is identified as EW09-CS-001-010.

2.1.4 MIS intertidal samples

Unique alphanumeric sample numbers have been assigned to each discrete surface sediment sample and each MIS composite sample as detailed in the MIS QAPP (Windward 2009a). For the discrete sediment samples, the first four characters are "EW09" to identify the East Waterway project area and the year of collection (2009). The next five characters, "ITSED," identify the sample as intertidal sediment. The next numbers identify the sampling area from which the sample was taken. The final identifier is a consecutive sample number. For example, the sample identifier EW09-01-ITSED01 represents the first discrete sediment sample collected from Area 1.

A unique sample number was assigned to each MIS composite sample once samples had been composited in the laboratory. The three area-wide (e.g., EW-wide) samples are identified as AWMIS samples, and the single public-access sample is identified as PAMIS. The AWMIS samples include a consecutive sample number following the letters "MIS." For example, the first MIS composite sample for the EW-wide intertidal areas is identified as EW09-ITSED-AWMIS-01.

2.2 SAMPLING LOCATIONS

The following subsections provide the location information for the surface sediment grab samples, the samples collected to create the subtidal composite samples, and the MIS intertidal samples.

2.2.1 Surface sediment grab sampling locations

EW Round 1 samples were collected March 1 to 6, 2009; EW Round 2 samples were collected June 22 to 24, 2009; T-30 PDM samples were collected February 18 and 19, 2009. The rationale for selecting sediment sampling locations is presented in the EW surface sediment QAPP (Windward 2009b) and the T-30 PDM plan (Windward and Anchor 2008). Table 2-1 provides the collection dates and times, coordinates, and field-collected data for each sampling location. The target locations and actual locations sampled are provided on Map 2-1. Section 2.3.1 discusses those samples that were collected farther than 10 m from their target locations.

Table 2-1. EW Round 1, EW Round 2, and T-30 post-dredge monitoring surface sediment sampling locations

Sampling Location	Date and Time	Target Location[a]		Actual Location[a]		Distance from Target (m)	Water Depth (m)
		(X)	(Y)	(X)	(Y)		
EW09-SS-001	03/04/09 1625	1267030	211463	1267029	211461	0.68	-5.6
EW09-SS-002	06/24/09 1035	1267119	211479	1267117	211499	6.1	0
EW09-SS-003	03/04/09 1549	1267015	211559	1267061	211559	14	-6.6
EW09-SS-004	06/24/09 1057	1267174	211679	1267165	211681	2.78	0
EW09-SS-005	06/24/09 1140	1267065	211700	1267066	211701	0.43	-8
EW09-SS-006	03/04/09 1526	1267010	211801	1267021	211808	4.0	0
EW09-SS-007	06/23/09 1003	1267344	211945	1267330	211948	4.4	0
EW09-SS-008	06/24/09 1215	1267006	211959	1267005	211954	1.5	-1.5
EW09-SS-009	03/04/09 1502	1267171	212029	1267172	212064	11	-1
EW09-SS-010	06/23/09 1024	1267171	212029	1267383	212101	7	0
EW09-SS-011	03/04/09 1430	1267088	212098	1267091	212087	3.5	-2
EW09-SS-012	03/05/09 0955	1267217	212146	1267207	212224	24	-1.2
EW09-SS-013	06/23/09 1034	1267077	212278	1267083	212277	1.9	-4.5
EW09-SS-014	06/22/09 1228	1267323	212298	1267325	212298	0.61	-6.2
EW09-SS-015	06/22/09 1400	1267387	212335	1267383	212344	3.0	0
EW09-SS-016	06/22/09 1202	1267596	212475	1267551	212483	14	0
EW09-SS-017	03/05/09 1017	1267330	212592	1267331	212586	1.9	-18
EW09-SS-018	03/04/09 1350	1267697	212791	1267755	212811	19	0
EW09-SS-019	03/05/09 1251	1267466	212736	1267474	212736	2.4	-15
EW09-SS-020	06/22/09 1252	1267599	212819	1267594	212822	1.8	-9.5
EW09-SS-021	03/04/09 1322	1267286	212830	1267288	212828	0.89	-11
EW09-SS-022	03/04/09 1300	1267125	212919	1267219	212920	29	-4
EW09-SS-023	03/04/09 1156	1267744	212960	1267743	212957	0.95	-15
EW09-SS-024	06/22/09 1422	1267409	213064	1267409	213062	0.61	-14
EW09-SS-025	03/02/09 1050	1267166	213065	1267167	213067	0.68	-9.7
EW09-SS-026	06/22/09 1318	1267674	213068	1267673	213068	0.30	-17
EW09-SS-027	03/04/09 1137	1267846	213088	1267850	213108	6.1	-11
EW09-SS-028	03/04/09 1114	1267073	213157	1267075	213153	1.3	-20
EW09-SS-029	03/04/09 1054	1267199	213378	1267200	213373	1.7	-14
EW09-SS-030	03/04/09 1034	1267509	213404	1267512	213407	1.2	-16
EW09-SS-031	03/04/09 1015	1267796	213552	1267791	213555	1.7	-17
EW09-SS-032	03/04/09 0930	1267438	213694	1267436	213693	0.76	-16
EW09-SS-033	03/04/09 0953	1267168	213772	1267166	213771	0.69	-15
EW09-SS-034	03/04/09 0909	1267730	213822	1267732	213815	2.2	-18

Sampling Location	Date and Time	Target Location[a]		Actual Location[a]		Distance from Target (m)	Water Depth (m)
		(X)	(Y)	(X)	(Y)		
EW09-SS-035	06/22/09 1459	1267081	213932	1267081	213933	0.33	-16
EW09-SS-036	03/04/09 0952	1267451	213969	1267395	214000	20	-16
EW09-SS-037	06/22/09 1340	1267626	214038	1267623	214036	0.92	-16
EW09-SS-038	06/22/09 1436	1267842	214046	1267846	214050	1.7	-13
EW09-SS-039	03/04/09 1035	1267162	212555	1267153	212597	13	-6.2
EW09-SS-040	03/04/09 1122	1267752	213333	1267753	213333	0.38	-27
EW09-SS-100	03/04/09 0843	1267027	214201	1267016	214210	4.3	-12
EW09-SS-101	06/22/09 1515	1267835	214262	1267840	214257	2.2	-13
EW09-SS-102	03/02/09 1036	1267150	214469	1267182	214443	12	-19
EW09-SS-103	06/22/09 1532	1267787	214525	1267786	214525	0.36	-16
EW09-SS-104	06/23/09 1108	1268359	214566	1268357	214572	1.8	-8.5
EW09-SS-105	06/23/09 1050	1268392	214696	1268389	214696	1.0	-13
EW09-SS-106	06/22/09 1642	1268158	214725	1268153	214726	1.5	0
EW09-SS-107	03/02/09 1014	1267935	214849	1267921	214851	4.2	0
EW09-SS-108	03/04/09 1208	1267146	214907	1267144	214903	1.5	-19
EW09-SS-109	03/02/09 0933	1268102	214916	1268100	214913	1.2	-10
EW09-SS-110	06/22/09 1550	1268241	215015	1268243	215019	1.3	-8.2
EW09-SS-111	03/02/09 0906	1267196	215035	1267196	215037	0.61	-20
EW09-SS-112	03/04/09 1305	1267987	215125	1267985	215131	2.0	-14
EW09-SS-113	06/22/09 1610	1267798	215150	1267798	215149	0.30	-15
EW09-SS-114	03/02/09 0829	1267049	215411	1267035	215406	4.4	-9.4
EW09-SS-115	06/22/09 1701	1267805	215433	1267818	215397	12	-15
EW09-SS-116	03/01/09 1554	1267257	215759	1267255	215762	1.1	-20
EW09-SS-118	03/01/09 1615	1267363	215923	1267364	215920	0.90	-19
EW09-SS-119	06/22/09 1716	1267535	216180	1267532	216179	0.81	-17
EW09-SS-120	03/01/09 1530	1267238	216343	1267256	216342	5.4	-18
EW09-SS-121	06/23/09 1702	1267499	216420	1267502	216417	1.3	-19
EW09-SS-122	06/23/09 1648	1267192	216667	1267186	216668	1.8	-16
EW09-SS-123	06/23/09 1624	1267534	216741	1267531	216756	4.7	-19
EW09-SS-124	03/05/09 0855	1267335	216885	1267334	216891	1.8	-20
EW09-SS-125	03/01/09 1512	1267276	217256	1267272	217261	1.9	-20
EW09-SS-126	06/23/09 1608	1267086	217296	1267067	217295	5.9	-10
EW09-SS-127	03/01/09 1453	1267422	217317	1267421	217316	0.43	-18
EW09-SS-128	03/01/09 1435	1267627	217355	1267629	217363	2.4	-19
EW09-SS-129	06/23/09 1545	1267910	217491	1267908	217496	1.5	-10
EW09-SS-130	03/01/09 1636	1267279	217523	1267267	217523	3.6	-16

Sampling Location	Date and Time	Target Location[a]		Actual Location[a]		Distance from Target (m)	Water Depth (m)
		(X)	(Y)	(X)	(Y)		
EW09-SS-131	06/22/09 1626	1267490	217547	1267482	217548	2.5	-18
EW09-SS-132	06/23/09 1538	1267117	215721	1267118	215706	4.5	-17
EW09-SS-133	03/01/09 1410	1267097	214637	1267102	214630	2.7	-18
EW09-SS-134	06/23/09 1502	1267658	217679	1267657	217669	3.0	-17
EW09-SS-200	03/01/09 1349	1267828	217834	1267829	217833	0.49	-11
EW09-SS-201	06/23/09 1354	1267454	217834	1267458	217833	1.1	-17
EW09-SS-202	03/01/09 1315	1267156	217860	1267157	217847	3.9	-16
EW09-SS-203	06/23/09 1319	1267252	218104	1267298	218114	14	-17
EW09-SS-204	06/23/09 1153	1267802	218285	1267800	218283	0.82	-13
EW09-SS-205	03/01/09 1256	1267257	218379	1267251	218363	5.1	-17
EW09-SS-206	06/23/09 1132	1267911	218526	1267860	218544	16	-6
EW09-SS-207	06/23/09 1436	1267172	218574	1267182	218590	5.6	-16
EW09-SS-208	06/23/09 1305	1267826	218789	1267898	218719	40	-6.2
EW09-SS-209	03/04/09 1434	1267826	218789	1267820	218797	3.0	-17
EW09-SS-210	06/23/09 1415	1267238	218821	1267243	218823	1.7	-15
EW09-SS-211	06/22/09 1036	1267133	218823	1267130	218822	0.87	-10
EW09-SS-212	06/22/09 1007	1267657	218838	1267658	218836	0.73	-16
EW09-SS-213	06/22/09 1121	1268348	218906	1268346	218903	1.2	-11
EW09-SS-214	03/01/09 1221	1268121	218951	1268122	218955	1.3	-12
EW09-SS-215	03/01/09 1130	1268990	218971	1268971	218968	5.9	-10
EW09-SS-216	03/01/09 1104	1267849	219059	1267853	219059	1.3	-14
EW09-SS-217	03/04/09 1512	1267274	219269	1267301	219270	8.3	-17
EW09-SS-218	03/01/09 0956	1267443	219327	1267468	219325	7.8	-18
EW09-SS-219	06/23/09 0929	1267974	219385	1267959	219386	4.6	-8.2
EW09-SS-220	06/23/09 0857	1267776	219554	1267783	219553	2.1	-19
EW09-SS-221	06/22/09 0903	1267683	219341	1267685	219343	0.75	-16
EW09-SS-222	02/18/09 0921	1267915	219529	1267923	219524	3.0	-16
EW09-SS-223	02/18/09 1003	1267927	219710	1267907	219714	6.2	-16
T30-01	02/18/09 1107	1267744	215688	1267740	215684	1.8	-19
T30-03	02/18/09 1157	1267828	215723	1267828	215721	0.67	-19
T30-04	02/18/09 1018	1267748	215903	1267751	215904	1.07	-19
T30-06	02/18/09 1050	1267832	215903	1267824	215902	2.43	-19
T30-07	02/18/09 1348	1267744	216056	1267740	216055	1.3	-14
T30-09	02/18/09 1444	1267828	216056	1267819	216066	4.1	-16
T30-13	02/18/09 1335	1267748	216344	1267745	216342	1.03	-20
T30-14	02/18/09 1455	1267830	216343	1267836	216340	1.9	-19

Sampling Location	Date and Time	Target Location[a]		Actual Location[a]		Distance from Target (m)	Water Depth (m)
		(X)	(Y)	(X)	(Y)		
T30-20	02/19/09 0957	1267828	216602	1267831	216605	1.3	-18
T30-21	02/19/09 1029	1267744	216722	1267744	216725	0.88	-17
T30-24	02/19/09 0928	1267832	216849	1267837	216846	1.88	-19
T30-26	03/04/09 1644	1267828	216968	1267863	216968	11	-19
T30-27	02/19/09 1007	1267748	217104	1267748	217103	0.23	-19
T30-28	02/19/09 1017	1267832	217104	1267839	217101	2.32	-19
T30-29	06/24/09 1010	1267744	217207	1267746	217213	1.9	-19
T30-31	02/19/09 1104	1267748	217315	1267747	217318	0.95	-19

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

NAD83 – North American Datum of 1983

2.2.2 Subtidal composite

Thirty-eight grab samples were collected to represent areas that were not sampled in Rounds 1 and 2 in the subtidal composite samples. These areas had sufficient surface sediment data and did not require additional sampling; however, samples were required to represent these areas in the subtidal composite samples. The rationale for selecting sediment sampling locations is presented in the surface sediment QAPP (Windward 2009b). As described in the QAPP, subtidal grab samples were collected to provide coverage in areas where surface grabs were not proposed because of the availability of historical data for Washington State Sediment Management Standards (SMS) chemicals in these areas. Locations that were sampled solely to contribute sediment to subtidal composite samples are provided in Table 2-2 and shown on Map 2-2.

Table 2-2. Surface sediment sampling locations for samples collected for subtidal composite samples

Sampling Location	Date and Time	Target Location[a]		Actual Location[a]		Distance from Target (m)	Water Depth (m)
		(X)	(Y)	(X)	(Y)		
EW09-SS-501	03/05/09 1034	1267289	213201	1267286	213203	1.0	-12
EW09-SS-502	03/05/09 1047	1267293	213498	1267292	213495	0.8	-13
EW09-SS-503	03/05/09 1100	1267274	213960	1267276	213959	0.7	-12
EW09-SS-504	03/05/09 1113	1267327	214203	1267330	214199	1.7	-16
EW09-SS-505	03/05/09 1126	1267625	214212	1267622	214211	0.9	-16
EW09-SS-506	03/05/09 1137	1267479	214421	1267485	214418	2.2	-16
EW09-SS-507	03/05/09 1147	1267671	214464	1267671	214465	0.3	-16
EW09-SS-508	03/05/09 1200	1267310	214765	1267307	214765	0.8	-16
EW09-SS-509	03/05/09 1343	1268266	214777	1268265	214775	0.7	-12
EW09-SS-510	03/05/09 1355	1267559	214828	1267557	214825	1.1	-16
EW09-SS-511	03/05/09 1404	1268002	214972	1267999	214970	1.2	-9

Sampling Location	Date and Time	Target Location[a]		Actual Location[a]		Distance from Target (m)	Water Depth (m)
		(X)	(Y)	(X)	(Y)		
EW09-SS-512	03/05/09 1414	1268089	215024	1268089	215023	0.3	-14
EW09-SS-513	03/05/09 1423	1267330	215140	1267329	215143	0.8	-16
EW09-SS-514	03/05/09 1432	1267593	215235	1267595	215240	1.6	-16
EW09-SS-515	03/05/09 1440	1267582	215504	1267580	215500	1.4	-16
EW09-SS-516	03/05/09 1450	1267221	215544	1267223	215543	0.8	-16
EW09-SS-517	03/05/09 1459	1267608	215917	1267608	215915	0.6	-16
EW09-SS-518	03/06/09 0836	1267228	215991	1267227	215992	0.6	-16
EW09-SS-519	03/05/09 1516	1267681	216258	1267682	216260	0.7	-16
EW09-SS-520	03/05/09 1525	1267338	216715	1267342	216708	2.3	-16
EW09-SS-521	03/06/09 0900	1267665	217049	1267663	217052	1.1	-16
EW09-SS-522	03/05/09 0918	1267772	217451	1267772	217455	1.3	-15
EW09-SS-523	03/05/09 0928	1267668	217763	1267669	217764	0.6	-16
EW09-SS-524	03/05/09 0936	1267565	218061	1267564	218065	1.4	-16
EW09-SS-525	03/05/09 0949	1267606	218283	1267605	218283	0.3	-16
EW09-SS-526	03/06/09 1020	1267399	218511	1267397	218506	1.7	-18
EW09-SS-527	03/06/09 1028	1267405	218820	1267406	218816	1.2	-17
EW09-SS-528	06/22/09 1057	1268682	218940	1268685	218966	7.9	-12
EW09-SS-529	06/22/09 1047	1268475	218967	1268478	218970	1.3	-11
EW09-SS-530	06/22/09 1109	1268871	219023	1268866	219035	4.0	-10
EW09-SS-531	06/22/09 0955	1268039	219050	1268037	219041	2.8	-12
EW09-SS-532	06/22/09 1027	1268313	219064	1268314	219068	1.4	-11
EW09-SS-533	03/06/09 1047	1267411	219112	1267412	219111	0.5	-18
EW09-SS-534	03/06/09 1105	1267665	219261	1267664	219260	0.5	-16
EW09-SS-535	03/06/09 0847	1267419	215558	1267419	215558	0.1	-16
EW09-SS-536	03/06/09 0909	1267279	217057	1267283	217063	2.1	-16
EW09-SS-537	03/06/09 0957	1267838	218078	1267841	218078	0.9	-12

[a] Coordinates given in NAD83 horizontal datum; X-Y coordinates in Washington State Plane N (US ft).
NAD83 – North American Datum of 1983

2.2.3 Intertidal MIS composite

Intertidal MIS samples were collected from August 17 to 20, 2009. The rationale for selecting sediment sampling locations is presented in the MIS QAPP (Windward 2009a). As described in the MIS QAPP, 11 intertidal areas were sampled using a grid technique, with a total of 140 samples collected to form the three area-wide and one public access intertidal MIS composite sample. Sampling areas and locations for individual sediment samples are shown on Map 2-3.

2.3 SAMPLE COLLECTION METHODS

2.3.1 Surface sediment samples

Sediment samples were collected following standardized procedures provided in the surface sediment QAPP (Windward 2009b). Surface sediments were collected from each location using a 0.1-m^2 single or double van Veen grab sampler (228 surface sediment grab samples), a 20-cm diameter (8 diver-collected samples), or a pre-cleaned stainless steel spoon (12 intertidal locations).

Each successful grab sample was evaluated for acceptability in accordance with the surface sediment QAPP (Windward 2009b). Sediment from the first acceptable grab at each location was collected for ammonia and total sulfides analyses prior to the collection and homogenization of sediment for the remaining chemical and toxicity analyses. At each grab location, one to two 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-to-10-cm depth interval, when possible, and homogenized in a clean, stainless steel bowl or stockpot using a stainless steel spoon until the texture and color were homogenous. The sediment penetration depths for each grab are included in Appendix E. Homogenized sediment was then split into the appropriate sample containers for chemical and toxicity analyses.

Subtidal composite samples were created at Analytical Resources, Inc. (ARI), using equal volumes of homogenized sediment from the 8 to 10 locations identified for each composite sample (Map 2-2). Composites were homogenized in a clean stainless steel bowl and then split into appropriate containers for analysis.

2.3.2 Intertidal MIS samples

The intertidal MIS samples were collected following the protocols described in the MIS QAPP (Windward 2009a). A reconnaissance survey was conducted to identify all accessible intertidal areas in the EW; 11 intertidal areas were identified (Map 2-3).The intertidal areas were calculated for each exposed area in order to determine the appropriate number of individual samples to be collected in each area. The two largest areas identified were Areas 1 and 3, with over a 1,000 m^2 each. These two areas represent 50% of the total intertidal area in the EW.

Each MIS sample was created from individual samples collected from at least 30 discrete locations. Two different types of MIS samples were collected: area-wide samples created for the tribal clamming and habitat restoration worker scenarios, and one sample created for the public-access areas for the 7-days-per-year clamming scenario. Three replicate samples were created for the area-wide samples, and one sample was created for the public-access areas. The variance of the area-wide samples will be used to estimate the variance around the public-access area sample for the purposes of calculating EPC values. Each area-wide MIS sample was created from 32 discrete samples, and the public-access area sample was created from 36 discrete samples.

The two largest sampling areas (Areas 1 and 3) were divided into three approximately equal subareas in the field. For all areas and subareas, the field crew measured the extent of the exposed intertidal area that had sediment that could be sampled. This area did not include intertidal areas that contained only riprap or cobble. The sampling area was then divided into grid cells based on the number of samples required for the area. Individual samples were collected from each grid cell. The grids established in the field were specific to the intertidal area on the day of sampling. The sampling locations for the intertidal MIS samples are shown on Map 2-3.

The target sediment depth for the discrete samples was 0.3 m (12 in.) in all areas except the southernmost subarea in Area 1, where the target depth was 0.46 m (18 in.). The sediment depths are consistent with potential sediment depths for clams and are therefore representative of potential clamming exposure. The southernmost portion of Area 1 is the only area where *Mya arenaria* were collected during the clam survey. This species can be found at depths greater than those of other clam species, so the target depth in that area was 0.46 m, rather than 0.3 m. The sediment samples were collected from the perimeter of a hole dug to the target depth with a shovel. The samples were collected using a stainless steel spoon, and every effort was made to sample an equal volume throughout the depth of the sample. If the target depth could not be achieved, then another attempt was made within the sample grid. If the target depth was not achieved after two attempts, then the sample was collected from the deepest available sediment depth.

The coordinates of the sampling location were recorded. At each discrete sampling location, the sediment sample was homogenized following protocols in the surface sediment QAPP (Windward 2009b), and two 8-oz jars were filled. Large rocks and shell debris were excluded from the homogenized sample to the extent practicable. One jar was used to create the MIS composite sample at ARI, and the other jar was archived for potential future analysis.

2.3.3 Field deviations from the QAPP

Field deviations from the surface sediment QAPP (Windward 2009b) included modifications to grab locations and acceptable sample penetration depths. These field deviations did not affect the data quality. The deviations were as follows:

- Samples collected at locations EW09-SS-039, EW09-SS-203, EW09-SS-218, EW09-SS-222, and EW09-SS-223 did not meet the 10-cm minimum penetration depth requirement because of the coarse bottom substrate. Multiple unsuccessful attempts were made before accepting grabs that did not meet the penetration depth requirements.

- Nine samples were collected from locations further than 10 m from their target sampling locations. Table 2-3 provides the rationale for these field deviations.
- There were difficulties in obtaining accurate global positioning system (GPS) coordinates at the head of the waterway because of overhead structures (e.g., bridges). Sampling locations were determined based on the sample location maps and relative distance to landmarks or the shoreline. For one location (SS-010), the location was identified based on the position relative to the shoreline and bridge structures because of problems with the GPS coordinates. Coordinates were plotted and reviewed relative to the field notes regarding the sample location in order to ensure the accuracy of the coordinates in areas where there were difficulties with the GPS.
- Thirty-eight additional subtidal samples were collected instead of the nineteen specified by the QAPP (Windward 2009b).
- To create the subtidal composites, four archived T-30 samples were included to represent the T-30 area.

Table 2-3. Actual sampling locations that were > 10 m from their target sampling locations

Sampling Location	Distance from Target (m)	Rationale
EW09-SS-009	11	Unable to obtain accurate GPS reading because target location was near or under bridge structures. Sample was collected as close to target location as possible, as positioned with GPS unit.
EW09-SS-012	24	Unable to obtain accurate GPS reading because target location was located near or under bridge structures. Sample was collected as close to target location as possible, as positioned with GPS unit.
EW09-SS-036	20	Unable to obtain accurate GPS reading because target location was located near or under dock structures. Sample was collected as close to target location as possible, as positioned with GPS unit.
EW09-SS-039	13	Cargo container was blocking the target location. Sample was collected at location closest to target coordinates.
EW09-SS-102	12	Unable to obtain accurate GPS reading because target location was located near or under dock structures. Sample was collected as close to target location as possible, as positioned with GPS unit.
EW09-SS-115	12	Unable to obtain accurate GPS reading because target location was located near or under dock structures. Sample was collected as close to target location as possible, as positioned with GPS unit.
EW09-SS-203	14	Coarse substrate prevented successful grabs at the target location and surrounding area. First acceptable grab was collected from beyond a 10-m radius.
EW09-SS-206	16	Intertidal location was dominated by riprap and gravel. Sample was collected at location closest to target coordinates that had available sediment.
EW09-SS-208	40	Intertidal location was dominated by riprap and gravel. Sample was collected at location closest to target coordinates that had available sediment.

GPS – global positioning system

3 Laboratory Methods

This section briefly describes the methods used to chemically analyze sediment samples and conduct sediment toxicity testing; these methods are described in detail in the surface sediment QAPP (Windward 2009b) and T-30 PDM plan (Windward and Anchor 2008). This section also summarizes any laboratory deviations from the QAPP.

3.1 Methods for Chemical Analyses

Table 3-1 summarizes, by type of analysis, the number of sediment samples analyzed for surface sediment samples, subtidal composite samples, and intertidal MIS samples. Table 3-2 lists the analyses conducted for each sample.

Table 3-1. Summary of sediment samples and analyses

Chemical Group	No. of Samples Analyzed				
	Surface Sediment Grabs			Subtidal Composites	MIS Intertidal Composites
	Bioassay Reference	Rounds 1 and 2	T-30		
Metals		104	17		4
Butyltins		49			4
SVOCs		105	17		4
PCB Aroclors		105	17	13	4
Pesticides		29			4
Grain size	6	104	10		
Total solids and TOC	6	105	17	13	4
Ammonia and total sulfides	6	104			
PCB congeners				13	4
Dioxins and furans				13	4

MIS – multi-increment sampling
PCB – polychlorinated biphenyl
SVOC – semivolatile organic compound
T-30 – Terminal 30
TOC – total organic carbon

Table 3-2. Surface sediment chemical analyses

Sample ID	Metals	SVOCs	PCB Aroclors	Ammonia and Total Sulfides	TOC and Total Solids	Grain Size	Butyltins	Pesticides	Dioxins and Furans	PCB Congeners
Bioassay Reference Sediments										
CI09-SS-020-010				X	X	X				
CI09-SS-060-010				X	X	X				
CI09-SS-080-010				X	X	X				
CI09-SS-120-010				X	X	X				
CI09-SS-140-010				X	X	X				
CI09-SS-180-010				X	X	X				
Surface Sediment Grab Samples										
EW09-SS-001-010	X	X	X	X	X	X				
EW09-SS-002-010	X	X	X	X	X	X				
EW09-SS-003-010	X	X	X	X	X	X	X			
EW09-SS-004-010	X	X	X	X	X	X	X			
EW09-SS-005-010	X	X	X	X	X	X				
EW09-SS-006-010	X	X	X	X	X	X	X			
EW09-SS-007-010	X	X	X	X	X	X				
EW09-SS-008-010	X	X	X	X	X	X		X		
EW09-SS-009-010	X	X	X	X	X	X				
EW09-SS-010-010	X	X	X	X	X	X	X			
EW09-SS-011-010	X	X	X	X	X	X		X		
EW09-SS-012-010	X	X	X	X	X	X				
EW09-SS-013-010	X	X	X	X	X	X	X	X		
EW09-SS-014-010	X	X	X	X	X	X				
EW09-SS-015-010	X	X	X	X	X	X		X		
EW09-SS-016-010	X	X	X	X	X	X				
EW09-SS-017-010	X	X	X	X	X	X	X			
EW09-SS-018-010	X	X	X	X	X	X				
EW09-SS-019-010	X	X	X	X	X	X				

Sample ID	Metals	SVOCs	PCB Aroclors	Ammonia and Total Sulfides	TOC and Total Solids	Grain Size	Butyltins	Pesticides	Dioxins and Furans	PCB Congeners
EW09-SS-020-010	X	X	X	X	X	X				
EW09-SS-021-010	X	X	X	X	X	X		X		
EW09-SS-022-010	X	X	X	X	X	X	X			
EW09-SS-023-010	X	X	X	X	X	X		X		
EW09-SS-024-010	X	X	X	X	X	X	X			
EW09-SS-025-010	X	X	X	X	X	X				
EW09-SS-026-010	X	X	X	X	X	X				
EW09-SS-027-010	X	X	X	X	X	X	X			
EW09-SS-028-010	X	X	X	X	X	X				
EW09-SS-029-010	X	X	X	X	X	X	X			
EW09-SS-030-010	X	X	X	X	X	X	X	X		
EW09-SS-031-010	X	X	X	X	X	X				
EW09-SS-032-010	X	X	X	X	X	X				
EW09-SS-033-010	X	X	X	X	X	X	X	X		
EW09-SS-034-010	X	X	X	X	X	X	X			
EW09-SS-035-010	X	X	X	X	X	X				
EW09-SS-036-010	X	X	X	X	X	X	X			
EW09-SS-037-010	X	X	X	X	X	X				
EW09-SS-038-010	X	X	X	X	X	X	X	X		
EW09-SS-039-010	X	X	X	X	X	X				
EW09-SS-040-010	X	X	X	X	X	X				
EW09-SS-100-010	X	X	X	X	X	X	X			
EW09-SS-101-010	X	X	X	X	X	X				
EW09-SS-102-010	X	X	X	X	X	X				
EW09-SS-103-010	X	X	X	X	X	X				
EW09-SS-104-010	X	X	X	X	X	X				
EW09-SS-105-010	X	X	X	X	X	X	X	X		
EW09-SS-106-010	X	X	X	X	X	X	X	X		
EW09-SS-107-010	X	X	X	X	X	X	X			

Sample ID	Metals	SVOCs	PCB Aroclors	Ammonia and Total Sulfides	TOC and Total Solids	Grain Size	Butyltins	Pesticides	Dioxins and Furans	PCB Congeners
EW09-SS-108-010	X	X	X	X	X	X	X			
EW09-SS-109-010	X	X	X	X	X	X				
EW09-SS-110-010	X	X	X	X	X	X	X	X		
EW09-SS-111-010	X	X	X	X	X	X				
EW09-SS-112-010	X	X	X	X	X	X				
EW09-SS-113-010	X	X	X	X	X	X	X	X		
EW09-SS-114-010	X	X	X	X	X	X	X			
EW09-SS-115-010	X	X	X	X	X	X	X			
EW09-SS-116-010	X	X	X	X	X	X				
EW09-SS-118-010	X	X	X	X	X	X	X	X		
EW09-SS-119-010	X	X	X	X	X	X	X			
EW09-SS-120-010	X	X	X	X	X	X				
EW09-SS-121-010	X	X	X	X	X	X				
EW09-SS-122-010	X	X	X	X	X	X	X	X		
EW09-SS-123-010	X	X	X	X	X	X	X	X		
EW09-SS-124-010	X	X	X	X	X	X	X	X		
EW09-SS-125-010	X	X	X	X	X	X				
EW09-SS-126-010	X	X	X	X	X	X	X			
EW09-SS-127-010	X	X	X	X	X	X	X			
EW09-SS-128-010	X	X	X	X	X	X				
EW09-SS-129-010	X	X	X	X	X	X	X	X		
EW09-SS-130-010	X	X	X	X	X	X				
EW09-SS-131-010	X	X	X	X	X	X				
EW09-SS-132-010	X	X	X	X	X	X				
EW09-SS-133-010	X	X	X	X	X	X	X			
EW09-SS-134-010	X	X	X	X	X	X				
EW09-SS-200-010	X	X	X	X	X	X	X	X		
EW09-SS-201-010	X	X	X	X	X	X	X			
EW09-SS-202-010	X	X	X	X	X	X				

Sample ID	Metals	SVOCs	PCB Aroclors	Ammonia and Total Sulfides	TOC and Total Solids	Grain Size	Butyltins	Pesticides	Dioxins and Furans	PCB Congeners
EW09-SS-203-010	X	X	X	X	X	X	X	X		
EW09-SS-204-010	X	X	X	X	X	X	X	X		
EW09-SS-205-010	X	X	X	X	X	X	X	X		
EW09-SS-206-010	X	X	X	X	X	X		X		
EW09-SS-207-010	X	X	X	X	X	X	X			
EW09-SS-208-010	X	X	X	X	X	X		X		
EW09-SS-209-010	X	X	X	X	X	X				
EW09-SS-210-010	X	X	X	X	X	X				
EW09-SS-211-010	X	X	X	X	X	X	X			
EW09-SS-212-010	X	X	X	X	X	X	X			
EW09-SS-213-010	X	X	X	X	X	X		X		
EW09-SS-214-010	X	X	X	X	X	X	X			
EW09-SS-215-010	X	X	X	X	X	X	X			
EW09-SS-216-010	X	X	X	X	X	X	X			
EW09-SS-217-010	X	X	X	X	X	X				
EW09-SS-218-010	X	X	X	X	X	X	X			
EW09-SS-219-010	X	X	X	X	X	X	X			
EW09-SS-220-010	X	X	X	X	X	X	X	X		
EW09-SS-221-010	X	X	X	X	X	X				
EW09-SS-222-010	X	X	X	X	X	X				
EW09-SS-223-010	X	X	X	X	X	X				
EW09-SS-300-010	X	X	X	X	X	X	X	X		
EW09-SS-301-010	X	X	X	X	X	X				
EW09-SS-302-010	X	X	X	X	X	X				
EW09-SS-303-010	X	X	X	X	X	X				
EW09-SS-304-010	X	X	X	X	X	X	X	X		
EW09-SS-305-010	X	X	X	X	X	X		X		
LSO-01SE-080723[a]		X			X					

Sample ID	Metals	SVOCs	PCB Aroclors	Ammonia and Total Sulfides	TOC and Total Solids	Grain Size	Butyltins	Pesticides	Dioxins and Furans	PCB Congeners
Subtidal Composite Samples										
EW09-CS-001-010			X		X				X	X
EW09-CS-002-010			X		X				X	X
EW09-CS-003-010			X		X				X	X
EW09-CS-004-010			X		X				X	X
EW09-CS-005-010			X		X				X	X
EW09-CS-006-010			X		X				X	X
EW09-CS-007-010			X		X				X	X
EW09-CS-008-010			X		X				X	X
EW09-CS-009-010			X		X				X	X
EW09-CS-010-010			X		X				X	X
EW09-CS-011-010			X		X				X	X
EW09-CS-012-010			X		X				X	X
EW09-CS-013-010			X		X				X	X
MIS Intertidal Composite Samples										
EW09-ITSED-AWMIS-01	X	X	X		X		X	X	X	X
EW09-ITSED-AWMIS-02	X	X	X		X		X	X	X	X
EW09-ITSED-AWMIS-03	X	X	X		X		X	X	X	X
EW09-ITSED-PAMIS-01	X	X	X		X		X	X	X	X
T-30 PDM Samples										
T30-09-01	X	X	X		X	X				
T30-09-03	X	X	X		X	X				
T30-09-04	X	X	X		X					
T30-09-06	X	X	X		X					
T30-09-07	X	X	X		X	X				
T30-09-09	X	X	X		X	X				
T30-09-13	X	X	X		X					
T30-09-101	X	X	X		X	X				
T30-09-14	X	X	X		X	X				

Sample ID	Metals	SVOCs	PCB Aroclors	Ammonia and Total Sulfides	TOC and Total Solids	Grain Size	Butyltins	Pesticides	Dioxins and Furans	PCB Congeners
T30-09-20	X	X	X		X	X				
T30-09-21	X	X	X		X	X				
T30-09-24	X	X	X		X					
T30-09-26	X	X	X		X	X				
T30-09-27	X	X	X		X					
T30-09-28	X	X	X		X					
T30-09-29	X	X	X		X	X				
T30-09-31	X	X	X		X					
Total	**125**	**126**	**138**	**110**	**145**	**120**	**53**	**33**	**17**	**17**

[a] Sample LSO-01-SE-080723 was collected by Anchor and analyzed for metals by Brooks Rand Laboratories (Anchor 2008). It was collected prior to the T-30 dredging project and represents pre-dredge conditions consistent with the rockfish sample collected in this area prior to dredging.

Anchor – Anchor Environmental LLC
ID – identification
PCB – polychlorinated biphenyl
PDM – post-dredge monitoring
SVOC – semivolatile organic compound
T-30 – Terminal 30
TOC – total organic carbon

All results presented in this data report are from analyses conducted by ARI. The results of dioxin/furan and polychlorinated biphenyl (PCB) congener analyses of surface sediment composite samples, which are currently being conducted by Analytical Perspectives (AP), will be presented in the draft final data report. Sample LSO-01SE-080723 was collected by Anchor Environmental LLC (Anchor) on July 23, 2008, for metals analysis by Brooks Rand Laboratories (Anchor 2008). This sample was selected for analysis because it was collected prior to the T-30 dredging project and represents pre-dredge conditions consistent with the rockfish sample collected in this area prior to dredging. The remaining archived sample volume was transferred from Brooks Rand Laboratories to ARI for the analysis of semivolatile organic compounds (SVOCs), PCB Aroclors, total organic carbon (TOC), and total solids. Analytical methods are presented in Table 3-3.

Table 3-3. Laboratory analytical methods for surface sediment samples

Parameter	Laboratory	Method	Reference
PCBs as Aroclors	ARI	GC/ECD	EPA 8082
PCB congeners	AP	HRGC/HRMS	EPA 1668
Dioxins and furans	AP	HRGC/HRMS	EPA 1613B
SVOCs (including PAHs)[a]	ARI	GC/MS	EPA 8270D
Selected SVOCs[b]	ARI	GC/MS	EPA 8270D-SIM
Organochlorine pesticides[c]	ARI	GC/ECD	EPA 8081A
Mercury	ARI	CVAA	EPA 7471A
Other metals[d]	ARI	ICP-AES and ICP-MS	EPA 6010B and EPA 200.8
Tributyltin, dibutyltin, monobutyltin (as ions)	ARI	GC/MS-SIM	Krone et al. (1989)
Grain size	ARI	sieve/pipette	PSEP (1986)
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	EPA 350.1 (modified)

a Target PAHs include: 1-methylnaphthalene, 2-chloronaphthalene, 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene.

b Selected SVOCs by SIM include: 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 2-methylphenol, benzyl alcohol, butyl benzyl phthalate, di-ethyl phthalate, di-methyl phthalate, hexachlorobenzene, hexachlorobutadiene, n-nitrosodimethylamine, n-nitrosodiphenylamine, n-nitroso-di-n-propylamine, and pentachlorophenol.

c Target pesticides include: 2,4′-DDT, 2,4′-DDE, 2,4′-DDD, 4,4′-DDT, 4,4′-DDE, 4,4′-DDD, aldrin, alpha-BHC, beta-BHC, delta-BHC, gamma-BHC, oxychlordane, alpha- and gamma-chlordane, cis- and trans-nonachlor, dieldrin, alpha-endosulfan, beta-endosulfan, endosulfan sulfate, endrin, endrin aldehyde, endrin ketone, heptachlor, heptachlor epoxide, hexachlorobenzene, methoxychlor, Mirex, and toxaphene.

d For the EW surface sediment samples, arsenic, selenium, and thallium were analyzed by EPA 200.8 using ICP-MS; antimony, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, selenium, silver, vanadium, and zinc were analyzed by EPA 6010B using ICP-AES. For the T-30 surface sediment samples, antimony, arsenic, cadmium, chromium, copper, lead, nickel, silver, and zinc were analyzed by EPA 6010B using ICP-AES.

AP – Analytical Perspectives
ARI – Analytical Resources, Inc.
BHC – benzene hexachloride
CVAA – cold vapor atomic absorption
DDD – dichlorodiphenyldichloroethane
DDE – dichlorodiphenyldichloroethylene
DDT – dichlorodiphenyltrichloroethane
EPA – US Environmental Protection Agency
EW – East Waterway
GC/ECD – gas chromatography/electron capture detection
GC/MS – gas chromatography/mass spectrometry
HRGC/HRMS – high-resolution gas chromatography/ high-resolution mass spectrometry
ICP-AES – inductively coupled plasma-atomic emission spectrometry
ICP-MS – inductively coupled plasma-mass spectrometry
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
PSEP – Puget Sound Estuary Program
SIM – selected ion monitoring
SVOC – semivolatile organic compound
T-30 – Terminal 30
TOC – total organic carbon

3.2 METHODS FOR TOXICITY TESTING

Sediment samples were selected for toxicity testing in consultation with EPA based on an evaluation of preliminary, unvalidated chemical concentrations. Samples were selected for toxicity testing if the chemical analysis results identified sediment quality standards (SQS) exceedances but no cleanup screening level (CSL) exceedances for all chemicals other than PCBs. Three standard SMS sediment toxicity tests were conducted with split sediment samples from each of nine selected locations from Round 1 and two selected locations from Round 2. These tests were:

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

Northwestern Aquatic Sciences conducted all the sediment toxicity tests. Sediment collected in Round 1 was tested with *Mytilus galloprovincialis,* and sediment collected in Round 2 was tested with *Crassostrea gigas.* Two different species were used because of seasonality in spawning and quality of the eggs and sperms. 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 Sediment Management Annual Review Meetings. The toxicity test methods are presented in detail in the surface sediment QAPP (Windward 2009b). The sediment toxicity tests were conducted in two rounds (Table 3-4).

Table 3-4. Toxicity test schedule

Test Round	Selected Sampling Locations	Amphipod Tests	Polychaete Tests	Bivalve Larvae Tests
Round 1	EW09-SS-005-010 EW09-SS-030-010 EW09-SS-032-010 EW09-SS-033-010 EW09-SS-034-010 EW09-SS-035-010 EW09-SS-217-010 EW09-SS-218-010 EW09-SS-220-010	Start Date: April 21, 2009 End Date: May 1, 2009	Start Date: April 17, 2009 End Date: May 7, 2009	Start Date: April 22, 2009 End Date: April 24, 2009
Round 2	EW09-SS-015-010 EW09-SS-215-010	Start Date: August 11, 2009 End Date: August 21, 2009	Start Date: August 11, 2009 End Date: August 31, 2009	Start Date: August 12, 2009 End Date: August 14, 2009

None of the samples were purged prior to the performance of the toxicity tests. All samples were aerated during testing according to the surface sediment QAPP (Windward 2009b).

The negative control sediment for the amphipod and polychaete tests was collected from the lower Yaquina Bay in Oregon, sieved through a 0.5--mm stainless steel screen, and stored at 4°C in the dark until test initiation.

The positive control tests were performed concurrently with the sediment toxicity tests. Reference toxicants were ammonia as ammonium chloride for the amphipod and polychaete tests and cadmium chloride 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.

Toxicity testing protocols require that test sediments be matched and tested simultaneously with appropriate reference sediment to account for potential sediment grain-size and 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 were collected from the northern end of Carr Inlet on March 12, 2009, by Windward Environmental LLC (Windward) and Gravity Consulting for the Round 1 tests (CI09-SS-020-010, CI09-SS-060-010, and CI09-SS-080-010) and on July 7, 2009, by Windward and Gravity Consulting for the Round 2 tests (CI09-SS-120-010, CI09-SS-140-010, and CI09-SS-160-010). Each of the EW sediment samples was matched with the reference sediment sample with the most similar percent fines, as shown in Table 3-5. The reference samples were also analyzed by ARI for SMS chemicals.

Table 3-5. EW sediment samples matched with reference sediment samples based on percent fines

EW Sample			Reference Sample			
Sample ID	TOC (% dw)	Percent Fines	Matched Sample ID	TOC (% dw)	Field-Measured Percent Fines	Laboratory-Measured Percent Fines[a]
EW09-SS-005-010	1.86	45.3	CI09-SS-060-010	0.367	60	8.2
EW09-SS-030-010	2.03	88.9	CI09-SS-080-010	0.210	80	4.3
EW09-SS-032-010	1.64	85	CI09-SS-080-010	0.210	80	4.3
EW09-SS-033-010	1.86	78.1	CI09-SS-080-010	0.210	80	4.3
EW09-SS-034-010	2.25	84.6	CI09-SS-080-010	0.210	80	4.3
EW09-SS-035-010	1.81	79.1	CI09-SS-080-010	0.210	80	4.3
EW09-SS-217-010	0.808	21.7	CI09-SS-020-010	0.605	20	5.5
EW09-SS-218-010	0.798	38	CI09-SS-020-010	0.605	20	5.5
EW09-SS-220-010	0.872	24.2	CI09-SS-020-010	0.605	20	5.5
EW09-SS-015-010	3.15	38	CI09-SS-120-010	0.453	20	nd
EW09-SS-215-010	3.37	24.2	CI09-SS-120-010	0.453	20	nd

[a] The laboratory percent fines results were not available until the conclusion of the testing. The disparity between the field-measurement and the lab-measurement is further discussed in Section 4.4. and Section 4.7

EW – East Waterway

ID – identification

nd – not detected

TOC – total organic carbon

All three reference sediment samples were included in the first round of toxicity tests. In the second round, two reference sediment samples were tested (CI09-SS-120-010 and CI09-SS-180-010), but only one reference sediment sample (CI09-SS-120-010) was used as a match for the test sediment samples that were tested.

The results from the three sediment toxicity tests were evaluated using the SMS rules for marine toxicity tests (Ecology 2008). The performance standards and biological effects criteria (SQS and CSLs of the SMS) are summarized in Table 3-6. The statistical analyses were conducted using the statistical package included in SedQual Release 5 (Ecology 2004).[1] Table 3-7 compares the results of the negative control and reference sediment toxicity tests to the SMS performance standards.

[1] Statistical analyses include Wilk-Shapiro's 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 3-6. SMS performance standards and biological effects criteria for sediment toxicity tests

Toxicity Test	SMS Performance Standards		Biological Effects Criteria	
	Negative Control	Reference Sediment	SQS	CSL
Amphipod	less than 10% mortality	less than 25% mortality	mean mortality > 25% on an absolute basis and statistically different from the reference sediment ($p \leq 0.05$)	mean mortality greater than the value in the reference sediment plus 30% and statistically different from the reference sediment ($p \leq 0.05$)
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 ($p \leq 0.05$)	mean individual growth rate < 50% of that of the reference sediment and statistically different ($p \leq 0.05$)
Bivalve larvae	> 70% normal survivorship	no criterion[a]	mean normal survivorship < 85% of that of the reference sediment and statistically different ($p \leq 0.10$)	mean normal survivorship < 70% of that of the reference sediment and statistically different ($p \leq 0.10$)

[a] Ecology has guidance that states that reference sample normal development must be ≥ 65% of the normal development of the negative control (Gries 2005).

CSL – cleanup screening level

Ecology – Washington State Department of Ecology

SMS – Washington State Sediment Management Standards

SQS – sediment quality standards

Table 3-7. Toxicity test results for the negative control and reference sediments compared to SMS performance standards

Toxicity Test	Negative Controls		Reference Sediments	
	Test Results	SMS Performance Standards	Test Results	SMS Performance Standards
Amphipod	mortality was 0.0 ± 0.0 and 4.0 ± 5.5% in the two tests	< 10% mortality	mortality ranged from 2.0 ± 2.7 to 22.0 ± 10.4% in six reference samples	< 25% mortality
Polychaete	mortality was 0.0 ± 0.0% in both tests; mean individual growth rate was 1.19 ± 0.21 and 1.13 ± 0.19 mg/day	< 10% mortality; mean individual growth rate ≥ 0.72 mg/day	mean individual growth rate ranged from 96 to 113% 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	normal survivorship was 91.1 ± 2.9 and 90.7 ± 9.3% in the two tests	> 70% normal survivorship	not applicable	no criterion[a]

[a] Ecology has guidance for reference sediments of ≥ 65% of the normal development exhibited by the negative control (Gries 2005); normal development in the reference sediment ranged from 74 to 96% of that of the negative control (see Appendix D-2).

Ecology – Washington State Department of Ecology
SMS – Washington State Sediment Management Standards

3.3 Laboratory Deviations from the QAPP

This section discusses laboratory deviations from the surface sediment QAPP (Windward 2009b) for both sediment chemical analyses and sediment toxicity testing.

3.3.1 Surface sediment chemical analysis

The laboratory followed the methods and procedures described in the surface sediment QAPP (Windward 2009b), with the following exceptions:

- The surface sediment QAPP (Windward 2009b) specified that total metals would be analyzed by ARI using inductively coupled plasma-atomic emission spectrometry or inductively coupled plasma-mass spectrometry per EPA Methods 6010B or 6020, respectively. Total metals were analyzed by ARI using EPA 6010B and EPA 200.8, which is equivalent to EPA 6020.
- Butyltins were analyzed using gas chromatography/mass spectrometry with selected ion monitoring (SIM). The surface sediment QAPP (Windward 2009b) listed butyltin analysis using gas chromatography/flame photometric detection in error. The quality of the data has not been affected by this deviation.

3.3.2 Sediment toxicity testing

The laboratories followed the methods and procedures described in the surface sediment QAPP (Windward 2009b), with the exceptions summarized below. These minor salinity deviations did not affect the data quality. No deviations from the protocol occurred in the two bivalve larvae sediment toxicity tests.

Amphipod tests

- Round 1 – Several overlying water salinity measurements were slightly above the protocol-specified range of 28 ± 1.0 parts per thousand (ppt) (maximum 31.0 ppt).
- Round 1 – One dissolved oxygen measurement was inadvertently omitted on day 0.
- Round 2 – Several overlying water salinity measurements were slightly above the protocol-specified range of 28 ± 1.0 ppt (maximum 29.5 ppt).
- Round 2 – Occasionally, during the test, aeration to one or more beakers was interrupted. In those cases, dissolved oxygen was measured, aeration was restarted, and dissolved oxygen was measured again. Minimum dissolved oxygen was 6.4 mg/L.

Polychaete tests

- Round 1 – Several overlying water salinity measurements were slightly above the protocol-specified range of 20 ± 1.0 ppt (maximum 21.4 ppt).
- Round 1 – In two instances, aeration to a beaker was interrupted, and dissolved oxygen decreased (minimum 2.4 mg/L). In those cases, aeration was restarted immediately upon discovery of the interruption.
- Round 1—The control sediment had an interstitial salinity of less than 20 ppt (17.0 ppt) and should have been adjusted before the addition of the worms; however, the control sediment was sand with very little water content.
- Round 2—One salinity measurement (30.5 ppt) exceeded the protocol-specified range of 28 ± 2.0 ppt.
- Round 2—Water quality measurements were accidentally not taken on day 9 before water renewal. Measurements were taken on day 10 when the omission was discovered.

4 Results

This section presents the results of chemical analyses conducted on the surface sediment samples (Section 4.1), subtidal composite samples (Section 4.2), and intertidal MIS samples (Section 4.3), as well as the grain size results for surface sediment samples collected from reference locations in Carr Inlet (Section 4.4). The results of the data validation, which was conducted by EcoChem, are discussed in Section 4.5 and presented in full in Appendix C. Section 4.6 presents the results of the sediment toxicity tests.

Complete data tables and laboratory report forms are presented in Appendices A and D, respectively. A detailed discussion of the approach used to average laboratory replicate sample results is presented in Appendix B. Methods for calculating concentrations for total PCBs, total polycyclic aromatic hydrocarbons (PAHs), low-molecular-weight polycyclic aromatic hydrocarbons (LPAHs), high-molecular-weight polycyclic aromatic hydrocarbons (HPAHs), carcinogenic polycyclic aromatic hydrocarbons (cPAHs), total dichlorodiphenyltrichloroethanes (DDTs), and total chlordane are also presented in Appendix B. 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 B. There was no additional manipulation of significant figures.

4.1 EW Surface Sediment Grab Sample Chemistry Results

All surface sediment grab samples collected from the EW were analyzed by ARI for metals, SVOCs (including PAHs), PCBs as Aroclors, grain size, TOC, and percent solids; a subset of these samples was also analyzed for butyltins, and organochlorine pesticides. The results of the analyses are discussed separately below by analyte group. In Section 4 maps, the field duplicate results are averaged with the original sample results for each of the locations where field duplicate samples were collected. Results for each field duplicate sample are summarized in this section and presented in Appendix A.

Chemical concentrations in the surface sediment grab samples were compared to SQS and CSL values of the SMS (Map 4-1). Concentrations of 10 chemicals not included in the SMS were compared with the screening level (SL) and maximum level (ML) of the Dredged Material Management Program (DMMP). If the TOC of a sediment sample was less than 0.5%, then organic carbon (OC) normalization was not appropriate, and the dry weight (dw) concentrations were compared to the lowest and second lowest apparent effects thresholds (AETs), which are analogous to the SQS and CSL, respectively. Appendix A contains detailed tables with results for each location compared to SMS, DMMP, or AET values. Map 4-1 provides the SMS exceedance status for each location based on comparison for all chemicals.

4.1.1 Metals

Table 4-1 presents a summary of results for the surface sediment samples that were analyzed for metals, including the number of detections, the range of detected concentrations, and the range of reporting limits (RLs) for chemicals reported as non-detects. Data tables containing metals results for each sample are presented in Appendix A. Table 4-1 also presents SQS/SL and CSL/ML values for comparison purposes. Mercury concentrations relative to SMS values are provided on Map 4-2.

Table 4-1. Summary of metal results in surface sediment samples

Chemical	Detection Frequency	Concentration (mg/kg dw)				
		Detected Concentration		RL or Range of RLs[a]	SQS/SL	CSL/ML
		Minimum	Maximum			
Antimony	1/121	7 J	7 J	0.3 – 30	150	200
Arsenic	111/121	2.3	26.2	6 – 8	57	93
Cadmium	71/121	0.3 J	5.7	0.2 – 1	5.1	6.7
Chromium	121/121	8	69	na	260	270
Cobalt	111/111	4	16	na	nc	nc
Copper	121/121	16.5	272 J	na	390	390
Lead	118/121	5 J	171 J	3 – 10	450	530
Mercury	121/121	0.02 J	1.07 J	na	0.41	0.59
Molybdenum	71/111	0.7	5	0.6 – 2	nc	nc
Nickel	120/121	9	42	6	140	370
Selenium	0/111	nd	nd	0.6 – 1	nc	nc
Silver	38/121	0.5	6	0.4 – 2	6.1	6.1

Chemical	Detection Frequency	Concentration (mg/kg dw)				
		Detected Concentration		RL or Range of RLs[a]	SQS/SL	CSL/ML
		Minimum	Maximum			
Thallium	0/111	nd	nd	0.2 – 0.5	nc	nc
Vanadium	111/111	24	94.1	na	nc	nc
Zinc	121/121	28	1,230 J	na	410	960

[a] RL range for non-detected samples only.

CSL – cleanup screening level
dw – dry weight
J – estimated concentration
ML – maximum level
na – not applicable
nc – no criterion available
nd – not detected
RL – reporting limit
SL – screening level
SQS – sediment quality standards

Six metals (chromium, cobalt, copper, mercury, vanadium, and zinc) were detected in all the surface sediment samples. Selenium and thallium were not detected in any of these samples. The sample collected at location EW09-SS-215 contained the highest concentrations of arsenic (26.2 mg/kg dw), chromium (69 mg/kg dw), copper (272 mg/kg dw), and lead (171 mg/kg dw). The sample collected at location EW09-SS-107 contained the highest concentrations of cadmium (5.7 mg/kg dw), molybdenum (5 mg/kg dw), and zinc (1,230 mg/kg dw). The highest concentrations of mercury (1.07 mg/kg dw) and nickel (42 mg/kg dw) were detected at location T30-07. The highest concentrations of cobalt (16 mg/kg dw), silver (6 mg/kg dw), antimony (7 mg/kg dw), and vanadium (94.1 mg/kg dw) were detected at locations EW09-SS-004, EW09-SS-018, EW09-SS-022, and EW09-SS-028, respectively.

Table 4-2 presents the number of samples with detected concentrations or RLs (for non-detected results) above the SQS/SL or CSL/ML for the 10 metals with SMS or DMMP values. Table A-1 in Appendix A presents the results for each sample and indicates which detected concentrations or RLs exceeded the SQS/SL or CSL/ML. Of the 10 metals with SMS or DMMP values, three metals (cadmium, mercury, and zinc) had at least one detected concentration that exceeded the SQS/SL, and two metals (mercury and zinc) had one or more detected concentrations that exceeded the CSL/ML. No RLs exceeded the SMS or DMMP criteria.

Table 4-2. Number of samples in each SQS/SL or CSL/ML category for detected concentrations and RLs for metals in surface sediment grab samples

Metal	Number of Samples					
	Detected Concentration			RL for Non-Detected Result		
	≤ SQS/SL	> SQS/SL ≤ CSL/ML	> CSL/ML	≤ SQS/SL	> SQS/SL ≤ CSL/ML	> CSL/ML
Antimony	1	0	0	120	0	0
Arsenic	111	0	0	10	0	0
Cadmium	70	1	0	50	0	0

Metal	Number of Samples					
	Detected Concentration			RL for Non-Detected Result		
	≤ SQS/SL	> SQS/SL ≤ CSL/ML	> CSL/ML	≤ SQS/SL	> SQS/SL ≤ CSL/ML	> CSL/ML
Chromium	121	0	0	0	0	0
Copper	121	0	0	0	0	0
Lead	118	0	0	3	0	0
Mercury	95	20	6	0	0	0
Nickel	120	0	0	1	0	0
Silver	38	0	0	83	0	0
Zinc	119	1	1	0	0	0

CSL – cleanup screening level
ML – maximum level
RL – reporting limit
SL – screening level
SQS – sediment quality standards

4.1.2 Butyltins

Table 4-3 presents a summary of butyltin results for the surface sediment grab samples analyzed for butyltins. Data tables with butyltin results for each sample, including field duplicate samples, are presented in Appendix A. Tributyltin (TBT) was detected in 42 of the 49 samples analyzed. Dibutyltin and monobutyltin were detected less frequently, in 16 and 4 samples respectively. The highest concentration of TBT (1,600 µg/kg dw) was detected at location EW09-SS-126. TBT concentrations for all locations are provided in Map 4-3.

Table 4-3. Summary of butyltin results in surface sediment grab samples

Chemical	Detection Frequency	Concentration (µg/kg dw)		
		Minimum Detected	Maximum Detected	Range of RLs[a]
Monobutyltin as ion	4/49	3.6	7.6	3.4 – 7.8
Dibutyltin as ion	16/49	5.9	25	4.8 – 11
Tributyltin as ion	42/49	4.1	1,600	3.4 – 3.7

[a] RL range for non-detected samples.
dw – dry weight
RL – reporting limit

4.1.3 SVOCs

Table 4-4 presents a summary of results for surface sediment samples that were analyzed for SVOCs and selected SVOCs using SIM. This table summarizes results from either Method 8270 or Method 8270-SIM according to rules presented in Appendix B for selecting a value when multiple results are reported for a single analyte in a single sample. Data tables containing SVOC results for each sample, including the field duplicate samples, are presented in Appendix A.

Table 4-4. Summary of SVOC results in surface sediment grab samples

Chemical	Detection Frequency	Concentration (µg/kg dw)		
		Minimum Detected	Maximum Detected	RL or Range of RLs[a]
PAHs				
1-Methylnaphthalene	27/122	9.9 J	2,700	19 – 59
2-Chloronaphthalene	0/122	nd	nd	19 – 59
2-Methylnaphthalene	40/122	9.7 J	2,800	19 – 59
Acenaphthene	62/122	10 J	3,000	19 – 21
Acenaphthylene	52/122	9.9 J	630	19 – 44
Anthracene	112/122	13 J	6,500	19 – 20
Benzo(a)anthracene	118/122	9.8 J	9,000	19 - 20
Benzo(a)pyrene	116/122	29	7,800	19 – 20
Benzo(b)fluoranthene	117/122	14 J	6,600	19 – 20
Benzo(g,h,i)perylene	112/122	14 J	1,800	19 – 20
Benzo(k)fluoranthene	116/122	32	5,400	19 – 20
Total benzofluoranthenes	117/122	14 J	10,800	19 – 20
Chrysene	118/122	12 J	13,000	19 – 20
Dibenzo(a,h)anthracene	74/122	7.9 J	690	6.0 – 59
Dibenzofuran	56/122	11 J	1,100	19 – 21
Fluoranthene	119/122	12 J	75,000	20
Fluorene	75/122	10 J	3,800	19 – 20
Indeno(1,2,3-cd)pyrene	113/122	13 J	1,800	19 – 20
Naphthalene	55/122	10 J	3,000	19 – 58
Phenanthrene	118/122	21	24,000	19 – 20
Pyrene	121/122	18 J	41,000	20
Total HPAHs	121/122	21	148,000 J	20
Total LPAHs	118/122	21	41,000	19 – 20
Total cPAHs	118/122	15 J	10,000	17 – 18
Total PAHs	121/122	21	155,000 J	20
Phthalates				
Bis(2-ethylhexyl) phthalate	106/122	18 J	37,000	19 – 1,400
Butyl benzyl phthalate	60/122	15	290	14 – 16
Diethyl phthalate	16/122	18	74	14 – 46
Dimethyl phthalate	8/122	13 J	69	14 – 16

Chemical	Detection Frequency	Concentration (µg/kg dw)		
		Minimum Detected	Maximum Detected	RL or Range of RLs[a]
Di-n-butyl phthalate	21/122	17 J	48,000	19 – 59
Di-n-octyl phthalate	6/122	14 J	83	19 – 59
Other SVOCs				
1,2,4-Trichlorobenzene	2/122	7.2	8.5	3.0 – 6.2
1,2-Dichlorobenzene	0/122	nd	nd	5.8 – 6.2
1,3-Dichlorobenzene	0/122	nd	nd	19 – 59
1,4-Dichlorobenzene	79/122	5.9	4,200	5.8 – 6.2
2,4,5-Trichlorophenol	0/122	nd	nd	96 – 290
2,4,6-Trichlorophenol	0/122	nd	nd	96 – 290
2,4-Dichlorophenol	0/122	nd	nd	96 – 290
2,4-Dimethylphenol	10/122	6.1	17	5.8 – 6.2
2,4-Dinitrophenol	0/122	nd	nd	190 – 590
2,4-Dinitrotoluene	0/122	nd	nd	96 – 290
2,6-Dinitrotoluene	0/122	nd	nd	96 – 290
2-Chlorophenol	0/122	nd	nd	19 – 59
2-Methylphenol	2/122	13	21	5.8 – 6.2
2-Nitroaniline	0/122	nd	nd	96 – 290
2-Nitrophenol	0/122	nd	nd	96 – 290
3,3′-Dichlorobenzidine	0/115	nd	nd	96 – 290
3-Nitroaniline	0/120	nd	nd	96 – 290
4,6-Dinitro-o-cresol	0/122	nd	nd	190 – 590
4-Bromophenyl phenyl ether	0/122	nd	nd	19 – 59
4-Chloro-3-methylphenol	0/122	nd	nd	96 – 290
4-Chloroaniline	0/112	nd	nd	96 – 290
4-Chlorophenyl phenyl ether	0/122	nd	nd	19 – 59
4-Methylphenol	19/122	15 J	180	19 – 59
4-Nitroaniline	0/121	nd	nd	96 – 290
4-Nitrophenol	0/122	nd	nd	96 – 290
Aniline	0/104	nd	nd	19 – 59
Benzoic acid	3/122	230	340 J	190 – 590
Benzyl alcohol	1/111	38 J	38 J	19 – 58
bis(2-chloroethoxy)methane	0/122	nd	nd	19 – 59
bis(2-chloroethyl)ether	0/122	nd	nd	19 – 59
bis(2-chloroisopropyl)ether	1/122	38 J	38 J	19 – 59
Carbazole	73/112	9.8 J	2,200	19 – 20

Chemical	Detection Frequency	Concentration (µg/kg dw)		
		Minimum Detected	Maximum Detected	RL or Range of RLs[a]
Hexachlorobenzene	0/122	nd	nd	0.96 – 6.2
Hexachlorobutadiene	0/122	nd	nd	0.96 – 6.2
Hexachlorocyclopentadiene	0/119	nd	nd	96 – 290
Hexachloroethane	0/122	nd	nd	19 – 59
Isophorone	0/122	nd	nd	19 – 59
n-Nitroso-di-n-propylamine	0/122	nd	nd	29 – 31
n-Nitrosodimethylamine	0/121	nd	nd	29 – 31
n-Nitrosodiphenylamine	0/122	nd	nd	5.8 – 47
Nitrobenzene	0/122	nd	nd	19 – 59
Pentachlorophenol	2/122	59	72	29 – 31
Phenol	37/122	14 J	350	19 – 59

[a] RL range for non-detected samples.

cPAH – carcinogenic polycyclic aromatic hydrocarbon
dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
J – estimated concentration
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
na – not applicable
nd – not detected
PAH – polycyclic aromatic hydrocarbon
RL – reporting limit
SVOC – semivolatile organic compound

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 at least 112 samples) 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 75 or fewer samples. Detected concentrations of total LPAHs ranged from 21 to 41,000 µg/kg dw (Map 4-4), with the highest concentration detected in the sample collected at EW09-SS-018. Detected concentrations of total HPAHs ranged from 21 to 148,000 µg/kg dw (Map 4-4), with the highest concentration detected in the sample collected at EW09-SS-200.

All six phthalates were detected in at least one sample. Bis(2-ethylhexyl) phthalate (BEHP), the most frequently detected phthalate compound, was detected in 106 of the 122 samples, with a maximum concentration of 37,000 µg/kg dw detected in the sample collected at location LSO-01 (Map 4-5). The second highest concentration of BEHP (1,000 µg/kg dw) was detected at EW09-SS-101. Di-n-butyl phthalate was the phthalate with the highest detected concentration (48,000 µg/kg dw), which was detected at EW09-SS-010. The second highest detected concentration of di-n-butyl phthalate was 280 µg/kg dw, which was detected at EW09-SS-002.

Two other SVOCs were detected in at least 70 of the surface sediment samples: dichlorobenzene with a maximum detected concentration of 4,200 µg/kg dw at location

EW09-SS-101, and carbazole with a maximum detected concentration of 2,200 µg/kg dw at location EW09-SS-018. Other SVOCs that were detected infrequently in the surface sediment samples include: 1,2,4-trichlorobenzene, 2-methylphenol, 2,4-dimethylphenol, 4-methylphenol, benzoic acid, benzyl alcohol, bis(2-chloroisopropyl)ether, pentachlorophenol (PCP), and phenol. The remaining 32 SVOCs were not detected in any samples.

Table 4-5 presents a summary of SVOC results expressed in appropriate units for comparison to SQS/SL and CSL/ML (i.e., OC-normalized for most of the SVOCs and dry weight for the remainder). 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. Surface sediment samples collected at two locations within the EW (EW09-SS-223 and T30-14) had TOC contents of less than 0.5%, so they were not compared to SQS or CSL values that were OC-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 4-5. Summary of SVOC results in surface sediment grab samples in comparison to SQS/SL and CSL/ML

Chemical	Unit	Detection Frequency	Detected Concentration		RL or Range of RLs[a]	SQS/SL	CSL/ML
			Minimum	Maximum			
PAHs							
2-Methylnaphthalene	mg/kg OC	40/120	0.39 J	85	0.59 – 4.9	38	64
Acenaphthene	mg/kg OC	61/120	0.45 J	130	0.69 – 3.5	16	57
Acenaphthylene	mg/kg OC	52/120	0.45 J	53	0.59 – 3.5	66	66
Anthracene	mg/kg OC	112/120	0.77 J	200	1.2 – 3.5	220	1,200
Benzo(a)anthracene	mg/kg OC	117/120	1.3	350	2.5 – 3.5	110	270
Benzo(a)pyrene	mg/kg OC	116/120	1.0	240	2.5 – 3.5	99	210
Benzo(g,h,i)perylene	mg/kg OC	112/120	0.41 J	55	1.2 – 3.5	31	78
Total benzofluoranthenes	mg/kg OC	117/120	2.5 J	915	2.5 – 3.5	230	450
Chrysene	mg/kg OC	117/120	2.0	1,100	2.5 – 3.5	110	460
Dibenzo(a,h)anthracene	mg/kg OC	74/120	0.25 J	21	0.75 – 3.5	12	33
Dibenzofuran	mg/kg OC	56/120	0.53 J	68 J	0.69 – 3.5	15	58
Fluoranthene	mg/kg OC	118/120	2.1 J	6,400	2.5 – 2.6	160	1,200
Fluorene	mg/kg OC	75/120	0.45 J	120	0.89 – 3.5	23	79
Indeno(1,2,3-cd)pyrene	mg/kg OC	113/120	0.38 J	58 J	1.4 – 3.5	34	88
Naphthalene	mg/kg OC	55/120	0.45 J	91	0.59 – 4.9	99	170
Phenanthrene	mg/kg OC	117/120	2.4	730	2.5 – 3.4	100	480
Pyrene	mg/kg OC	119/120	2.6	3,500	2.6	1,000	1,400
Total HPAHs	mg/kg OC	119/120	2.6	12,500 J	2.6	960	5,300
Total LPAHs	mg/kg OC	117/120	2.6	1,300	2.5 – 3.4	370	780

Chemical	Unit	Detection Frequency	Detected Concentration		RL or Range of RLs[a]	SQS/SL	CSL/ML
			Minimum	Maximum			
Phthalates							
Bis(2-ethylhexyl) phthalate	mg/kg OC	106/120	1.3	1,900	1.0 – 130	47	78
Butyl benzyl phthalate	mg/kg OC	60/120	0.69 J	14	0.44 – 2.8	4.9	64
Diethyl phthalate	mg/kg OC	15/120	0.82	5.3	0.45 – 2.9	61	110
Dimethyl phthalate	mg/kg OC	8/120	0.60 J	4.2	0.44 – 2.8	53	53
Di-n-butyl phthalate	mg/kg OC	20/120	0.79	2,600	0.60 – 4.9	220	1,700
Di-n-octyl phthalate	mg/kg OC	6/120	0.49 J	5.8	0.59 – 4.9	58	4,500
Other SVOCs							
1,2,4-Trichlorobenzene	mg/kg OC	2/120	0.43	0.46	0.18 – 1.1	0.81	1.8
1,2-Dichlorobenzene	mg/kg OC	0/120	nd	nd	0.18 – 1.1	2.3	2.3
1,3-Dichlorobenzene	µg/kg dw	0/120	nd	nd	19 – 59	170	nc
1,4-Dichlorobenzene	mg/kg OC	79/120	0.18	310	0.18 – 1.1	3.1	9
2,4-Dimethylphenol	µg/kg dw	10/120	6.1	17	5.8 – 6.2	29	29
2-Methylphenol	µg/kg dw	2/120	13	21	5.8 – 6.2	63	63
4-Methylphenol	µg/kg dw	19/120	15 J	180	19 – 59	670	670
Benzoic acid	µg/kg dw	3/120	230	340 J	190 – 590	650	650
Benzyl alcohol	µg/kg dw	1/110	38 J	38 J	19 – 58	57	73
Hexachlorobenzene	mg/kg OC	0/120	nd	nd	0.030 – 1.1	0.38	2.3
Hexachlorobutadiene	mg/kg OC	0/120	nd	nd	0.030 – 1.1	3.9	6.2
Hexachloroethane	µg/kg dw	0/120	nd	nd	19 – 59	1,400	14,000
n-Nitrosodiphenylamine	mg/kg OC	0/120	nd	nd	0.18 – 2.4	11	11
Pentachlorophenol	µg/kg dw	2/120	59	72	29 – 31	360	690
Phenol	µg/kg dw	37/120	14 J	350	19 – 59	420	1,200

[a] RL range for non-detect samples only.

CSL – cleanup screening level
dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
J – estimated concentration
ML – maximum level
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
nc – no criterion
nd – not detected
PAH – polycyclic aromatic hydrocarbon
OC – organic carbon
RL – reporting limit
SL – screening level
SQS – sediment quality standards
SVOC – semivolatile organic compound

Table 4-6 presents the numbers of samples with detected concentrations (including J-qualified results) or final RLs (for non-detected results) above the SQS/SL or CSL/ML for the 40 SVOCs with SMS or DMMP values. Of the 40 SVOCs with SMS or DMMP values, 20 never had detected concentrations that exceeded the SQS/SL, 4 had detected concentrations that exceeded only the SQS/SL, and 16 had detected concentrations that exceeded the CSL/ML.

Table 4-6. Numbers of samples in each SQS/SL or CSL/ML category for detected concentrations and reporting limits for SVOCs for sediment grab samples

Chemical	Number of Samples					
	Detected Concentration			RL for Non-Detected Result		
	≤ SQS/SL	> SQS/SL ≤ CSL/ML	> CSL/ML	≤ SQS/SL	> SQS/SL ≤ CSL/ML	> CSL/ML
PAHs						
2-Methylnaphthalene	39	0	1	82	0	0
Acenaphthene	55	5	2	60	0	0
Acenaphthylene	52	0	0	70	0	0
Anthracene	112	0	0	10	0	0
Benzo(a)anthracene	114	3	1	4	0	0
Benzo(a)pyrene	111	4	1	6	0	0
Benzo(g,h,i)perylene	109	3	0	10	0	0
Total benzofluoranthenes	112	4	1	5	0	0
Chrysene	113	4	1	4	0	0
Dibenzo(a,h)anthracene	71	3	0	48	0	0
Dibenzofuran	53	2	1	66	0	0
Fluoranthene	112	6	1	3	0	0
Fluorene	69	4	2	47	0	0
Indeno(1,2,3-cd)pyrene	109	4	0	9	0	0
Naphthalene	55	0	0	67	0	0
Phenanthrene	110	6	2	4	0	0
Pyrene	120	0	1	1	0	0
Total HPAHs	116	4	1	1	0	0
Total LPAHs	114	2	2	4	0	0
Phthalates						
Bis(2-ethylhexyl) phthalate	102	2	2	15	0	1
Butyl benzyl phthalate	55	5	0	62	0	0
Diethyl phthalate	16	0	0	106	0	0
Dimethyl phthalate	8	0	0	114	0	0
Di-n-butyl phthalate	20	0	1	101	0	0
Di-n-octyl phthalate	6	0	0	116	0	0
Other SVOCs						
1,2,4-Trichlorobenzene	2	0	0	115	5	0
1,2-Dichlorobenzene	0	0	0	122	0	0
1,3-Dichlorobenzene	0	0	0	122	0	0
1,4-Dichlorobenzene	70	4	5	43	0	0

Chemical	Number of Samples					
	Detected Concentration			RL for Non-Detected Result		
	≤ SQS/SL	> SQS/SL ≤ CSL/ML	> CSL/ML	≤ SQS/SL	> SQS/SL ≤ CSL/ML	> CSL/ML
2,4-Dimethylphenol	10	0	0	112	0	0
2-Methylphenol	2	0	0	120	0	0
4-Methylphenol	19	0	0	103	0	0
Benzoic acid	3	0	0	119	0	0
Benzyl alcohol	1	0	0	109	1	0
Hexachlorobenzene	0	0	0	86	36	0
Hexachlorobutadiene	0	0	0	122	0	0
Hexachloroethane	0	0	0	122	0	0
n-Nitrosodiphenylamine	0	0	0	122	0	0
Pentachlorophenol	2	0	0	120	0	0
Phenol	37	0	0	85	0	0

CSL – cleanup screening level
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
ML – maximum level
PAH – polycyclic aromatic hydrocarbon
RL – reporting limit
SL – screening level
SQS – sediment quality standards
SVOC – semivolatile organic compound

Fourteen individual PAHs or PAH groups had a total of forty-nine detected concentrations that exceeded their respective SQS but not the CSL. Thirteen individual PAHs or PAH groups had a total of seventeen detected concentrations that exceeded their respective CSLs. All RLs for non-detected PAH results were less than the SMS criteria.

BEHP and butyl benzyl phthalate had a total of seven detected concentrations that exceeded their SQS but not their CSLs. Detected concentrations of BEHP exceeded the CSL in the samples collected at locations LSO-01 and EW09-SS-211. A detected concentration of di-n-butyl phthalate exceeded the CSL in the sample collected at location EW09-SS-010. All RLs for non-detected phthalate results were less than the SMS criteria.

Only one other SVOC, 1,4-dichlorobenzene, was detected at concentrations that exceeded its SQS and CSL. The concentrations of 1,4-dichlorobenzene exceeded the CSL in five samples, and only the SQS (not the CSL) was exceeded in four samples. Three other SVOCs (1,2,4-trichlorobenzene, benzyl alcohol, and hexachlorobenzene) were not detected but had RLs that exceeded their SQS/SL or CSL/ML values.

4.1.4 PCB Aroclors

Table 4-7 presents a summary of results for the surface sediment samples that were analyzed for PCB Aroclors. Results are presented for both individual Aroclors and total

PCBs. Total PCB concentrations for each location relative to SMS are provided on Map 4-6. Data tables that contain results for each sample are presented in Appendix A.

Table 4-7. Summary of PCB Aroclor results in surface sediment grab samples

Chemical	Detection Frequency	Concentration (µg/kg dw)		
		Minimum Detected	Maximum Detected	RL or Range of RLs[a]
Aroclor-1016	0/122	nd	nd	3.8 – 600
Aroclor-1221	0/122	nd	nd	3.8 – 600
Aroclor-1232	0/122	nd	nd	3.8 – 600
Aroclor-1242	5/122	21	57	3.8 – 600
Aroclor-1248	43/122	4.3	330	3.9 – 600
Aroclor-1254	90/122	6.0	1,100	3.9 – 760
Aroclor-1260	112/122	7.3	2,400	3.9 – 20
Aroclor-1262	0/122	nd	nd	3.8 – 600
Aroclor-1268	0/122	nd	nd	3.8 – 600
Total PCBs	113/122	6.0	3,200	3.9 – 20

[a] RL range for non-detected samples.

dw – dry weight

nd –not detected

PCB – polychlorinated biphenyl

RL – reporting limit

Four of the seven Aroclors were detected in at least one sediment sample. The most frequently detected were Aroclors 1254 and 1260. The maximum total PCB concentration (3,200 µg/kg dw) was detected in the sample collected at location EW09-SS-104. None of the Aroclors were detected at eight sampling locations.

Table 4-8 presents a summary of OC-normalized results for the samples with TOC contents ≥ 0.5%. Two samples with TOC contents < 0.5% were not OC-normalized and were compared to the SL/ML values on a dry weight basis.

Table 4-8. Summary of total PCB results for surface sediment grab samples in comparison with SQS and CSL

Chemical	Detection Frequency	Concentration (µg/kg dw)				
		Minimum Detected	Maximum Detected	Range of RLs[a]	SQS	CSL
Total PCBs	112/120	0.83	160	0.51 – 3.4	12	65

[a] RL range for only non-detected samples.

CSL – cleanup screening level

OC – organic carbon

PCB – polychlorinated biphenyl

RL – reporting limit

SQS – sediment quality standards

Table 4-9 presents the numbers of samples with detected PCB concentrations or RLs (for non-detected results) above the SQS or CSL. Table A-1 in Appendix A presents the results for each sample and indicates which results exceeded the SQS or CSL. Total PCBs exceeded the SQS but were less than CSL in 56 samples and exceeded the CSL in 11 samples. RLs for non-detected total PCBs were all less than the SQS.

Table 4-9. Numbers of samples in each SQS or CSL category for detected concentrations and reporting limits for PCBs for surface sediment grab samples

Chemical	Number of Samples					
	Detected Concentration[a]			RL		
	≤ SQS	> SQS ≤ CSL	> CSL	≤ SQS	> SQS ≤ CSL	> CSL
Total PCBs	46	56	11	9	0	0

[a] The RL for total PCBs was given a value equal to the highest RL of the nine Aroclors for a given sample.
CSL – cleanup screening level
PCB – polychlorinated biphenyl
RL – reporting limit
SQS – sediment quality standards

4.1.5 Organochlorine pesticides

Table 4-10 presents a summary of results for the surface sediment grab samples that were analyzed for organochlorine pesticides. Data tables that contain results for each sample, including field duplicate samples, for pesticides are presented in Appendix A. Table 4-10 also presents SL and ML values for comparison purposes. Two organochlorine pesticides were detected in surface sediment samples. A component of total DDTs (4,4′-dichlorodiphenyldichloroethane [DDD]) was detected in four samples and a component of total chlordane (trans-nonachlor) was detected in one sample.

Table 4-10. Summary of organochlorine pesticide results in surface sediment grab samples

Chemical	Detection Frequency	Concentration (µg/kg dw)				
		Minimum Detected	Maximum Detected	RL or Range of RLs[a]	SL	ML
2,4′-DDD	0/29	nd	nd	1.9 – 30	nc	nc
2,4′-DDE	0/29	nd	nd	1.9 – 55	nc	nc
2,4′-DDT	0/29	nd	nd	1.9 – 30	nc	nc
4,4′-DDD	4/29	2.3	8.6 J	1.9 – 30	nc	nc
4,4′-DDE	0/29	nd	nd	1.9 – 30	nc	nc
4,4′-DDT	0/29	nd	nd	1.9 – 41	nc	nc
Total DDTs	4/29	2.3	8.6 J	1.9 – 55	6.9	69
Aldrin	0/29	nd	nd	0.96 – 270	10	nc
Dieldrin	0/29	nd	nd	1.9 – 41	10	nc
alpha-BHC	0/29	nd	nd	0.96 – 15	nc	nc

Chemical	Detection Frequency	Concentration (µg/kg dw)				
		Minimum Detected	Maximum Detected	RL or Range of RLs[a]	SL	ML
beta-BHC	0/29	nd	nd	0.96 – 15	nc	nc
gamma-BHC	0/29	nd	nd	0.96 – 15	10	nc
delta-BHC	0/29	nd	nd	0.96 – 15	nc	nc
alpha-Chlordane	0/29	nd	nd	0.96 – 15	nc	nc
gamma-Chlordane	0/29	nd	nd	0.96 – 15	nc	nc
Total chlordane	1/29	4.4	4.4	1.9 – 100	10	nc
alpha-Endosulfan	0/29	nd	nd	0.96 – 15	nc	nc
beta-Endosulfan	0/29	nd	nd	1.9 – 50	nc	nc
Endosulfan sulfate	0/29	nd	nd	1.9 – 30	nc	nc
Endrin	0/29	nd	nd	1.9 – 30	nc	nc
Endrin aldehyde	0/29	nd	nd	1.9 – 30	nc	nc
Endrin ketone	0/29	nd	nd	1.9 – 30	nc	nc
Heptachlor	0/29	nd	nd	0.96 – 15	10	nc
Heptachlor epoxide	0/29	nd	nd	0.96 – 29	nc	nc
Methoxychlor	0/29	nd	nd	9.6 – 150	nc	nc
Mirex	0/29	nd	nd	1.9 – 85	nc	nc
cis-Nonachlor	0/29	nd	nd	1.9 – 30	nc	nc
Oxychlordane	0/29	nd	nd	1.9 – 30	nc	nc
Toxaphene	0/29	nd	nd	96 – 1,500	nc	nc
trans-Nonachlor	1/29	4.4	4.4	1.9 – 100	nc	nc

[a] RL range for non-detected samples.

BHC – benzene hexachloride
DDD – dichlorodiphenyldichloroethane
DDE – dichlorodiphenyldichloroethylene
DDT – dichlorodiphenyltrichloroethane
dw – dry weight
J – estimated concentration
ML – maximum level
nc – no criterion
nd – not detected
RL – reporting limit
SL – screening level

There are no SMS values for pesticides; instead, results for six pesticides were compared to the available SL and ML values. Table 4-11 presents the number of samples with detected pesticide concentrations or RLs (for non-detected results) above the SL or ML. Table A-1 in Appendix A presents the results for each sample, including field duplicate samples; one detected concentration exceeded the SL for total DDTs. RLs for all six pesticides exceeded the SL but not the ML at one or more locations.

Table 4-11. Numbers of samples in each SL or ML category for detected concentrations and reporting limits for organochlorine pesticides for surface sediment grab samples

Chemical	Number of Samples					
	Detected Concentration			RL		
	≤ SL	> SL ≤ ML	> ML	≤ SL	> SL ≤ ML	>ML
Total DDTs	3	1	0	18[a]	7[a]	0
Aldrin	0	0	na	25	4	na
Dieldrin	0	0	na	22	7	na
gamma-BHC (Lindane)	0	0	na	28	1	na
Total chlordane	0	0	na	26[b]	3[b]	na
Heptachlor	0	0	na	28	1	na

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.

BHC – benzene hexachloride
DDT – dichlorodiphenyltrichloroethane
ML – maximum level
na – not applicable
RL – reporting limit
SL – screening level

4.1.6 Conventional parameters

Table 4-12 presents a summary of results for surface sediment samples for the following conventional parameters: grain size, TOC, total solids, sulfides, and ammonia. Data tables that contain results for each sample, including field duplicate samples, are presented in Appendix A.

Table 4-12. Summary of grain size and conventional parameter results in surface sediment samples

Parameter	Unit	Detection Frequency	Detected Concentration		RL or Range of RLs[a]
			Minimum	Maximum	
Sediment Grain Size					
Gravel	% dw	107/114	0.1	68.1	0.1
Sand	% dw	114/114	8.1	86.9	na
Silt	% dw	112/112	3.0	58.8	na
Clay	% dw	112/112	1.9	34.9	na
Fines	% dw	112/112	4.9	92.0	na
Conventional Parameters					
TOC	% dw	122/122	0.192	3.40 J	na
Total solids	% ww	122/122	40.60	78.60	na
Total solids (preserved)	% ww	104/104	31.57	82.80	na
Sulfides (total)	mg/kg dw	102/104	1.30	3,250	1.49 – 8.41
Ammonia (total as nitrogen)	mg-N/kg dw	104/104	0.23	36.0	na

[a] RL range for non-detect samples.

dw – dry weight
J – estimated concentration
na – not applicable
RL – reporting limit
TOC – total organic carbon
ww – wet weight

Percent fines in surface sediment samples collected in the EW ranged widely from 4.9% (at EW09-SS-012) to 92.0% (at EW09-SS-023). TOC ranged from 0.192% (at EW09-SS-223) to 3.40% (at T30-07). The maximum concentration of sulfides (3,250 mg/kg dw) and ammonia (36.0 mg-N/kg) were detected in the sample collected at location EW09-SS-105.

4.2 INTERTIDAL MIS SAMPLES

The MIS intertidal composite samples were analyzed for metals, butyltins, SVOCs, PCBs, pesticides and dioxin/furans. These samples were collected for the purpose of assessing the human health risk associated with direct contact sediment exposure. Accordingly, these samples were not compared with the SMS because the samples were not collected to assess benthic invertebrate exposures, and it is not appropriate to compare composites that covered large spatial areas to the SMS. Therefore, the results of these samples are provided on a dry weight-basis only.

4.2.1 Metals

Table 4-13 presents the results for the MIS intertidal surface sediment composite samples that were analyzed for metals. Four metals were not detected in any of the samples, these being antimony, selenium, silver, and thallium. All other metals were detected in all of the samples, with the exception of cadmium, which was detected in the area-wide samples but not in the public access sample.

Table 4-13. Metals results for MIS intertidal surface sediment composite samples

Chemical	Concentration (mg/kg dw)			
	Area-Wide MIS Samples			Public Access Area Sample
	EW09-ITSED-AWMIS-01	EW09-ITSED-AWMIS-02	EW09-ITSED-AWMIS-03	EW09-ITSED-PAMIS-01
Antimony	6 UJ	6 UJ	6 UJ	6 UJ
Arsenic	9.1	7.9	13.3	7.7
Cadmium	0.5	0.6	0.6	0.3 U
Chromium	21.5	27.3	44.8	20.5
Cobalt	5.7	6.2	6.8	5.0
Copper	36.2	40.8	41.4	28.0
Lead	50	60	49	23
Mercury	0.06	0.08	0.10	0.08
Molybdenum	1.5	2.0	2.2	1.3
Nickel	21	24	27	20

Chemical	Concentration (mg/kg dw)			
	Area-Wide MIS Samples			Public Access Area Sample
	EW09-ITSED-AWMIS-01	EW09-ITSED-AWMIS-02	EW09-ITSED-AWMIS-03	EW09-ITSED-PAMIS-01
Selenium	0.6 U	0.6 U	0.6 U	0.6 U
Silver	0.4 U	0.4 U	0.4 U	0.4 U
Thallium	0.3 U	0.3 U	0.3 U	0.2 U
Vanadium	34.3 J	43.4 J	45.5 J	30.6 J
Zinc	100	113	117	57

dw – dry weight
J – estimated concentration
MIS – multi-increment sampling
U – not detected at reporting limit shown

4.2.2 Butyltins

The results for butyltins in the MIS samples are presented in Table 4-14. TBT was detected in all four samples with concentrations ranging from 7.9 to 11 µg/kg dw.

Table 4-14. Butyltin results for MIS intertidal surface sediment composite samples

Chemical	Concentration (µg/kg dw)			
	Area-Wide MIS Samples			Public Access Area Sample
	EW09-ITSED-AWMIS-01	EW09-ITSED-AWMIS-02	EW09-ITSED-AWMIS-03	EW09-ITSED-PAMIS-01
Monobutyltin as ion	3.7 U	3.5 U	3.6 U	3.6 U
Dibutyltin as ion	5.3 UJ	5.0 UJ	5.3 J	5.1 UJ
Tributyltin as ion	8.8 J	7.9 J	8.9 J	11 J

dw – dry weight
J – estimated concentration
MIS – multi-increment sampling
U – not detected at reporting limit shown

4.2.3 SVOCs

The results for SVOCs analyzed in the MIS intertidal surface sediment composite samples are presented below by PAHs, phthalates, and other SVOCs. PAH results for the four MIS samples are presented in Table 4-15. All of the PAHs, except for 2-chloronaphthalene, were detected in the MIS samples. The public access area MIS composite sample had lower LPAH and HPAH concentrations than the area-wide MIS composite samples.

Table 4-15. PAH results for MIS intertidal surface sediment composite samples

Chemical	Concentration (µg/kg dw)			
	Area-Wide MIS Samples			Public Access Area sample
	EW09-ITSED-AWMIS-01	EW09-ITSED-AWMIS-02	EW09-ITSED-AWMIS-03	EW09-ITSED-PAMIS-01
1-Methylnaphthalene	35	57	640	690
2-Chloronaphthalene	20 U	19 U	20 U	20 U
2-Methylnaphthalene	35	61	740	11 J
Acenaphthene	44	74	820	29
Acenaphthylene	62	40	20 U	19 J
Anthracene	240	170 J	1,100	140
Benzo(a)anthracene	480	320	1,500	290
Benzo(a)pyrene	550	320	1,400	270
Benzo(b)fluoranthene	550	300	1,000	310
Benzo(g,h,i)perylene	170	110	440	58
Benzo(k)fluoranthene	550	300	1,000	310
Total benzofluoranthenes	1,100	600	2,000	620
Chrysene	740	450 J	1,500	440
Dibenzo(a,h)anthracene	110	60	260	45
Dibenzofuran	27	44	340	10 J
Fluoranthene	790	850 J	3,700	580
Fluorene	74	100	940	20
Indeno(1,2,3-cd)pyrene	200	120	480	71
Naphthalene	28	85 J	850	14 J
Phenanthrene	560	800 J	5,100	180
Pyrene	690	720	3,900	510
Total HPAHs	4,830	3,550 J	15,200	2,880
Total LPAHs	1,010	1,270 J	8,800	400 J
Total cPAHs	780	450 J	1,900	390
Total PAHs	5,840	4,820 J	24,000	3,290 J

DL – detection limit
dw – dry weight
cPAH – carcinogenic polycyclic aromatic hydrocarbon
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
J – estimated concentration
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
MIS – multi-increment sampling
PAH – polycyclic aromatic hydrocarbon
U – not detected at reporting limit shown

All of the phthalates except for BEHP and di-n-octylphthalate were detected in at least one sample (Table 4-16). Butyl benzyl phthalate was the only phthalate detected in all of the MIS samples. The other SVOCs that were detected were 1,4-dichlorobenzene, 4-methyl phenol, carbazole, PCP, and phenol (Table 4-17). For the phthalates or other

SVOCs that were detected at least once, the detected concentration tended to be similar to the RLs for the non-detected compounds.

Table 4-16. Phthalate results for MIS intertidal surface sediment composite samples

Chemical	Concentration (µg/kg dw)			
	Area-Wide MIS Samples			Public Access Area Sample
	EW09-ITSED-AWMIS-01	EW09-ITSED-AWMIS-02	EW09-ITSED-AWMIS-03	EW09-ITSED-PAMIS-01
Bis(2-ethylhexyl) phthalate	410 U	280 U	330 U	330 U
Butyl benzyl phthalate	31	82	18	17
Diethyl phthalate	15 U	19 U	12 J	15 U
Dimethyl phthalate	15 U	11 J	15 U	15 U
Di-n-butyl phthalate	17 J	19 U	20 U	20 U
Di-n-octyl phthalate	20 U	19 U	20 U	20 U

dw – dry weight
J – estimated concentration
MIS – multi-increment sampling
U – not detected at reporting limit shown

Table 4-17. Other SVOC results for MIS intertidal surface sediment composite samples

Chemical	Concentration (µg/kg dw)			
	Area-Wide MIS Samples			Public Access Area Sample
	EW09-ITSED-AWMIS-01	EW09-ITSED-AWMIS-02	EW09-ITSED-AWMIS-03	EW09-ITSED-PAMIS-01
1,2,4-Trichlorobenzene	5.9 U	5.8 U	6.0 U	6.0 U
1,2-Dichlorobenzene	5.9 U	5.8 U	6.0 U	6.0 U
1,3-Dichlorobenzene	20 U	19 U	20 U	20 U
1,4-Dichlorobenzene	12	5.8 U	6.0 U	13 J
2,4,5-Trichlorophenol	97 U	96 U	98 U	99 U
2,4,6-Trichlorophenol	97 U	96 U	98 U	99 U
2,4-Dichlorophenol	97 U	96 U	98 U	99 U
2,4-Dimethylphenol	5.9 UJ	5.8 UJ	6.0 UJ	6.0 UJ
2,4-Dinitrophenol	200 U	190 U	200 U	200 U
2,4-Dinitrotoluene	97 U	96 U	98 U	99 U
2,6-Dinitrotoluene	97 U	96 U	98 U	99 U
2-Chlorophenol	20 U	19 U	20 U	20 U
2-Methylphenol	5.9 U	5.8 U	6.0 U	6.0 U
2-Nitroaniline	97 U	96 U	98 U	99 U
2-Nitrophenol	97 U	96 U	98 U	99 U
3,3′-Dichlorobenzidine	97 U	96 U	98 U	99 U
3-Nitroaniline	97 U	96 U	98 U	99 U
4,6-Dinitro-o-cresol	200 U	190 U	200 U	200 U

Chemical	Concentration (µg/kg dw)			
	Area-Wide MIS Samples			Public Access Area Sample
	EW09-ITSED-AWMIS-01	EW09-ITSED-AWMIS-02	EW09-ITSED-AWMIS-03	EW09-ITSED-PAMIS-01
4-Bromophenyl phenyl ether	20 U	19 U	20 U	20 U
4-Chloro-3-methylphenol	97 U	96 U	98 U	99 U
4-Chloroaniline	97 U	96 UJ	98 U	99 U
4-Chlorophenyl phenyl ether	20 U	19 U	20 U	20 U
4-Methylphenol	20 U	11 J	24	20 U
4-Nitroaniline	97 U	96 U	98 U	99 U
4-Nitrophenol	97 U	96 U	98 U	99 U
Aniline	20 U	R	20 U	20 U
Benzoic acid	200 U	190 U	200 U	200 U
Benzyl alcohol	20 U	19 U	20 U	20 U
bis(2-chloroethoxy)methane	20 U	19 U	20 U	20 U
bis(2-chloroethyl)ether	20 U	19 U	20 U	20 U
bis(2-chloroisopropyl)ether	20 U	19 U	20 U	20 U
Carbazole	84	110 J	980	82
Hexachlorobenzene	0.86 U	2.1 U	1.4 U	1.4 U
Hexachlorobutadiene	0.86 U	2.1 U	1.4 U	1.4 U
Hexachlorocyclopentadiene	97 U	R	98 U	99 U
Hexachloroethane	20 U	19 U	20 U	20 U
Isophorone	20 U	19 U	20 U	20 U
n-Nitroso-di-n-propylamine	30 U	29 U	30 U	30 U
n-Nitrosodimethylamine	30 U	29 U	30 U	30 U
n-Nitrosodiphenylamine	8.3 U	9.8 U	8.3 U	6.0 U
Nitrobenzene	20 U	19 U	20 U	20 U
Pentachlorophenol	30 U	42 J	30 U	30 U
Phenol	210	110	140	98

dw – dry weight
J – estimated concentration
MIS – multi-increment sampling
R – result rejected due to low LCS recoveries (Section 4.6)
U – not detected at reporting limit shown

4.2.4 PCB Aroclors

The PCB Aroclor concentrations in the MIS intertidal surface sediment composite samples are provided in Table 4-18. PCB Aroclors were detected in all of the MIS samples. The most commonly detected PCB Aroclors were Aroclor 1254 and Aroclor 1260.

Table 4-18. PCB Aroclor results for MIS intertidal surface sediment composite samples

Chemical	Concentration (µg/kg dw)			
	Area-Wide MIS Samples			Public Access Area Sample
	EW09-ITSED-AWMIS-01	EW09-ITSED-AWMIS-02	EW09-ITSED-AWMIS-03	EW09-ITSED-PAMIS-01
Aroclor 1016	27 U	36 U	27 U	20 U
Aroclor 1221	27 U	36 U	27 U	20 U
Aroclor 1232	27 U	36 U	27 U	20 U
Aroclor 1242	96	680	27 U	20 U
Aroclor 1248	27 U	36 U	140	71
Aroclor 1254	220	550	320	150
Aroclor 1260	220	360	310	150
Aroclor 1262	27 U	36 U	27 U	20 U
Aroclor 1268	27 U	36 U	27 U	20 U
Total PCBs	540	1,590	770	370

dw – dry weight
PCB – polychlorinated biphenyl
MIS – multi-increment sampling
U – not detected at reporting limit shown

4.2.5 Organochlorine pesticides

No organochlorine pesticides were detected in the MIS samples (Table 4-19).

Table 4-19. Organochlorine pesticide results for MIS intertidal surface sediment composite samples

Chemical	Concentration (µg/kg dw)			
	Area-Wide MIS Samples			Public Access Area Sample
	EW09-ITSED-AWMIS-01	EW09-ITSED-AWMIS-02	EW09-ITSED-AWMIS-03	EW09-ITSED-PAMIS-01
2,4′-DDD	1.7 U	4.2 U	2.7 U	2.7 U
2,4′-DDE	1.7 U	20 U	9.7 U	2.7 U
2,4′-DDT	1.7 U	4.2 U	2.7 U	2.7 U
4,4′-DDD	3.2 U	4.2 U	2.7 U	2.7 U
4,4′-DDE	1.7 U	4.2 U	2.7 U	2.7 U
4,4′-DDT	1.7 U	4.2 U	29 U	2.7 U
Total DDTs	3.2 U	20 U	29 U	2.7 U
Aldrin	0.86 U	2.1 U	1.4 U	1.4 U
Dieldrin	1.7 U	4.2 U	2.7 U	2.7 U
Total aldrin/dieldrin	1.7 U	4.2 U	2.7 U	2.7 U
alpha-BHC	0.86 U	2.1 U	1.4 U	1.4 U
beta-BHC	0.86 U	2.1 U	1.4 U	1.4 U
gamma-BHC	0.86 U	2.1 U	1.4 U	1.4 U

Chemical	Concentration (µg/kg dw)			
	Area-Wide MIS Samples			Public Access Area Sample
	EW09-ITSED-AWMIS-01	EW09-ITSED-AWMIS-02	EW09-ITSED-AWMIS-03	EW09-ITSED-PAMIS-01
delta-BHC	1.8 U	20 U	1.4 U	1.4 U
alpha-Chlordane	0.86 U	2.1 U	1.4 U	1.4 U
gamma-Chlordane	0.86 U	2.1 U	1.4 U	1.4 U
Total chlordane	1.7 U	4.2 U	2.7 U	2.7 U
alpha-Endosulfan	0.86 U	5.7 U	1.4 U	1.4 U
beta-Endosulfan	1.7 U	4.2 U	2.7 U	2.7 U
Endosulfan sulfate	1.7 U	4.2 U	8.2 U	2.7 U
Endrin	1.7 U	4.2 U	2.7 U	2.7 U
Endrin aldehyde	9.5 U	4.2 U	2.7 U	2.7 U
Heptachlor	0.86 U	3.4 U	1.4 U	1.4 U
Heptachlor epoxide	5.3 U	21 U	1.4 U	1.4 U
Methoxychlor	8.6 U	21 U	14 U	14 U
Mirex	1.7 U	4.2 U	2.7 U	2.7 U
cis-Nonachlor	1.7 U	4.2 U	2.7 U	2.7 U
Oxychlordane	1.7 U	4.2 U	2.7 U	2.7 U
Toxaphene	340 U	840 U	540 U	540 U
trans-Nonachlor	1.7 U	4.2 U	2.7 U	2.7 U

dw – dry weight
BHC – benzene hexachloride
DDD – dichlorodiphenyldichloroethane
DDE – dichlorodiphenyldichloroethylene
DDT – dichlorodiphenyltrichloroethane
MIS – multi-increment sampling
U – not detected at reporting limit shown

4.2.6 Dioxins and furans

The MIS intertidal surface sediment composite samples were analyzed for dioxins and furans (Table 4-20), which were detected in all four MIS samples. Dioxin toxic equivalent (TEQ) values were calculated following the protocols provided in the Data Management appendix (Appendix B). The dioxin TEQ values calculated with the full RL, half RL, and zero as the value for non-detected results are provided in Table 4-20. Because of the high detection frequencies for the dioxin and furan congeners, the TEQ values do not change substantially due to the treatment of non-detected values.

Table 4-20. Dioxin/furan results in MIS intertidal surface sediment composite samples

Chemical	Concentration (ng/kg dw)			
	Area-wide MIS samples			Public Access Area Sample
	EW09-ITSED-AWMIS-01	EW09-ITSED-AWMIS-02	EW09-ITSED-AWMIS-03	EW09-ITSED-PAMIS-01
2,3,7,8-TCDD	0.248 J	0.300 U	0.495 J	0.328 J
1,2,3,7,8-PeCDD	1.46 J	1.09 U	1.54 J	1.00 J

Chemical	Concentration (ng/kg dw)			
	Area-wide MIS samples			Public Access Area Sample
	EW09-ITSED-AWMIS-01	EW09-ITSED-AWMIS-02	EW09-ITSED-AWMIS-03	EW09-ITSED-PAMIS-01
1,2,3,4,7,8-HxCDD	2.36 J	2.25 J	1.66 J	1.41 J
1,2,3,6,7,8-HxCDD	14.4	9.52	10.4	6.42
1,2,3,7,8,9-HxCDD	5.88	3.74	4.54	2.91
1,2,3,4,6,7,8-HpCDD	544	363	311	201
OCDD	4,670	2,860	2,770	1,820
2,3,7,8-TCDF	4.78	3.43	8.66	6.26
1,2,3,7,8-PeCDF	1.70 J	1.12 U	2.62	1.70 J
2,3,4,7,8-PeCDF	2.42 U	2.44 U	7.70	4.10
1,2,3,4,7,8-HxCDF	5.31	4.54	6.10	3.88
1,2,3,6,7,8-HxCDF	2.74	2.16 J	2.88	2.12 J
1,2,3,7,8,9-HxCDF	2.42 U	2.44 U	2.49 U	2.42 U
2,3,4,6,7,8-HxCDF	4.10	3.44	4.54	3.25
1,2,3,4,6,7,8-HpCDF	63.3	50.5	74.3	52.9
1,2,3,4,7,8,9-HpCDF	3.55	3.12	4.19 U	3.43
OCDF	197	179	326	146
Total TCDD	10.9 U	18.1 U	13.1 U	9.74 U
Total PeCDD	20.0 U	21.4 U	21.2 U	13.0 U
Total HxCDD	176	125	107	59.1
Total HpCDD	1,810	1,340	965	540
Total TCDF	41.4 U	38.1 U	167 U	35.7 U
Total PeCDF	50.1 U	43.2 U	77.5 U	37.3 U
Total HxCDF	95.7 U	80.3	104 U	67.8
Total HpCDF	224 U	190	294 U	167
Dioxin/furan TEQ (zero RL)	13.3 J	7.99 J	13.1 J	8.40 J
Dioxin/furan TEQ (half RL)	13.8 J	9.19 J	13.2 J	8.52 J
Dioxin/furan TEQ (full RL)	14.3 J	10.4 J	13.4 J	8.64 J

dw – dry weight
HpCDD – heptachlorodibenzo-*p*-dioxin
HpCDF – heptachlorodibenzofuran
HxCDD – hexachlorodibenzo-*p*-dioxin
HxCDF – hexachlorodibenzofuran
J – estimated concentration
MIS – multi-increment sampling
OCDD – octachlorodibenzo-*p*-dioxin
OCDF – octachlorodibenzofuran
PCB – polychlorinated biphenyl
PeCDD – pentachlorodibenzo-*p*-dioxin
PeCDF – pentachlorodibenzofuran
TCDD – tetrachlorodibenzo-*p*-dioxin
TCDF – tetrachlorodibenzofuran
TEQ – toxic equivalent
U – not detected at reporting limit shown

4.2.7 PCB congeners

The MIS intertidal surface sediment composite samples were analyzed for PCB congeners. The coplanar PCB congeners, the PCB TEQ, and the total PCBs based on the sum of detected congeners are presented in Table 4-21. The TEQ values were calculated following the protocols provided in the Data Management appendix (Appendix B). The total PCB concentrations calculated as the sum of detected congeners were comparable to the total PCB concentrations calculated as the sum of Aroclors. For the MIS samples, the total PCBs (sum of congeners) ranged from 432.7 to 1,129 µg/kg dw (Table 4-21), and the total PCBs (sum of Aroclors) ranged from 370 to 1,590 µg/kg dw (Table 4-18). Full congener results can be found in Table A-4 in Appendix A. PCB congener TEQ values calculated using zero, half RL and full RL for the non-detected values are similar (Table 4-21) due to the high detection frequency of the TEQ congeners and low RL values for individual congeners. The only exception is the Public Access Area sample TEQ which ranges from 0.380 to 2.42 ng/kg dw due to the fact that PCB 126 was not detected in this sample. This PCB congener has a substantial influence on the TEQ due to the relatively high TEF value of 0.1.

Table 4-21. PCB coplanar, total, and TEQ congener results in MIS intertidal surface sediment composite samples

	Concentration (ng/kg dw)			
	Area-Wide MIS Samples			Public Access Area Sample
Chemical	EW09-ITSED-AWMIS-01	EW09-ITSED-AWMIS-02	EW09-ITSED-AWMIS-03	EW09-ITSED-PAMIS-01
PCB 077	613	1,820	592	406
PCB 081	22.2	69.8	20.2	16.3
PCB 105	5,120 J	4,490 J	2,730	1,740
PCB 114	292	301	145	94.0
PCB 118	15,600 J	15,700 J	8,090 J	5,840 J
PCB 123	253	291	135	86.0
PCB 126	29.2	53.1	27.7	19.8 U
PCB 156	3,960 C	2,900 C	2,030 C	1,940 C
PCB 157	C156	C156	C156	C156
PCB 167	1,860	1,420	979	908
PCB 169	1.99 U	1.96 U	1.98 U	1.95 U
PCB 189	894	627 J	434	521 J
Total PCB congeners[a]	791,900 J	1,128,800 J	451,300 J	432,700 J
PCB TEQ (zero RL)	3.83 J	6.28 J	3.27 J	0.380 J
PCB TEQ (half RL)	3.86 J	6.31 J	3.30 J	1.40 J
PCB TEQ (full RL)	3.89 J	6.34 J	3.33 J	2.42 J

[a] Sum of detected PCB congeners following summation protocol in Appendix B.

C – PCB congener co-elution, concentration represents combined result for co-eluting congeners
dw – dry weight
MIS – multi-increment sampling
PCB – polychlorinated biphenyl
TEQ – toxic equivalent
J – estimated concentration
U – not detected at given concentration

4.2.8 Conventional parameters

MIS intertidal surface sediment composite samples were analyzed for TOC and total solids (Table 4-22). The TOC ranged from 1.38 to 2.59% dw and total solids ranged from 72.1 to 75.4% ww.

Table 4-22. Conventional parameters in MIS intertidal surface sediment composite samples

Conventionals	Unit	EW09-ITSED-AWMIS			EW09-ITSED-PAMIS
		EW09-ITSED-AWMIS-01	EW09-ITSED-AWMIS-02	EW09-ITSED-AWMIS-03	EW09-ITSED-PAMIS-01
TOC	% dw	2.59	2.22	2.03	1.38
Total solids	% ww	73.40	72.10	75.40	72.50

dw – dry weight
TOC – total organic carbon
ww – wet weight

4.3 Surface Sediment Subtidal Composite Samples

4.3.1 PCB Aroclors

A summary of the PCB Aroclor detection frequencies, minimum and maximum concentrations, and ranges of RLs for the subtidal surface sediment composite samples are provided in Table 4-23. PCB Aroclors 1248, 1254, and 1260 were detected in at least one of the composite samples. The most commonly detected PCB Aroclors were Aroclor 1254 and Aroclor 1260, with Aroclor 1260 being detected in all samples. The total PCBs ranged 146 to 1,080 µg/kg dw.

Table 4-23. Summary of PCB Aroclor results in subtidal composite surface sediment samples

Chemical	Detection Frequency	Concentration (µg/kg dw)		
		Minimum Detected	Maximum Detected	RL or Range of RLs[a]
Aroclor 1016	0/13	nd	nd	7.8 – 39
Aroclor 1221	0/13	nd	nd	7.8 – 39
Aroclor 1232	0/13	nd	nd	7.8 – 39
Aroclor 1242	0/13	nd	nd	7.8 – 39
Aroclor 1248	1/13	110	110	24 – 190
Aroclor 1254	10/13	73	340	250 – 410
Aroclor 1260	13/13	73	910	na
Aroclor 1262	0/13	nd	nd	7.8 – 39
Aroclor 1268	0/13	nd	nd	7.8 – 39
Total PCBs	13/13	146	1,080	na

[a] RL range for non-detected samples.

dw – dry weight
nd –not detected
PCB – polychlorinated biphenyl
RL – reporting limit

4.3.2 Dioxins and furans

A summary of the dioxin and furan detection frequencies, minimum and maximum concentrations, and ranges of RLs for the subtidal surface sediment composite samples are provided in Table 4-24.Dioxins and furans were detected in all 13 MIS samples. The dioxin/furan TEQs ranged from 4.15 to 30.7 ng TEQ/kg dw.

Table 4-24. Dioxin and furan results for subtidal composite surface sediment samples

Chemical	Detection Frequency	Concentration (ng/kg dw)		
		Minimum Detected	Maximum Detected	Range of RLs[a]
2,3,7,8-TCDD	7/13	0.422 J	1.31	0.239 – 0.839
1,2,3,7,8-PeCDD	9/13	1.83 J	4.51	0.748 – 2.69
1,2,3,4,7,8-HxCDD	8/13	1.04 J	5.72	1.86 – 2.64
1,2,3,6,7,8-HxCDD	13/13	3.01	24.4	na
1,2,3,7,8,9-HxCDD	12/13	1.69 J	12.9	3.81
1,2,3,4,6,7,8-HpCDD	13/13	85.9	673	na
OCDD	13/13	693	5,620	na
2,3,7,8-TCDF	13/13	1.24	14.7	na
1,2,3,7,8-PeCDF	10/13	0.775 J	3.34	0.548 – 2.33
2,3,4,7,8-PeCDF	13/13	3.02	18.2	na
1,2,3,4,7,8-HxCDF	13/13	2.73	17.7	na
1,2,3,6,7,8-HxCDF	12/13	1.22 J	7.55	4.01
1,2,3,7,8,9-HxCDF	13/13	2.33	2.50	na
2,3,4,6,7,8-HxCDF	12/13	2.52	12.9	1.49
1,2,3,4,6,7,8-HpCDF	13/13	21.9	156	na
1,2,3,4,7,8,9-HpCDF	11/13	1.88 J	10.5	4.70 – 4.79
OCDF	13/13	74.0	516	na
Dioxin/furan TEQ	13/13	4.15 J	30.7	na

[a] RL range for non-detect samples.

dw – dry weight
HpCDD – heptachlorodibenzo-*p*-dioxin
HpCDF – heptachlorodibenzofuran
HxCDD – hexachlorodibenzo-*p*-dioxin
HxCDF – hexachlorodibenzofuran
J – estimated concentration
na – not applicable
OCDD – octachlorodibenzo-*p*-dioxin
OCDF – octachlorodibenzofuran
PeCDD – pentachlorodibenzo-*p*-dioxin
PeCDF – pentachlorodibenzofuran
RL – reporting limit
TCDD – tetrachlorodibenzo-*p*-dioxin
TCDF – tetrachlorodibenzofuran
TEQ – toxic equivalent

The dioxin TEQ values for each subtidal composite sample calculated with the full RL, half RL, and zero as the value for non-detected results are provided in Table 4-25.

Because of the high detection frequencies for the dioxin and furan congeners, the TEQ values do not change substantially due to the treatment of non-detected values. The highest TEQ value was calculated for the subtidal composite sample CS-06, which included samples from throughout Slip 27. The dioxin and furan TEQ concentrations for each subtidal composite area are provided on Map 4-7.

Table 4-25. Dioxin/furan TEQ calculated with RL as zero, half RL, and full RL

Sample ID	Concentration (ng/kg dw)		
	Dioxin/Furan TEQ – Mammal (zero RL)	Dioxin/Furan TEQ – Mammal (half RL)	Dioxin/Furan TEQ – Mammal (full RL)
EW09-CS-001-010	17.0 J	17.4 J	17.8 J
EW09-CS-002-010	24.0	24.2	24.3
EW09-CS-003-010	15.9	18.1	20.2
EW09-CS-004-010	9.54 J	10.1 J	10.6 J
EW09-CS-005-010	13.9 J	14.1 J	14.4 J
EW09-CS-006-010	30.4	30.6	30.7
EW09-CS-007-010	18.5	19.2	19.8
EW09-CS-008-010	15.4 J	15.6 J	15.7 J
EW09-CS-009-010	16.2 J	17.1 J	18.1 J
EW09-CS-010-010	13.8 J	14.0 J	14.3 J
EW09-CS-011-010	3.31 J	4.02 J	4.73 J
EW09-CS-012-010	5.02 J	5.69 J	6.37 J
EW09-CS-013-010	14.1 J	14.3 J	14.5 J

dw – dry weight
ID – identification
J – estimated concentration
RL – reporting limit
TEQ – toxic equivalent

4.3.3 PCB congeners

A summary of coplanar PCB detection frequencies, PCB TEQ detection frequencies, and minimum and maximum concentrations for the subtidal surface sediment composite samples are provided in Table 4-26. All of the coplanar PCBs, except PCB-169, were detected in all samples. Full congener results can be found in TableA-5 in Appendix A.

Table 4-26. Summary of PCB coplanar and TEQ congener results in subtidal composite surface sediment samples

Chemical	Detection Frequency	Detected Concentration (ng/kg dw)		Range of RLs[a]
		Minimum	Maximum	
PCB 077	13/13	183	945	na
PCB 081	13/13	8.23	40.9	na
PCB 105	13/13	883	8,520 J	na
PCB 114	13/13	53.0	495	na

Chemical	Detection Frequency	Detected Concentration (ng/kg dw)		Range of RLs[a]
		Minimum	Maximum	
PCB 118	13/13	3,290	26,400 J	na
PCB 123	13/13	49.3	390	na
PCB 126	13/13	8.61	82.2	na
PCB 156	13/13	805 C	16,800 CJ	na
PCB 157	13/13	C156	C156	na
PCB 167	13/13	371	8,260 J	na
PCB 169	0/13	nd	nd	1.90 – 1.99
PCB 189	13/13	150	4,680 J	na
Total PCB Congeners[b]	13 / 13	168,200 J	2,859,000 J	na
PCB TEQ	13/13	1.08	9.50 J	na

a RL range for non-detect samples.

b Sum of detected PCB congeners following summation protocol in Appendix B. C – PCB congener co-elution, concentration represents combined result for co-eluting congeners

dw – dry weight
J – estimated concentration
na – not applicable
nd – not detected
PCB – polychlorinated biphenyl
RL – reporting limit
TEQ – toxic equivalent

The PCB TEQ ranged from 1.08 to 9.5 ng TEQ/kg dw. PCB congener TEQ values were calculated following the protocols provided in the Data Management appendix (Appendix B). The PCB congener TEQ values calculated with the full RL, half RL, and zero as the value for non-detected results are provided in Table 4-27. Because of the high detection frequencies for the PCB congeners, the TEQ values do not change substantially due to the treatment of non-detected values. The highest TEQ value was calculated for subtidal composite sample CS-06, which included samples from throughout Slip 27. The PCB TEQ concentrations for each subtidal composite area are provided on Map 4-7.

Table 4-27. PCB congener TEQ calculated with RL as zero, half RL, and full RL

Sample ID	Concentration (ng/kg dw)		
	PCB TEQ – Mammal (zero RL)	PCB TEQ – Mammal (half RL)	PCB TEQ – Mammal (full RL)
EW09-CS-001-010	3.23 J	3.26 J	3.29 J
EW09-CS-002-010	6.56 J	6.59 J	6.62 J
EW09-CS-003-010	5.25 J	5.28 J	5.31 J
EW09-CS-004-010	2.70 J	2.73 J	2.75 J
EW09-CS-005-010	4.28 J	4.31 J	4.34 J
EW09-CS-006-010	9.47 J	9.50 J	9.53 J
EW09-CS-007-010	5.69 J	5.72 J	5.75 J
EW09-CS-008-010	7.93 J	7.96 J	7.99 J
EW09-CS-009-010	3.39 J	3.42 J	3.45 J
EW09-CS-010-010	2.63 J	2.66 J	2.69 J

Sample ID	Concentration (ng/kg dw)		
	PCB TEQ – Mammal (zero RL)	PCB TEQ – Mammal (half RL)	PCB TEQ – Mammal (full RL)
EW09-CS-011-010	1.05	1.08	1.11
EW09-CS-012-010	1.33	1.35	1.38
EW09-CS-013-010	2.86 J	2.89 J	2.92 J

dw – dry weight
ID – identification
J – estimated concentration
PCB – polychlorinated biphenyl
RL – reporting limit
TEQ – toxic equivalent

4.3.4 Conventional parameters

Subtidal composite samples were analyzed for TOC and total solids (Table 4-28). The TOC ranged from 1.05 to 2.55% dw and total solids ranged from 52.3 to 70.3% ww.

Table 4-28. Summary of conventional parameter results in subtidal composite surface sediment samples

Parameter	Unit	Detection Frequency	Detected Concentration		Range of RLs[a]
			Minimum	Maximum	
TOC	% dw	13/13	1.05	2.55	na
Total solids	% ww	13/13	52.30	70.30	na

[a] RL range for non-detect samples.

dw – dry weight
na – not applicable
RL – reporting limit
TOC – total organic carbon
ww – wet weight

4.4 Comparison of Total PCBs Calculated as the Sum of PCB Aroclors and as the Sum of PCB Congeners

The total PCBs based on the sum of detected PCB Aroclors and the sum of detected PCB congeners for each subtidal composite sample are shown in Table 4-29. The total PCB concentrations calculated as the sum of congeners were comparable to the total PCB concentrations calculated as the sum of Aroclors. For the subtidal composite samples, the total PCBs (sum of congeners) ranged from 168.2 to 2,859 µg/kg dw and the total PCBs (sum of Aroclors) ranged from 146 to 1,080 µg/kg dw. A plot of total PCBs (sum of congeners) and total PCBs (sum of Aroclors) is provided in Figure 4-1. One sample (EW09-CS-008-010) had a much higher total PCB concentration from the sum of congeners (2,860 µg/kg dw) relative to the sum of Aroclors (630 µg/kg dw). ARI confirmed the Aroclor result, and it is likely that the results reflect sample heterogeneity. There is no evidence of a systemic bias between the two methods for these samples.

Table 4-29. Total PCB concentrations calculated as the sum of PCB Aroclors and the sum of PCB congeners.

Sample	Concentrations (µg/kg dw)	
	Total PCBs (sum of PCB Aroclors)	Total PCBs (sum of PCB congeners)
Subtidal Composite Samples		
EW09-CS-001-010	410	340
EW09-CS-002-010	670	819
EW09-CS-003-010	820	821
EW09-CS-004-010	290	400
EW09-CS-005-010	740	837
EW09-CS-006-010	1,080	1,080
EW09-CS-007-010	590	863
EW09-CS-008-010	630	2,860
EW09-CS-009-010	910	932
EW09-CS-010-010	380	405
EW09-CS-011-010	640	236
EW09-CS-012-010	146	168
EW09-CS-013-010	400	403
Intertidal MIS Composite Samples		
EW09-ITSED-AWMIS-01	540	792
EW09-ITSED-AWMIS-02	1,590	1,130
EW09-ITSED-AWMIS-03	770	451
EW09-ITSED-PAMIS-01	370	433

dw – dry weight
PCB – polychlorinated biphenyl
MIS – multi-increment sampling

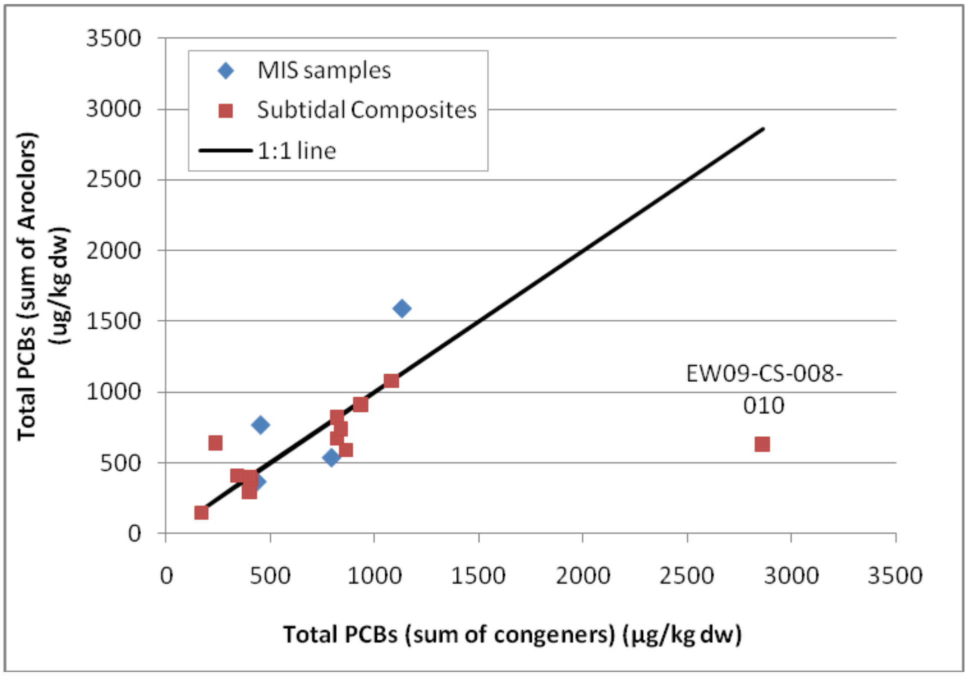


Figure 4-1.Total PCBs (sum of Aroclors) vs. total PCBs (sum of congeners)

4.5 Reference Sediment Chemical Results

Table 4-30 presents a summary of results for the six sediment samples collected from Carr Inlet reference locations (CI09-SS-020, CI09-SS-060, CI09-SS-080, CI09-SS-120, CI09-SS-140, and CI09-SS-180) for use in the laboratory toxicity tests. Grain size results from ARI were not consistent with the field-measured grain size results. All the reference samples had lower percent fines than indicated by the field measurements. All samples had relatively low TOC concentrations (< 1%).

Table 4-30. Summary of reference sample results

Parameter	Unit	Detection Frequency	Detected Concentration		RL or Range of RLs[a]
			Minimum	Maximum	
Sediment Grain Size					
Gravel	% dw	5/6	0.1	16.1	0.1
Sand	% dw	6/6	11.5	96.8	na
Silt	% dw	5/5	2.7	22.7	na
Clay	% dw	5/5	1.6	62.6	na
Fines (percent silt+clay)	% dw	5/5	4.3	85.4	na
Conventional Parameters					
TOC	% dw	6/6	0.210	0.605	na
Total solids	% ww	6/6	63.10	74.83	na
Total solids (preserved)	% ww	6/6	69.80	77.33	na

Parameter	Unit	Detection Frequency	Detected Concentration		RL or Range of RLs[a]
			Minimum	Maximum	
Total sulfides	mg/kg dw	4/6	4.38	54.5 J	1.15 – 1.36
Ammonia (total as nitrogen)	mg-N/kg dw	6/6	0.39	12.8	na

[a] RL range for non-detect samples.

dw – dry weight
na – not applicable
RL – reporting limit
TOC – total organic carbon
ww – wet weight

4.6 Comparison of Non-detected Results with Analytical Concentration Goals

This section compares RLs and method detection limits (MDLs) of non-detected concentrations for all surface sediment samples (including intertidal MIS samples and subtidal composite samples) with site-specific analytical concentration goals (ACGs). These goals were presented in Appendix C of the EW surface sediment QAPP (Windward 2009b)and Appendix D of the EW clam survey QAPP (Windward 2008).

Actual MDLs and RLs may differ from the target detection limits as a result of necessary analytical dilutions or the adjustment of extracted sample volumes of some samples based on a preliminary screen of the sample prior to analysis. 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 chemicals other than the target analytes that required dilution. The sample-specific RL is based on the lowest point of the calibration curve associated with each analysis, whereas the MDL is statistically derived following EPA methods (40 Code of Federal Regulations [CFR] 136). Both the RL and MDL will be elevated in cases where the sample extracts required dilution. Detected concentrations between the MDL and RL were reported by the laboratories and flagged with J-qualifiers to indicate that the reported concentration was an estimate because it fell below the lowest point on the calibration curve. Non-detected results were reported at the RLs. The analytical laboratory performed the appropriate sample cleanups to achieve the lowest possible detection limits.

All RLs and MDLs for surface sediment samples were lower than the risk-based ACGs developed for human health with indirect exposure, with the exception of the non-detected results listed in Table 4-31. These chemicals were identified in the project QAPP (Windward 2009a, b) as having target RLs and MDLs above the ACGs for human health with indirect exposure, with the exception of the results for BEHP, Aroclor 1016, PCB-126, endrin, 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD), 1,2,3,7,8-pentachlorodibenzo-*p*-dioxin (PeCDD), and 1,2,3,4,7,8-hexachlorodibenzo-*p*-dioxin (HxCDD). The RLs for these chemicals were elevated because of analytical dilutions and/or analytical interferences.

Table 4-31. Number of RLs and MDLs above the human health ACGs for indirect exposure (updated)

Chemical	Unit	Number of Detected Results	Range of Detected Results	Number of Non-Detected Results	Range of RLs for Non-Detected Results	Number of RLs > ACG	Range of MDLs for Non-Detected Results	Number of MDLs > ACG	Target MDL	Target RL	Human Health ACG with Indirect Exposure
Metals											
Arsenic	mg/kg dw	115	2.3 – 26.2	10	6 – 8	10	0.64 – 0.88	10	0.17	0.5	0.006
Cadmium	mg/kg dw	74	0.3 – 5.7	51	0.2 – 1	51	0.024 – 0.12	51	0.016	0.2	0.003
Organometals											
Tributyltin as ion	µg/kg dw	46	4.1 – 1,600	7	3.4 – 3.7	7	1.6 – 1.7	7	1.2	4.0	0.28
PAHs											
Benzo(a)anthracene	µg/kg dw	122	9.8 – 9,000	4	19 – 20	4	4.1 – 5.9	2	5.9	20	5.2
Benzo(a)pyrene	µg/kg dw	120	29 – 7,800	6	19 – 20	6	3.5 – 8.1	6	8.2	20	0.76
Benzo(b)fluoranthene	µg/kg dw	121	14 – 6,600	5	19 – 20	5	7.6 – 9.4	5	9.5	20	4.7
Indeno(1,2,3-cd)pyrene	µg/kg dw	117	13 – 1,800	9	19 – 20	9	4.8 – 8.5	9	8.6	20	2.9
Phthalates											
Bis(2-ethylhexyl) phthalate	µg/kg dw	106	18 – 37,000	20	19 – 1,400	11	3.6 – 11	0	27	67	120
PCBs											
Aroclor 1016	µg/kg dw	0	nd	139	3.8 – 600	127	2.1 – 320	127	1.3	4.0	6.1
Aroclor 1221	µg/kg dw	0	nd	139	3.8 – 600	139	2.1 – 320	139	1.3	4.0	0.21
Aroclor 1232	µg/kg dw	0	nd	139	3.8 – 600	139	2.1 – 320	139	1.3	4.0	0.21
Aroclor 1242	µg/kg dw	7	21 – 680	132	3.8 – 600	1320	2.1 – 320	132	2.8	4.0	0.21
Aroclor 1248	µg/kg dw	46	4.3 – 330	93	3.9 – 600	93	2.1 – 320	93	2.8	4.0	0.21
Aroclor 1254	µg/kg dw	104	6.0 – 1,100	35	3.9 – 760	35	2.1 – 260	35	2.8	4.0	0.21
Aroclor 1260	µg/kg dw	129	7.3 – 2,400	10	3.9 – 20	10	2.1 – 18	10	2.8	4.0	0.21
Total PCBs	µg/kg dw	130	6 – 3,200	9	3.9 – 20	9	2.1 – 18	9	2.8	4.0	0.21
PCB-126	ng/kg dw	16	8.61 – 82.2	1	19.8	1	3.85	1	0.42	1.0	3.5
Pesticides											
2,4′-DDD	µg/kg dw	0	nd	33	1.7 – 30	4	0.68 – 10	1	15	20	8.3
2,4′-DDE	µg/kg dw	0	nd	33	1.7 – 55	10	0.85 – 13	7	12	20	2.6

Chemical	Unit	Number of Detected Results	Range of Detected Results	Number of Non-Detected Results	Range of RLs for Non-Detected Results	Number of RLs > ACG	Range of MDLs for Non-Detected Results	Number of MDLs > ACG	Target MDL	Target RL	Human Health ACG with Indirect Exposure
2,4′-DDT	µg/kg dw	0	nd	33	1.7 – 30	33	0.52 – 8.0	26	13	20	0.92
4,4′-DDD	µg/kg dw	4	2.3 – 8.6	29	1.9 – 30	4	0.31 – 4.7	0	15	20	8.3
4,4′-DDE	µg/kg dw	0	nd	33	1.7 – 30	13	0.35 – 5.4	2	12	20	2.6
4,4′-DDT	µg/kg dw	0	nd	33	1.7 – 41	33	0.35 – 5.4	10	13	20	0.92
Total DDTs	µg/kg dw	4	2.3 – 8.6	29	1.9 – 55	29	0.52 – 8.0	26	15	20	0.92
Aldrin	µg/kg dw	0	nd	33	0.86 – 270	33	0.23 – 3.6	33	5.7	10	0.063
Dieldrin	µg/kg dw	0	nd	33	1.7 – 41	33	0.33 – 5.1	33	12	20	0.033
beta-BHC	µg/kg dw	0	nd	33	0.86 – 15	33	0.28 – 4.3	10	3.9	10	0.63
gamma-BHC	µg/kg dw	0	nd	33	0.86 – 15	33	0.13 – 2.0	2	5.0	10	0.83
Total chlordane	µg/kg dw	1	4.4 – 4.4	32	1.7 – 100	31	0.51 – 8.0	9	60	10	1.7
Endrin	µg/kg dw	0	nd	33	1.7 – 30	1	0.51 – 7.9	0	15	20	27
Heptachlor	µg/kg dw	0	nd	33	0.86 – 15	33	0.23 – 3.6	28	5.6	10	0.25
Dioxin/Furan											
2,3,7,8-TCDD	ng/kg dw	10	0.248 – 1.31	7	0.239 – 0.839	4	0.062 – 0.176	0	0.0740	0.500	0.35
1,2,3,7,8-PeCDD	ng/kg dw	12	1.00 – 4.51	5	0.748 – 2.69	5	0.140 – 0.454	2	0.210	2.50	0.35
1,2,3,4,7,8-HxCDD	ng/kg dw	12	1.04 – 5.72	5	1.86 – 2.64	5	0.322 – 0.782	1	0.260	2.50	0.7
1,2,3,7,8,9-HxCDD	ng/kg dw	16	1.69 – 12.9	1	3.81	1	0.458	0	0.248	2.50	3.5

ACG – analytical concentration goal
BHC – benzene hexachloride
DDD – dichlorodiphenyldichloroethane
DDE – dichlorodiphenyldichloroethylene
DDT – dichlorodiphenyltrichloroethane
dw – dry weight
HxCDD – hexachlorodibenzo-*p*-dioxin
HxCDF – hexachlorodibenzofuran
MDL – method detection limit
nd – not detected
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
PeCDD – pentachlorodibenzo-*p*-dioxin
RL – reporting limit
TCDD – tetrachlorodibenzo-*p*-dioxin

All RLs for surface sediment samples were lower than the risk-based ACGs developed for human health with direct exposure, except for the results summarized in Table 4-32. All RLs and MDLs for antimony and n-nitrosodimethylamine were above the ACGs for human health with direct exposure. Both of these chemicals are known to be difficult to quantify in sediment. The RLs for six PCB Aroclors, aldrin, dieldrin, and Mirex—chemicals that were not identified in the QAPP (Windward 2009b) as having RLs above ACGs—were elevated because of analytical dilutions and/or analytical interferences.

Table 4-32. Number of RLs and MDLs above the human health ACGs for direct exposure

Chemical	Unit	Number of Detected Results	Range of Detected Results	Number of Non-Detected Results	Range of RLs for Non-Detected Results	Number of RLs > ACG	Range of MDLs for Non-Detected Results	Number of MDLs > ACG	Target MDL	Target RL	Human Health ACG with Direct Exposure
Metals											
Antimony	mg/kg dw	1	7 – 7	124	6 – 30	117	0.11 – 2.3	0	0.013	0.2	3.1
Arsenic	mg/kg dw	115	2.3 – 26.2	10	6 – 8	10	0.64 – 0.88	10	0.17	0.5	0.39
PAHs											
Benzo(a)pyrene	µg/kg dw	120	29 – 7,800	6	19 – 20	6	3.5 – 8.1	0	8.2	20	15
Dibenzo(a,h)anthracene	µg/kg dw	78	7.9 – 690	48	6.0 – 59	46	2.3 – 25	1	8.6	20	15
Other SVOCs											
n-Nitrosodimethylamine	µg/kg dw	0	nd	125	29 – 31	125	21 – 22	125	8.6	33	2.3
PCBs											
Aroclor 1016	µg/kg dw	0	nd	139	3.8 – 600	1	2.1 – 320	0	1.3	4.0	390
Aroclor 1221	µg/kg dw	0	nd	139	3.8 – 600	17	2.1 – 320	2	1.3	4.0	170
Aroclor 1232	µg/kg dw	0	nd	139	3.8 – 600	17	2.1 – 320	2	1.3	4.0	170
Aroclor 1242	µg/kg dw	7	21 – 680	132	3.8 – 600	2	2.1 – 320	1	2.8	4.0	220
Aroclor 1248	µg/kg dw	46	5.2 – 330	93	3.9 – 600	2	2.1 – 320	1	2.8	4.0	220
Aroclor 1254	µg/kg dw	104	6 – 1,100	35	3.9 – 760	9	2.1 – 260	1	2.8	4.0	220
Pesticides											
Aldrin	µg/kg dw	0	nd	33	0.86 – 270	2	0.23 – 3.6	0	5.7	10	29
Dieldrin	µg/kg dw	0	nd	33	1.7 – 41	2	0.33 – 5.1	0	12	20	30
Mirex	µg/kg dw	0	nd	33	1.7 – 85	2	0.62 – 9.6	0	20	20	27
Toxaphene	µg/kg dw	0	nd	33	96 – 1,500	7	33 – 520	1	1,000	1,000	440

ACG – analytical concentration goal
dw – dry weight
MDL – method detection limit
nd – not detected
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
RL – reporting limit
SVOC – semivolatile organic compound

Table 4-33 lists 21 chemicals with RLs above applicable ACGs for benthic invertebrates. None of these chemicals had MDLs above their respective ACGs, with the exception of two results for total DDTs. Twelve chemicals had RLs above the ACGs that were not anticipated in the QAPP (Windward 2009b) (2-methylnapthalene, acenaphthene, aldrin, benzyl alcohol, dibenzofuran, dieldrin, gamma-benzene hexachloride (BHC), heptachlor, hexachlorobutadiene, total chlordane, total DDTs, and total PCBs); however, these ACGs were met by the associated MDLs for all results, with the exception of two results for total DDTs. The RLs for these chemicals were elevated because of analytical dilutions and/or analytical interferences.

The SQS for some chemicals are expressed on an OC-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 two surface sediment samples collected in the EW had a TOC concentration below 0.5%, and the mean TOC concentration was 1.7%.

Table 4-33. Number of RLs and MDLs above the benthic ACGs

Chemical	Unit	Number of Detected Results	Range of Detected Results	Number of Non-Detected Results	Range of RLs for Non-Detected Results	Number of RLs > ACG	Range of MDLs for Non-Detected Results	Number of MDLs > ACG	Target MDL	Target RL	Benthic Invertebrate ACG[a]
PAHs											
2-Methylnaphthalene	mg/kg OC	44	9.7 – 2,800	80	19 – 59	3	0.24 – 2.0	0	na[b]	na[b]	38
Acenaphthene	mg/kg OC	65	11 – 3,000	59	19 – 21	59	0.28 – 1.4	0	na[b]	na[b]	16
Dibenzo(a,h)anthracene	mg/kg OC	78	7.9 – 690	46	6.0 – 59	45	0.31 – 1.5	0	na[b]	na[b]	12
Dibenzofuran	mg/kg OC	60	10 – 1,100	64	19 – 21	64	0.26 – 1.3	0	na[b]	na[b]	15
Phthalates											
bis(2-ethylhexyl) phthalate	mg/kg OC	106	18 – 37,000	18	34 – 1,400	15	0.14 – 1.7	0	na[b]	na[b]	47
Butyl benzyl phthalate	mg/kg OC	64	15 – 290	60	14 – 15	60	0.11 – 0.67	0	na[b]	na[b]	4.9
Di-n-octyl phthalate	mg/kg OC	6	14 – 83	118	19 – 59	2	0.12 – 2	0	na[b]	na[b]	58
Other SVOCs											
1,2,4-Trichlorobenzene	mg/kg OC	2	7.2 – 8.5	122	3.0 – 6.2	122	0.058 – 0.37	0	na[b]	na[b]	0.81
1,2-Dichlorobenzene	mg/kg OC	0	nd	124	5.8 – 6.2	124	0.035 – 0.22	0	na[b]	na[b]	2.3
1,4-Dichlorobenzene	mg/kg OC	81	5.9 – 4,200	43	5.8 – 6.2	43	0.059 – 0.37	0	na[b]	na[b]	3.1
Benzyl Alcohol	µg/kg dw	1	38 – 38	113	19 – 58	1	12 – 42	0	na[b]	15/20	57
Hexachlorobenzene	mg/kg OC	0	nd	124	0.86 – 6.2	124	0.0057 – 0.33	0	na[b]	na[b]	0.38
Hexachlorobutadiene	mg/kg OC	0	nd	124	0.86 – 6.2	95	0.0045 – 0.48	0	na[b]	na[b]	3.9
n-Nitrosodiphenylamine	mg/kg OC	0	nd	124	5.8 – 47	7	0.079 – 0.50	0	na[b]	na[b]	11
PCBs											
Total PCBs	mg/kg OC	129	14.1 – 3,200	8	3.9 – 20	7	0.27 – 1.8	0	na[b]	na[b]	12
Pesticides											
Total DDTs	µg/kg dw	4	2.3 – 8.6	29	1.9 – 55	9	0.52 – 8.0	2	1.3	2.0	6.9
Aldrin	µg/kg dw	0	nd	33	0.86 – 270	4	0.23 – 3.6	0	0.48	1.0	10
Dieldrin	µg/kg dw	0	nd	33	1.7 – 41	7	0.33 – 5.1	0	0.84	2.0	10
gamma-BHC	µg/kg dw	0	nd	33	0.86 – 15	1	0.13 – 2.0	0	0.49	1.0	10

Chemical	Unit	Number of Detected Results	Range of Detected Results	Number of Non-Detected Results	Range of RLs for Non-Detected Results	Number of RLs > ACG	Range of MDLs for Non-Detected Results	Number of MDLs > ACG	Target MDL	Target RL	Benthic Invertebrate ACG[a]
Total chlordane	µg/kg dw	1	nd	32	1.7 – 100	3	0.51 – 8.0	0	1.0	2.0	10
Heptachlor	µg/kg dw	0	nd	33	0.86 – 15	1	0.23 – 3.6	0	0.40	1.0	10

[a] In Appendix D of the QAPP (Windward 2009b), the OC-normalized ACGs were converted to dry weight for comparison to dry-weight RLs and MDLs using an OC content of 0.5%. In the comparison presented in this table, the RLs and MDLs are converted to OC-normalized values using sample-specific TOC contents for comparison to OC-normalized ACGs.

[b] The target RLs and MDLs presented in the QAPP (Windward 2009b) are dry-weight values.

ACG – analytical concentration goal
dw – dry weight
BHC – benzene hexachloride
DDT – dichlorodiphenyltrichloroethane
MDL – method detection limit
na – not applicable
nd – not detected
OC – organic carbon
QAPP – quality assurance project plan
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
RL – reporting limit
SVOC – semivolatile organic compound
TOC – total organic carbon

4.7 CHEMICAL DATA VALIDATION RESULTS

The analyses were conducted using the sample delivery group (SDG) assignments listed in Table 4-34.

Table 4-34. SDGs and level of data validation

Sampling Event	SDG	Number of Sediment Samples	Level of Data Validation	Analyses[a, b]
2009 T-30 PDM	ON35	8	full	SMS chemistry
	ON50	2	full	SMS chemistry
	QF22	7	summary	SMS chemistry
EW Round 1	OO97	16	summary	SMS chemistry, butyltins, pesticides
	OP22	6	summary	SMS chemistry, butyltins, pesticides
	OP33	7	full – pesticides; summary – rest of data	SMS chemistry, pesticides
	OP35	21	full	SMS chemistry, butyltins, pesticides
	OP65	4	summary	SMS chemistry, pesticides
	OQ68	3	summary	grain size, conventionals
	OQ77	1	summary	pesticides, butyltins
EW Round 2	PD95	13	full	SMS chemistry, butyltins, pesticides
	PD97[c]	10	summary	SMS chemistry, butyltins, pesticides
	PE07	10	summary	SMS chemistry, butyltins, pesticides
	PE14	12	summary	SMS chemistry, butyltins, pesticides
	PE25[d]	10	summary	SMS chemistry, butyltins
	PE40[d]	5	summary	SMS chemistry, butyltins
	PG13	3	summary	grain size, conventionals
	PH64	1	summary	butyltins
EW MIS intertidal and subtidal composites	QC54	17	full	SMS chemistry, butyltins, pesticides
	P1855	4	full	PCB congeners and dioxins/furans
	P1940	13	full	PCB congeners and dioxins/furans

a SMS chemistry parameters include SVOCs, selected SVOCs by SIM, PCB Aroclors, mercury, other metals, grain size, and conventional parameters on all samples. Pesticides and butyltins were also analyzed in select samples as listed in Table 3-2.

b Conventional parameters included TOC, total solids, total preserved solids, total sulfides, and ammonia (total as nitrogen).

c One sample from PD97 was reanalyzed for copper in SDG PG50.

d One sample from PE25 and five samples from PE40 were reanalyzed for SVOCs in SDGs PH67 and PH68, respectively.

EW – East Waterway
MIS – multi-increment sampling
PCB – polychlorinated biphenyl
PDM – post-dredge monitoring
SDG – sample delivery group
SIM – selected ion monitoring
SMS – Washington State Sediment Management Standards
SVOC – semivolatile organic compound
T-30 – Terminal 30
TOC – total organic carbon

Independent data validation was performed on all results by EcoChem. A minimum of 20% of sediment results per analysis underwent full-level data validation; the rest of the sediment results underwent summary-level data validation. The level of data validation performed by EcoChem meets the requirements specified in the surface sediment QAPP (Windward 2009b), the intertidal MIS QAPP (Windward 2009a), and the T-30 PDM plan (Windward and Anchor 2008). The data validation included a review of all quality control (QC) summary forms, including initial calibration, continuing calibration verification (CCV), internal standard, surrogate, laboratory control sample (LCS), laboratory control sample duplicate (LCSD), matrix spike (MS), matrix spike duplicate (MSD), standard reference material (SRM), and interference check sample (ICS) summary forms. The majority of the data did not require qualification or were qualified with a J, indicating an estimated value. Fifty-two results for eight chemicals were rejected as a result of data validation. Rejected results will not be used for any purpose. Based on the information reviewed, the overall data quality was considered acceptable for all uses, as qualified. Issues that resulted in the qualification of data are summarized below. Detailed information regarding every qualified sample is presented in Appendix C.

SVOCs and organometals

- Ten results each for aniline and benzyl alcohol were rejected because of extremely low LCS recoveries (less than 10%). These chemicals are known to be difficult to quantify in sediment, so no reanalyses were performed.
- Results for the following chemicals were rejected because of extremely low MS/MSD recoveries (less than 10%): 10 results for 4-chloroaniline; 9 results for aniline; 7 results for 3,3-dichlorobenzidine; 3 results for hexachlorocyclopentadiene; 2 results for 3-nitroaniline ; and 1 result each for 4-nitroaniline, benzyl alcohol, and n-nitrosodimethylamine. Associated LCS recoveries were acceptable, so no reanalyses were performed. Only the results for the sample spiked to create the MS/MSD were rejected; other samples in the batch were not qualified.
- Final results for the following two phthalates, which are common laboratory contaminants, were requalified as non-detected (U-qualified) because of method blank contamination: 19 results for BEHP, ranging from 34 to 1,400 µg/kg dw; and 10 results for diethylphthalate, ranging from 15 to 46 µg/kg dw. Diethyl phthalate was analyzed by both EPA 8270D and EPA 8270D-SIM. Method blank contamination was prevalent in the EPA 8270D-SIM analysis, but was rarely found in the EPA 8270D analysis. The final results for this chemical were selected in accordance with the data management rules presented in Appendix B; therefore, when the EPA 8270D-SIM analysis resulted in higher RLs because of method blank contamination, the final results for diethyl phthalate were preferentially selected from the EPA 8270D analysis. The availability and use of

EPA 8270D data for diethyl phthalate largely compensates for the method blank contamination issue in the EPA 8270D-SIM analysis.

- Results for various chemicals were qualified as estimated (J- or UJ-qualified) because CCV, LCS/LCSD, MS/MSD, SRM, or surrogate percent recoveries or relative percent differences (RPDs) were outside of control limits. Results qualified as estimated included the following: 56 results for benzo(g,h,i)perylene; 52 results for indeno(1,2,3-cd)pyrene; 29 results for dibenzo(a,h)anthracene; 23 results for aniline; 18 results for benzyl alcohol; 17 results for benzoic acid; 12 results for 3-nitroaniline; 8 results each for hexachlorocyclopentadiene and TBT; 11 results for PCP; 10 results each for 2,4-dimethylphenol, 2-methylphenol, and 4-nitrophenol; 7 results each for 2,4-dinitrophenol and 4,6-dinitro-2-methylphenol; 5 results for dibutyltin, 4 results for benzo(b)fluoranthene; 2 results each for 4-chloroaniline, butyl benzyl phthalate, 3,3′-dichlorobenzidine, carbazole, and fluoranthene; and 1 result each for 4-nitroaniline, acenaphthylene, anthracene, BEHP, benzo(a)pyrene, benzo(k)fluoranthene, chrysene, dibenzofuran, dibutyltin, diethyl phthalate, fluorene, hexachloroethane, naphthalene, and phenanthrene.
- Results for various chemicals (i.e., perylene-d12, chrysene-d12, and/or di-n-octylphthalate) were J- or UJ-qualified as estimated because the associated internal standard recoveries were outside of control limits. The following results were J- or UJ-qualified as estimated: seven results for dibenz(a,h)anthracene, two results for benzo(g,h,i)perylene, and one result each for di-n-octyl phthalate and indeno(1,2,3-cd)pyrene.
- Four results for phenol were qualified by ARI to indicate an estimated concentration with a low spectral match (M-qualified). These results were qualified during data validation to indicate an estimated concentration with tentative ID (JN-qualified).
- Three other SVOCs were qualified by ARI to indicate that chromatographic interference in the sample prevented adequate resolution of the compound at the standard RLs (Y-qualified). The Y-qualified results were U-qualified during data validation, including: 14 results for n-nitrosodiphenylamine, 4 results for 2-chlorophenol, and 1 result for hexachlorobutadiene.

Metals

- Results for various chemicals were J- or UJ-qualified as estimated because ICS, LCS/LCSD, MS/MSD, laboratory replicate, contract-required detection limit standard recoveries, or RPDs were outside of control limits. J- or UJ-qualified results qualified as estimated include: 135 results for antimony, 63 results for mercury, 29 results for zinc, 19 results for molybdenum, 12 results for cadmium, 11 results each for cobalt and lead, 10 results for copper, 5 results for silver, and 4 results for vanadium.

- Seven mercury results were J-qualified as estimated because analysis occurred after the 6-month holding time. The affected samples were all archived T-30 post-dredge monitoring samples.
- Results for all SRM samples were reviewed. One detected result for TBT was J-qualified as estimated because the associated SRM result was outside of acceptance limits.

PCBs and pesticides

- The RPDs between the results of dual-column analyses for Aroclor 1254 and 4,4′-dichlorodiphenyldichloroethylene (DDE), in one sample for each chemical, were greater than the control limit of ± 40%. These results were J-qualified to indicate estimated concentrations.
- Two detected results for 4,4′-DDD were J-qualified as estimated because the internal standard recoveries for hexabromobiphenyl were outside of control limits.
- When more than one Aroclor is present in a sample, the potential exists for a high bias from the contribution of one Aroclor to another caused by common peaks or peaks that cannot be completely resolved. Analytical peaks are selected, and Aroclor ID is made based on the best resolution possible for that particular sample. In this analysis, Aroclor concentrations were reported based on the individual Aroclors that provided the best match to the observed sample pattern. One-hundred-fourteen results for twenty different Aroclors or pesticides were Y-qualified by the laboratory as non-detects at elevated RLs because of overlapping Aroclor patterns. The Y-qualifier indicated that chromatographic interference in the sample prevented adequate resolution of the compound at the standard RLs. These results were U-qualified during data validation.

Conventionals and grain size

- The TOC and total solids results for eight samples were J-qualified as estimated because analysis occurred after the 6-month holding time for these analyses.
- Seventy-two total sulfides results, fourteen TOC results, and four grain-size results were J-qualified because the laboratory replicate or MS/MSD (total sulfides and TOC only) percent recoveries and/or RPDs were outside of QC limits.

PCB congeners and dioxins/furans

- Eighty-nine PCB congner results were J- or UJ-qualified as estimated because labeled compound recoveries were outside of QC limits. One result, PCB-001 in sample EW09-CS-012-010, was rejected because there was no recovery (0%) of the associated labeled compound.

- One-hundred-sixty-seven PCB congener results had secondary ion traces that had significantly elevated noise levels relative to the lock mass compounds. The concentrations for these analytes were calculated using the primary ion areas only and were consequently J-qualified as estimated.
- Five results for PCB-011 were requalified as non-detect at RLs ranging from 51.9 to 63.2 ng/kg dw because of method blank contamination.
- Numerous PCB congener results (638) were J-qualified as estimated because they were above the calibrated range of the instrument; all results were within the linear operating range of the instrument.

4.8 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* and *Crassostrea gigas*). The results for each location are provided in Map 4-8. The complete laboratory toxicity test reports are presented in Appendix D-2, and raw data summaries from the laboratory are presented in Appendix D-3.

4.8.1 Amphipod tests

Mean mortality results from the 10-day sediment toxicity tests with the amphipod *Eohaustorius estuarius* are presented in Table 4-35. The mean mortality in the test sediment samples ranged from 0% in EW09-SS-220-010 to 35% in EW09-SS-033-010.

Table 4-35. Percent mean mortality in the amphipod sediment toxicity tests and exceedances of the SMS biological effects criteria

Sample ID	Reference Sediment Match	Percent Mean Mortality ± SD	SMS Exceedance[a]
Round 1			
Negative control	na	0.0 ± 0.0	na
CI09-SS-020-010 (ref)	na	2.0 ± 2.7	na
CI09-SS-060-010 (ref)	na	6.0 ± 4.2	na
CI09-SS-080-010 (ref)	na	2.0 ± 2.7	na
EW09-SS-005-010	CI09-SS-060-010	10.0 ± 6.1	no exceedances
EW09-SS-030-010	CI09-SS-080-010	26.0 ± 8.2	SQS
EW09-SS-032-010	CI09-SS-080-010	14.0 ± 5.5	no exceedances
EW09-SS-033-010	CI09-SS-080-010	35.0 ± 5.0	CSL[b]
EW09-SS-034-010	CI09-SS-080-010	18.0 ± 11.0	no exceedances
EW09-SS-035-010	CI09-SS-080-010	33.0 ± 16.8	CSL[b]
EW09-SS-217-010	CI09-SS-020-010	2.0 ± 2.7	no exceedances
EW09-SS-218-010	CI09-SS-020-010	3.0 ± 2.7	no exceedances
EW09-SS-220-010	CI09-SS-020-010	0.0 ± 0.0	no exceedances

Sample ID	Reference Sediment Match	Percent Mean Mortality ± SD	SMS Exceedance[a]
Round 2			
Negative control	na	4.0 ± 5.5	na
CI09-SS-120-010 (ref)	na	6.0 ± 4.2	na
CI09-SS-180-010 (ref)	na	22.0 ± 10.4	na
EW09-SS-015-010	CI09-SS-120-010	6.0 ± 5.5	no exceedances
EW09-SS-215-010	CI09-SS-120-010	13.0 ± 7.6	no exceedances

[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] Mean mortality greater than the value in the reference sediment plus 30%, and statistically different from the reference sediment ($p \leq 0.05$).

CSL – cleanup screening level
ID – identification
na – not applicable
SD – standard deviation
SMS – Washington State Sediment Management Standards
SQS – sediment quality standards

The mean mortality in the negative control was 0 and 4% in Rounds 1 and 2, and the mean mortality in the reference sediments ranged from 2 to 22%. The negative control and reference sediments met the performance standards of less than 10 and 25% mortality, respectively (Table 3-7).

The LC50 (concentration that is lethal to 50% of an exposed population) values from the positive control tests were within the laboratory warning limits of two standard deviations (SDs) 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. Further details on the positive control and calculation of the LC50 values are presented in Appendix D.

Results were compared to SMS biological effects criteria for amphipod toxicity tests (Table 3-7); two test sediment samples, EW09-SS-033-010 and EW09-SS-035-010, were classified as CSL exceedances using the statistical package included in SEDQUAL Release 5 (Table 4-35).

Water quality results for the amphipod toxicity tests are summarized in Table 4-36. All water quality parameters in the two rounds were within protocol-specified ranges, with the exception of the salinity measurements listed in Section 3.3.2. As discussed in that section, these salinity deviations did not affect the data quality. The water quality results are presented in detail in Appendices D-2 and D-3.

Table 4-36. Water quality measurements for the amphipod sediment toxicity tests

Parameter	Unit	Round 1			Round 2		
		Mean ± SD	Minimum	Maximum	Mean ± SD	Minimum	Maximum
Overlying Water							
Temperature	°C	15.7 ± 0.2	15.0	16.0	15.7 ± 0.1	15.4	16.0

Parameter	Unit	Round 1			Round 2		
		Mean ± SD	Minimum	Maximum	Mean ± SD	Minimum	Maximum
Dissolved oxygen	mg/L	7.8 ± 0.4	6.6	9.2	7.8 ± 0.4	6.4	8.5
Salinity	ppt	28.9 ± 0.1	27.0	31.0	28.5 ± 0.6	27.0	29.5
pH	na	8.1 ± 0.2	7.8	8.7	8.3 ± 0.2	8.0	8.7
Interstitial Water							
Salinity	ppt	28.7 ± 1.2	26.5	30.5	28.2 ± 0.4	28.0	29.0
pH	na	7.3 ± 0.3	7.0	8.0	7.4 ± 0.3	7.0	7.8

C – centigrade
na – not applicable
ppt – parts per thousand
SD – standard deviation

Sulfides and ammonia results for the amphipod tests are summarized in Table 4-37. Positive control tests for ammonia were conducted concurrently with the sediment toxicity tests. The LC50 values for the Rounds 1 and 2 were 183 mg/L and 226 mg/L total ammonia-N, respectively. All ammonia concentrations in the water overlying the test sediment samples were well below the LC50 concentrations.

Table 4-37. Sulfides and ammonia measurements for the amphipod sediment toxicity tests

Parameter	Unit	Round 1		Round 2	
		Minimum	Maximum	Minimum	Maximum
Overlying Water					
Dissolved sulfides	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Total ammonia-N	mg/L	< 0.1	1.8	< 0.1	6.0
Un-ionized ammonia	mg/L	< 0.003	0.148	< 0.003	0.670
Interstitial Water					
Total ammonia-N	mg/L	< 0.1	5.6	< 0.5	18.1
Un-ionized ammonia	mg/L	< 0.003	0.148	< 0.007	0.155

4.8.2 Polychaete tests

Mortality and growth rate results for the 20-day sediment toxicity test with the polychaete *Neanthes arenaceodentata* are presented in Table 4-38. A mortality rate of 8% was observed in one of the sediment test samples (EW09-SS-032-010); no mortality was observed in the other polychaete test samples. The mean individual growth rate in the sediment test samples ranged from 0.69 mg/day for EW09-SS-015-010 to 1.25 mg/day for EW09-SS-218-010.

Table 4-38. Mean mortality and individual growth rate in the polychaete sediment toxicity tests and exceedances of the SMS biological effects criteria

Sample ID	Reference Sediment Match	Mean Mortality ± SD	Mean Individual Growth Rate (mg/day) ± SD	SMS Exceedance[a]
Round 1				
Negative control	na	0.0 ± 0.0	1.19 ± 0.21	na
CI09-SS-020-010 (ref)	na	0.0 ± 0.0	1.15 ± 0.20	na
CI09-SS-060-010 (ref)	na	0.0 ± 0.0	1.21 ± 0.24	na
CI09-SS-080-010 (ref)	na	0.0 ± 0.0	1.35 ± 0.11	na
EW09-SS-005-010	CI09-SS-060-010	0.0 ± 0.0	1.06 ± 0.24	no exceedances
EW09-SS-030-010	CI09-SS-080-010	0.0 ± 0.0	0.98 ± 0.12	no exceedances
EW09-SS-032-010	CI09-SS-080-010	8.0 ± 11.0	1.10 ± 0.11	no exceedances
EW09-SS-033-010	CI09-SS-080-010	0.0 ± 0.0	1.06 ± 0.09	no exceedances
EW09-SS-034-010	CI09-SS-080-010	0.0 ± 0.0	1.19 ± 0.10	no exceedances
EW09-SS-035-010	CI09-SS-080-010	0.0 ± 0.0	1.02 ± 0.17	no exceedances
EW09-SS-217-010	CI09-SS-020-010	0.0 ± 0.0	1.18 ± 0.22	no exceedances
EW09-SS-218-010	CI09-SS-020-010	0.0 ± 0.0	1.25 ± 0.11	no exceedances
EW09-SS-220-010	CI09-SS-020-010	0.0 ± 0.0	1.06 ± 0.11	no exceedances
Round 2				
Negative control	na	0.0 ± 0.0	1.13 ± 0.19	na
CI09-SS-120-010 (ref)	na	0.0 ± 0.0	1.16 ± 0.11	na
CI09-SS-180-010 (ref)	na	0.0 ± 0.0	1.08 ± 0.07	na
EW09-SS-015-010	CI09-SS-120-010	0.0 ± 0.0	0.69 ± 0.12	SQS[b]
EW09-SS-215-010	CI09-SS-120-010	0.0 ± 0.0	0.89 ± 0.14	no exceedances

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

ID – identification

na – not applicable

SD – standard deviation

SMS – Washington State Sediment Management Standards

SQS – sediment quality standards

In Rounds 1 and two, the mean individual growth rates in the negative control were 1.19 and 1.13 mg/day, and the mean individual growth rate in the reference sediments ranged from 1.08 to 1.35 mg/day. The negative controls 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 3-7), and the reference sediments met the performance criterion of an individual growth rate of at least 80% of the negative control (Table 3-7).

The LC50 values from the positive control tests were within the laboratory warning limits of two SDs 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 with SMS biological effects criteria for polychaete toxicity tests, one test sediment sample was classified as exceeding SQS, and no samples exceeded the CSL. There are no SMS standards for mortality in the polychaete toxicity test (Table 4-38).

Water quality results for the 20-day polychaete toxicity test are summarized in Table 4-39. All water quality parameters in Rounds 1 and 2 were within protocol-specified ranges, except for one salinity value (see Section 3.3.2). The water quality results are presented in detail in Appendices D-2 and D-3.

Table 4-39. Water quality measurements for overlying water for the polychaete sediment toxicity tests

Parameter	Unit	Round 1			Round 2		
		Mean ± SD	Minimum	Maximum	Mean ± SD	Minimum	Maximum
Temperature	°C	19.92 ± 0.6	19.2	21.4	20.1 ± 0.3	19.4	20.6
Dissolved oxygen	mg/L	6.5 ± 0.7	2.4	7.3	6.8 ± 0.5	5.7	7.5
Salinity	ppt	28.3 ± 1.0	26.0	30.0	29.2 ± 0.8	28.0	30.5
pH	na	7.9 ± 0.2	7.4	8.4	8.1 ± 0.2	7.7	8.6

C – Celsius
na – not applicable
ppt – parts per thousand
SD – standard deviation

The sulfides and ammonia results for the polychaete tests are summarized in Table 4-40. Positive control tests for ammonia were conducted concurrently with the sediment toxicity tests. The LC50 values for Rounds 1 and 2 were 259 mg/L and 234 mg/L total ammonia-N, respectively. All ammonia concentrations in the water overlying the test sediment samples were well below the LC50 concentrations.

Table 4-40. Sulfides and ammonia measurements for the polychaete sediment toxicity tests

Parameter	Unit	Round 1		Round 2	
		Minimum	Maximum	Minimum	Maximum
Dissolved sulfides	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Total ammonia-N	mg/L	< 0.1	9.8	< 0.1	10.0
Un-ionized ammonia	mg/L	< 0.002	0.283	< 0.005	0.482

4.8.3 Bivalve larvae tests

Results for the 48-hr sediment toxicity test with the bivalve larvae *Mytilus galloprovincialis* and *Crassostrea gigas* are presented in Table 4-41. The Round 1 sediments were tested with *Mytilus galloprovincialis,* and the Round 2 sediments were tested with *Crassostrea gigas.* The mean normal survivorship in the test sediment samples ranged from 80.1% in EW09-SS-215-010 to 96.7% in EW09-SS-217-010.

Table 4-41. Percent mean normal survivorship in the bivalve larvae sediment toxicity tests and exceedances of the SMS biological effects criteria

Sample ID	Reference Sediment Match	Percent Mean Normal Survivorship ± SD[a]	Percent Mean Effective Mortality ± SD[b]	SMS Exceedance[c]
Round 1				
Negative control	na	100.0 ± 3.2	0.0 ± 3.2	na
CI09-SS-020-010 (ref)	na	95.8 ± 6.0	4.2 ± 6.0	na
CI09-SS-060-010 (ref)	na	89.6 ± 7.1	10.4 ± 7.1	na
CI09-SS-080-010 (ref)	na	88.5 ± 10.0	11.5 ± 10.0	na
EW09-SS-005-010	CI09-SS-060-010	92.7 ± 8.4	9.7 ± 8.4	no exceedances
EW09-SS-030-010	CI09-SS-080-010	90.3 ± 5.0	9.7 ± 5.0	no exceedances
EW09-SS-032-010	CI09-SS-080-010	87.4 ± 11.0	12.6 ± 11.0	no exceedances
EW09-SS-033-010	CI09-SS-080-010	90.7 ± 4.3	9.3 ± 4.3	no exceedances
EW09-SS-034-010	CI09-SS-080-010	84.0 ± 3.8	16.0 ± 3.8	no exceedances
EW09-SS-035-010	CI09-SS-080-010	84.0 ± 9.4	16.0 ± 9.4	no exceedances
EW09-SS-217-010	CI09-SS-020-010	96.7 ± 8.3	3.3 ± 8.3	no exceedances
EW09-SS-218-010	CI09-SS-020-010	94.9 ± 5.6	5.1 ± 5.6	no exceedances
EW09-SS-220-010	CI09-SS-020-010	89.1 ± 8.6	10.9 ± 8.6	no exceedances
Round 2				
Negative control	na	100.0 ± 10.2	0.0 ± 10.2	na
CI09-SS-120-010 (ref)	na	84.4 ± 12.2	15.6 ± 6.3	na
CI09-SS-180-010 (ref)	na	74.3 ± 12.2	25.7 ± 9.2	na
EW09-SS-215-010	CI09-SS-120-010	80.1 ± 6.3	19.9 ± 16.7	no exceedances
EW09-SS-015-010	CI09-SS-120-010	86.4 ± 1.6	13.6 ± 6.1	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 (sea water) control, as is done, for example, for the purposes of dredged material evaluation and disposal (USACE et al. 2000). To have calculated normal survivorship in this way would have resulted in slightly higher percent survivorship values but would not have changed 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 (mean normal survivorship < 85% of that of the reference sediment and statistically different [$p \le 0.10$]) and CSL (mean normal survivorship < 70% of that of the reference sediment and statistically different [$p \le 0.10$]) biological effects criteria of the SMS.

[c] 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).

CSL – cleanup screening level
ID – identification
na – not applicable
PSEP – Puget Sound Estuary Program
SD – standard deviation
SQS – sediment quality standards
SMS – Washington State Sediment Management Standards

The results for mean normal survivorship in the negative controls were 100.0% in both Rounds 1 and 2, and the results for mean normal survivorship in the reference sediments ranged from 74.30 to 95.8%. The negative controls in the two rounds met the performance standard of > 70% mean normal survivorship (Table 3-7). There is no SMS performance standard for reference sediments for use in the bivalve larvae test, although the Washington State Department of Ecology (Ecology) has guidance stating that normal development in the reference sample must be ≥ 65% of the normal development in the negative control (Gries 2005). Normal development in the reference sediments ranged from 74 to 96% of that of the negative control (see Appendix D-2).

The EC50 (concentration that causes a non-lethal effect in 50% of an exposed population) values from the positive control tests were within the laboratory warning limits of one SD 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 bivalve larvae toxicity tests, none of the samples exceeded the SQS or the CSL criterion (Table 4-41).

Water quality results for the 48-hr bivalve larvae toxicity test are summarized in Table 4-42. All water quality parameters in Rounds 1 and 2 were within protocol-specified ranges. The water quality results are presented in detail in Appendices D-2 and D-3.

Table 4-42. Water quality measurements for the bivalve larvae sediment toxicity tests

Parameter	Unit	Round 1			Round 2		
		Mean ± SD	Minimum	Maximum	Mean ±SD	Minimum	Maximum
Temperature	°C	15.5 ± 0.2	15.1	15.9	19.8 ± 0.6	19.0	20.9
Dissolved oxygen	mg/L	7.8 ± 0.2	7.2	8.2	7.2 ± 0.3	6.5	7.6
Salinity	ppt	27.7 ± 0.3	27.5	28.5	28.8 ± 0.3	28.5	29.0
pH	na	8.0 ± 0.1	7.8	8.1	8.1 ± 0.1	7.9	8.1

C – centigrade
na – not applicable
ppt – parts per thousand
SD – standard deviation

The sulfides and ammonia results for the 48-hr bivalve larvae toxicity test are summarized in Table 4-43. Positive control tests for copper and cadmium were conducted concurrently with the sediment toxicity tests. The EC50 value for copper and *Mytilus galloprovincialis* was 9.82 mg/L, and the EC50 value for cadmium and *Crassostrea gigas* was 1.14 mg/L.

Table 4-43. Sulfides and ammonia measurements for overlying water in the bivalve larvae sediment toxicity tests

Parameter	Unit	Round 1		Round 2	
		Minimum	Maximum	Minimum	Maximum
Dissolved sulfides	mg/L	< 0.02	< 0.1	0.004	0.155
Total ammonia-N	mg/L	< 0.1	0.4	< 0.1	0.54

4.9 Summary of Toxicity Test Results

Table 4-44 presents results from the comparison between SMS biological effects criteria and each of the three toxicity tests. One sediment sample exceeded the SQS, and two sediment samples exceeded the CSL. According to SMS rules, if two toxicity tests exceed SQS in the same sample, the exceedances for that sample would be a CSL. This exceedance pattern did not occur in any of the samples. There is some uncertainty associated with the fact that the grain size of the reference sediments measured in the laboratory was not consistent with grain size of the same sediments measured in the field. The reference sediments contained less fines than the test sediments; therefore the test exceedances represent a conservative estimate of toxicity due to chemical concentrations, because the reference sediment did not control the effects due to elevated fines in the sediment.

Table 4-44. 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	
EW09-SS-005-010	ne	ne	ne	ne
EW09-SS-030-010	ne	ne	ne	ne
EW09-SS-032-010	ne	ne	ne	ne
EW09-SS-033-010	CSL	ne	ne	CSL
EW09-SS-034-010	ne	ne	ne	ne
EW09-SS-035-010	CSL	ne	ne	CSL
EW09-SS-217-010	ne	ne	ne	ne
EW09-SS-218-010	ne	ne	ne	ne
EW09-SS-220-010	ne	ne	ne	ne
EW09-SS-215-010	ne	ne	ne	ne
EW09-SS-015-010	ne	SQS	ne	SQS

ne – no exceedance
CSL – cleanup screening level
ID – identification
SMS – Washington State Sediment Management Standards
SQS – sediment quality standards

5 References

Anchor. 2008. Memorandum to Port of Seattle: T30/Lander Street combined sewer overflow spill - surface sediment metals results. August 12, 2008. Anchor Environmental, L.L.C., Seattle, WA.

Ecology. 2004. SEDQUAL sediment quality information system. Release 5. [online]. Sediment Management Unit, Washington Department of Ecology, Olympia, WA. Available from: http://www.ecy.wa.gov/programs/tcp/smu/sedqualfirst.htm.

Ecology. 2008. Sediment sampling and analysis plan appendix: guidance on the development of sediment sampling and analysis plans meeting the requirements of the sediment management standards (chapter 173-204 WAC). Ecology Publication No. 03-09-043. Washington State Department of Ecology, Olympia, WA.

Gries TH. 2005. Personal communication (e-mail to Berit Bergquist, Windward Environmental, regarding WDOE bioassay performance criteria). Washington Department of Ecology, Lacey, WA. 9/22/05.

Krone CA, Brown DW, Burrows DG, Chan SL, Varanasi U. 1989. Butyltins in sediment from marinas and waterways in Puget Sound Washington State, USA. Mar Pollut Bull 20:528-531.

Plumb R, Jr. 1981. Procedures for handling and chemical analysis of sediment and water samples. Waterways Experiment Station, US Army Corps of Engineers, Vicksburg, MS.

PSEP. 1986. Recommended protocols for measuring conventional sediment variables in Puget Sound. Prepared for the Puget Sound Estuary Program. US Environmental Protection Agency, Region 10, Seattle, WA.

PSEP. 1995. Recommended guidelines for conducting laboratory bioassays on Puget Sound sediments. Final Report. Prepared for the Puget Sound Estuary Program, U.S. Environmental Protection Agency, Region 10, Office of Puget Sound, and U.S. Army Corps of Engineers, Seattle District, Seattle, WA. PTI Environmental Services, Inc., Seattle, WA.

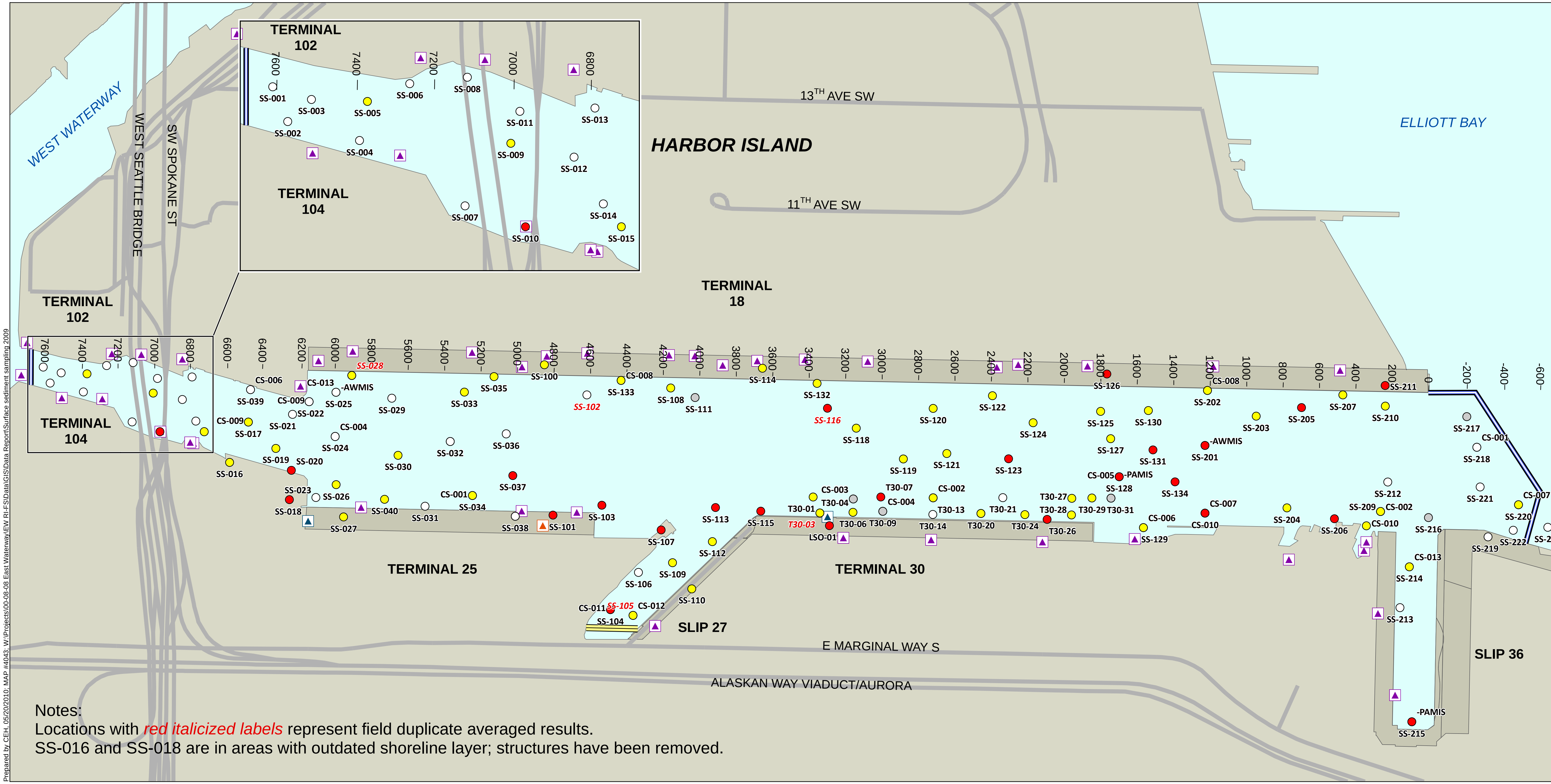
USACE, EPA, WDNR, Ecology. 2000. Dredged material evaluation and disposal procedures. A user's manual for the Puget Sound Dredged Disposal Analysis (PSDDA) Program. US Army Corps of Engineers, Seattle District, Seattle, WA; US Environmental Protection Agency, Region 10, Seattle, WA; Washington Department of Natural Resources; and Washington Department of Ecology.

Windward. 2008. Quality assurance project plan: clam studies. East Waterway Operable Unit supplemental remedial investigation/feasibility study. Windward Environmental LLC, Seattle, WA.

Windward. 2009a. Quality assurance project plan: intertidal MIS sediment sampling. East Waterway Operable Unit supplemental remedial investigation/feasibility study. Windward Environmental LLC, Seattle, WA.

Windward. 2009b. Quality assurance project plan: surface sediment sampling for chemical analyses and toxicity testing of the East Waterway. East Waterway Operable Unit supplemental remedial investigation/feasibility study. Windward Environmental LLC, Seattle, WA.

Windward, Anchor. 2008. East Waterway T-30 post dredge monitoring plan. Final. Prepared for Port of Seattle. Windward Environmental LLC and Anchor Environmental, L.L.C., Seattle, WA.

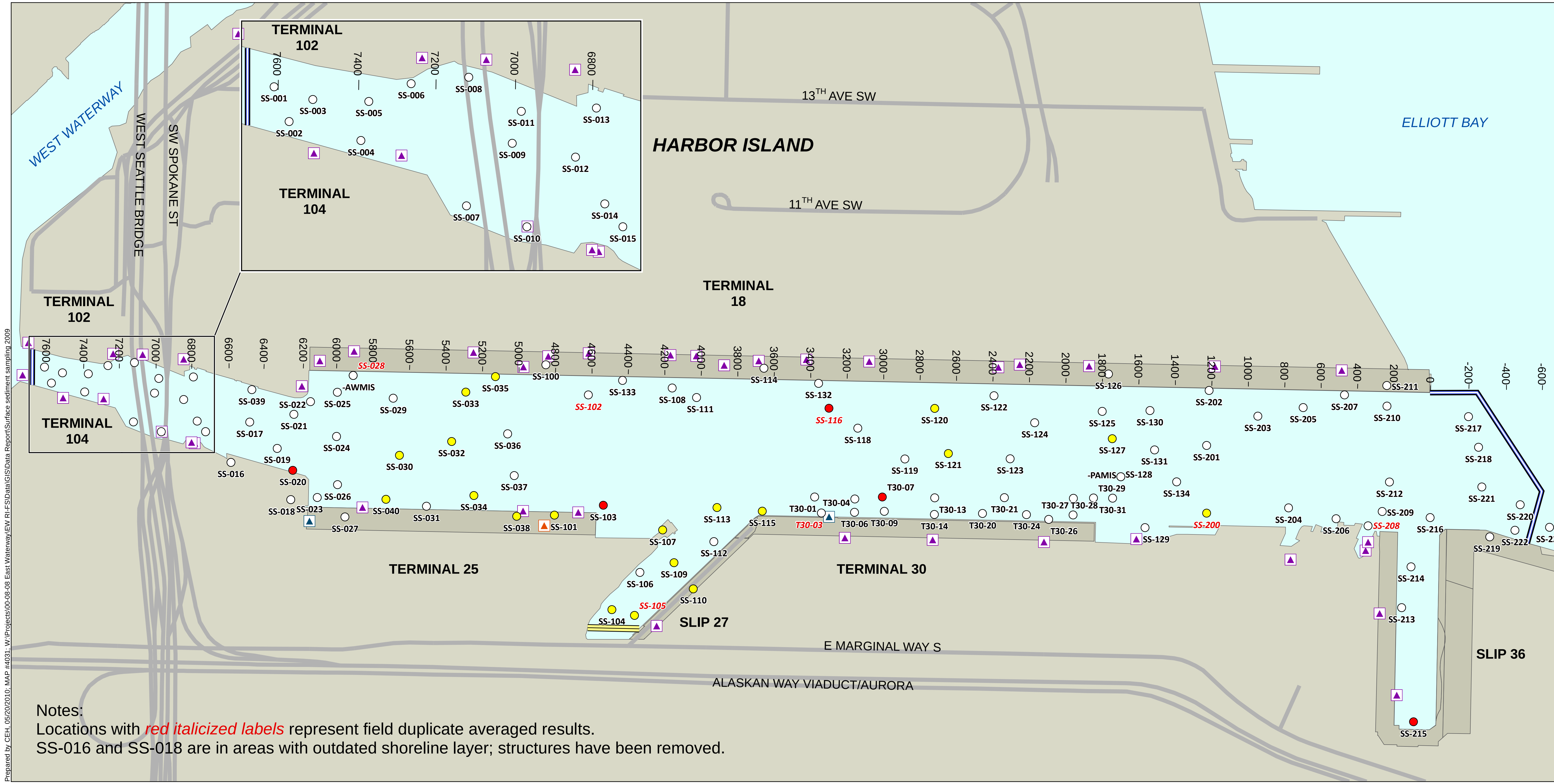


Notes:
Locations with *red italicized labels* represent field duplicate averaged results.
SS-016 and SS-018 are in areas with outdated shoreline layer; structures have been removed.

Prepared by CEH, 05/20/2010, MAP #4043; W:\Projects\00-08-08 East Waterway\EW RI-FS\Data\GIS\Data Report\Surface sediment sampling 2009

Exceedances of SQS/SL or CSL/ML
- > CSL/ML, detect
- > SQS/SL and ≤ CSL/ML, detect
- > SQS/SL and ≤ CSL/ML, non-detect
- ≤ SQS/SL, detect
- CSO
- Storm Drain
- CSO/Storm Drain
- Dock/Pier
- Road
- Slip 27 Bridge
- East Waterway Study Area Boundary

Map 4-1
Exceedances of SQS/SL or CSL/ML by All Chemicals in Surface Sediment Samples
Surface Sediment Draft Data Report
East Waterway Study Area



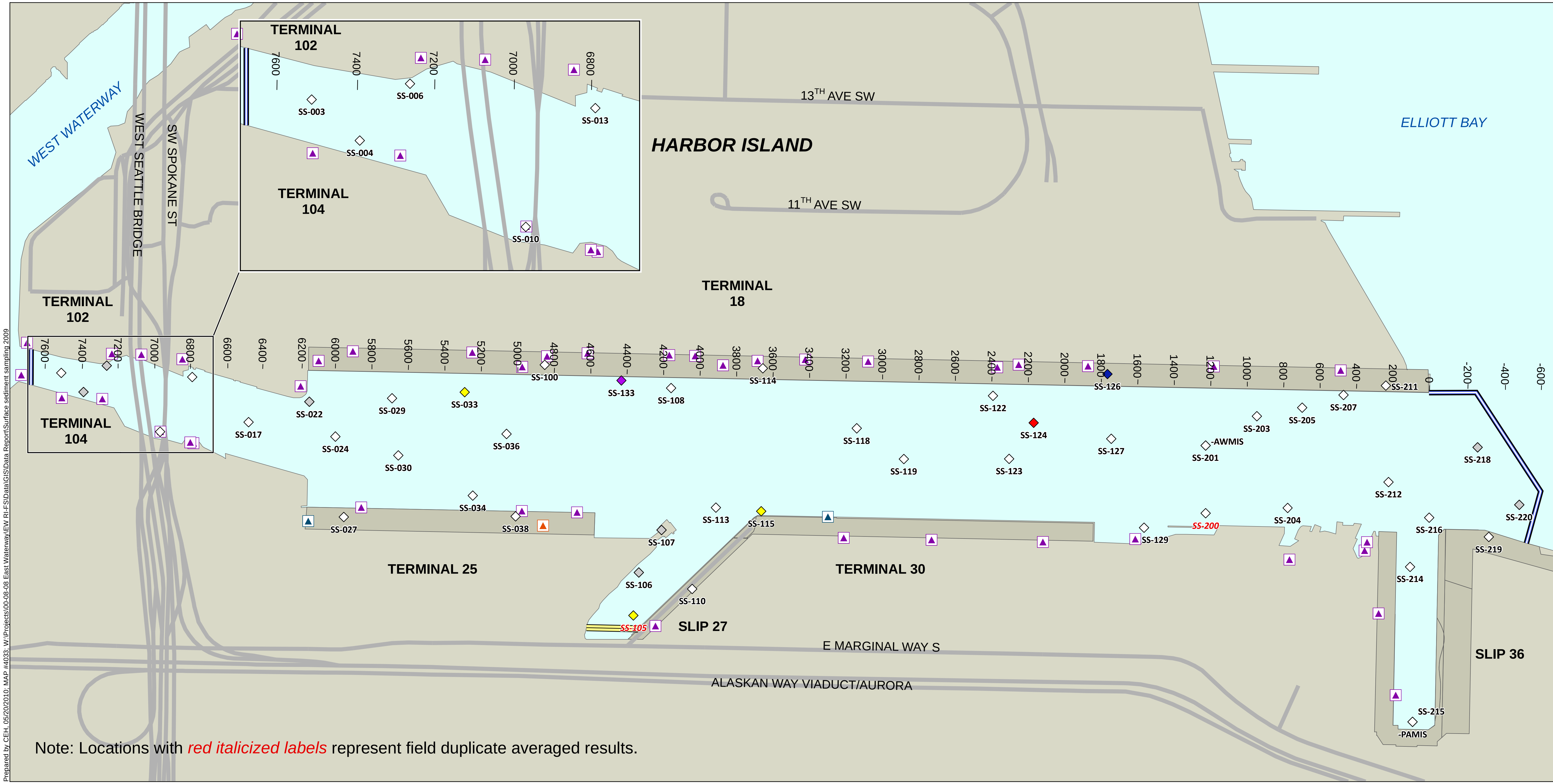
Notes:
Locations with *red italicized labels* represent field duplicate averaged results.
SS-016 and SS-018 are in areas with outdated shoreline layer; structures have been removed.

SQS/CSL Categories for Mercury in Surface Sediment
- > CSL, detect
- > SQS and ≤ CSL, detect
- ≤ SQS, detect

- CSO
- Storm Drain
- CSO/Storm Drain
- Dock/Pier
- Road
- Slip 27 Bridge
- East Waterway Study Area Boundary

Map 4-2
Mercury Concentrations in Surface Sediment
Samples Based on SMS Comparisons
Surface Sediment Draft Data Report
East Waterway Study Area

Prepared by CEH, 05/20/2010; MAP #4033; W:\Projects\00-08-08 East Waterway\EW RI-FS\Data\GIS\Data Report\Surface sediment sampling 2009



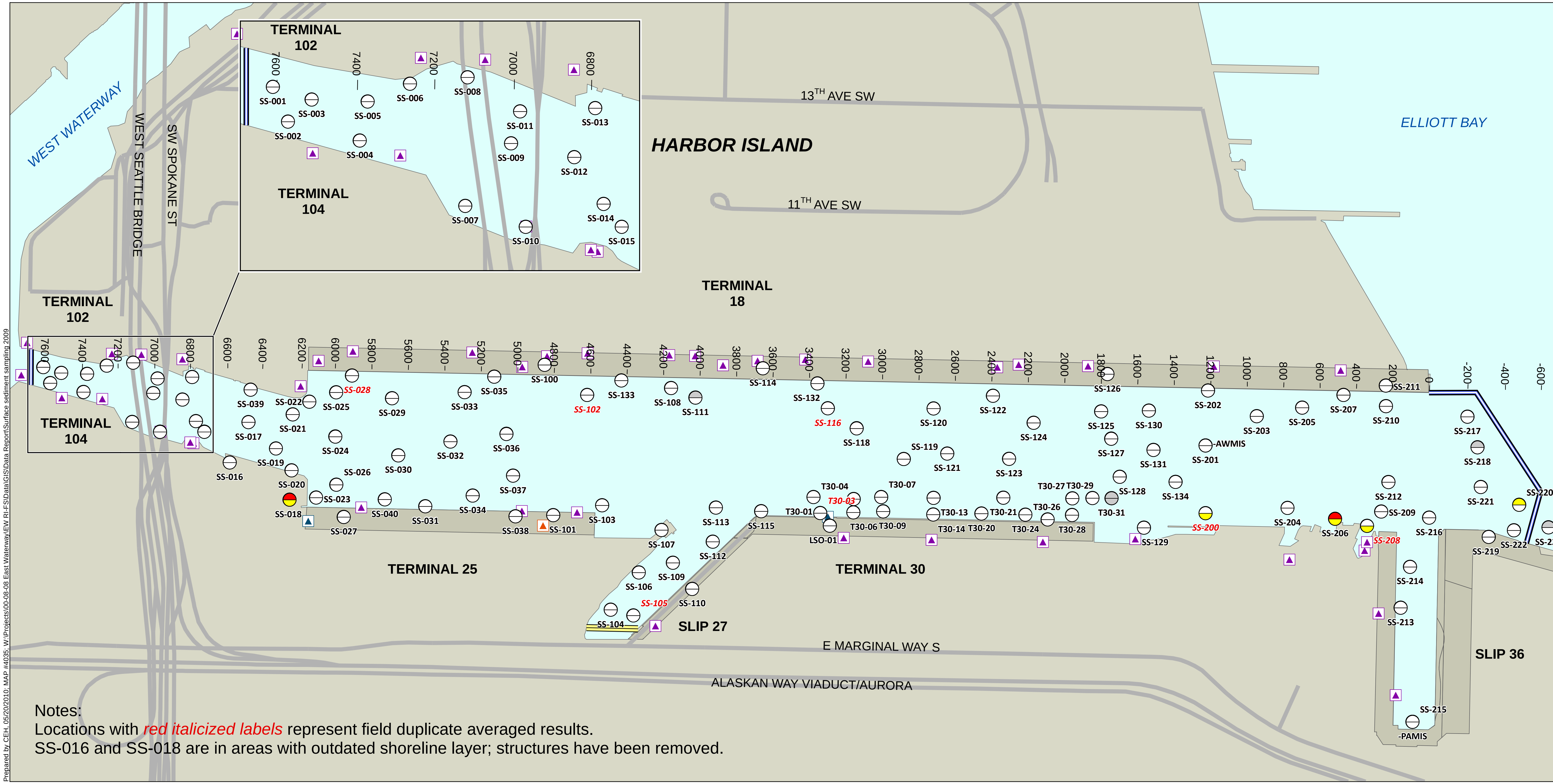
Tributyltin as Ion (µg/kg dw)[a] Concentrations in Surface Sediment

- > 1,000 detect
- > 500 and ≤ 1,000 detect
- > 200 and ≤ 500 detect
- > 100 and ≤ 200 detect
- ≤ 100 detect
- Non-detect

- Dock/Pier
- Road
- Slip 27 Bridge
- East Waterway Study Area Boundary

0 600
Scale in feet

Map 4-3
TBT Concentrations in Surface Sediment Samples
Surface Sediment Draft Data Report
East Waterway Study Area



Prepared by CEH, 05/20/2010; MAP #4035; W:\Projects\00-08-08 East Waterway\EW RI-FS\Data\GIS\Data Report\Surface sediment sampling 2009

SQS/CSL Categories for Total Low-Molecular-Weight Polycyclic Aromatic Hydrocarbons in Surface Sediment

- > CSL, detect
- > SQS and ≤ CSL, detect
- ≤ SQS, detect
- ≤ SQS, non-detect

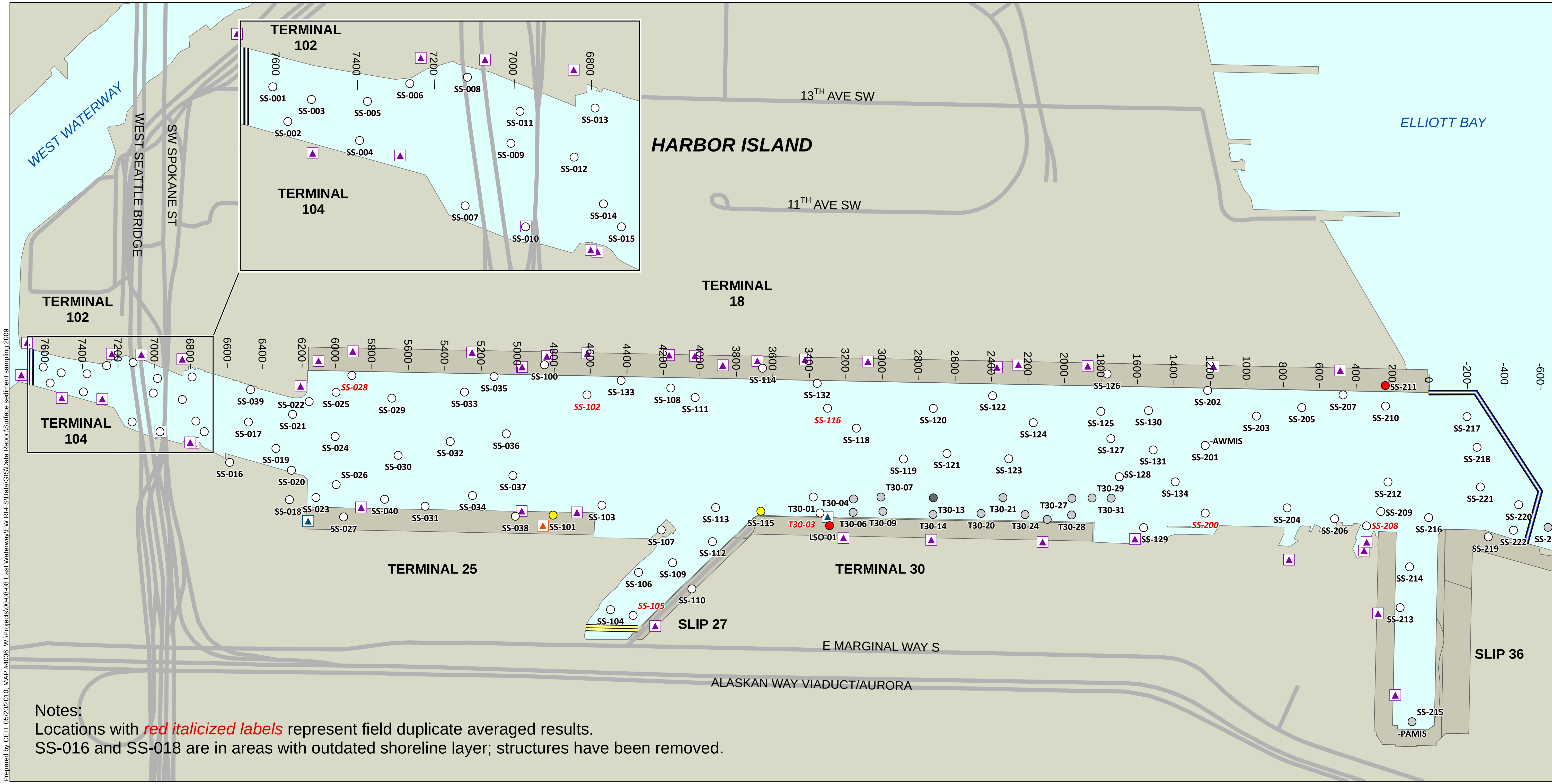
SQS/CSL Categories for Total High-Molecular-Weight Polycyclic Aromatic Hydrocarbons in Surface Sediment

- > SQS and ≤ CSL, detect
- ≤ SQS, detect
- ≤ SQS, non-detect

- CSO
- Storm Drain
- CSO/Storm Drain
- Dock/Pier
- Road
- Slip 27 Bridge
- East Waterway Study Area Boundary

0 600
Scale in feet

Map 4-4
Total LPAH and Total HPAH Concentrations in Surface Sediment Samples Based on SMS Comparisons
Surface Sediment Draft Data Report
East Waterway Study Area



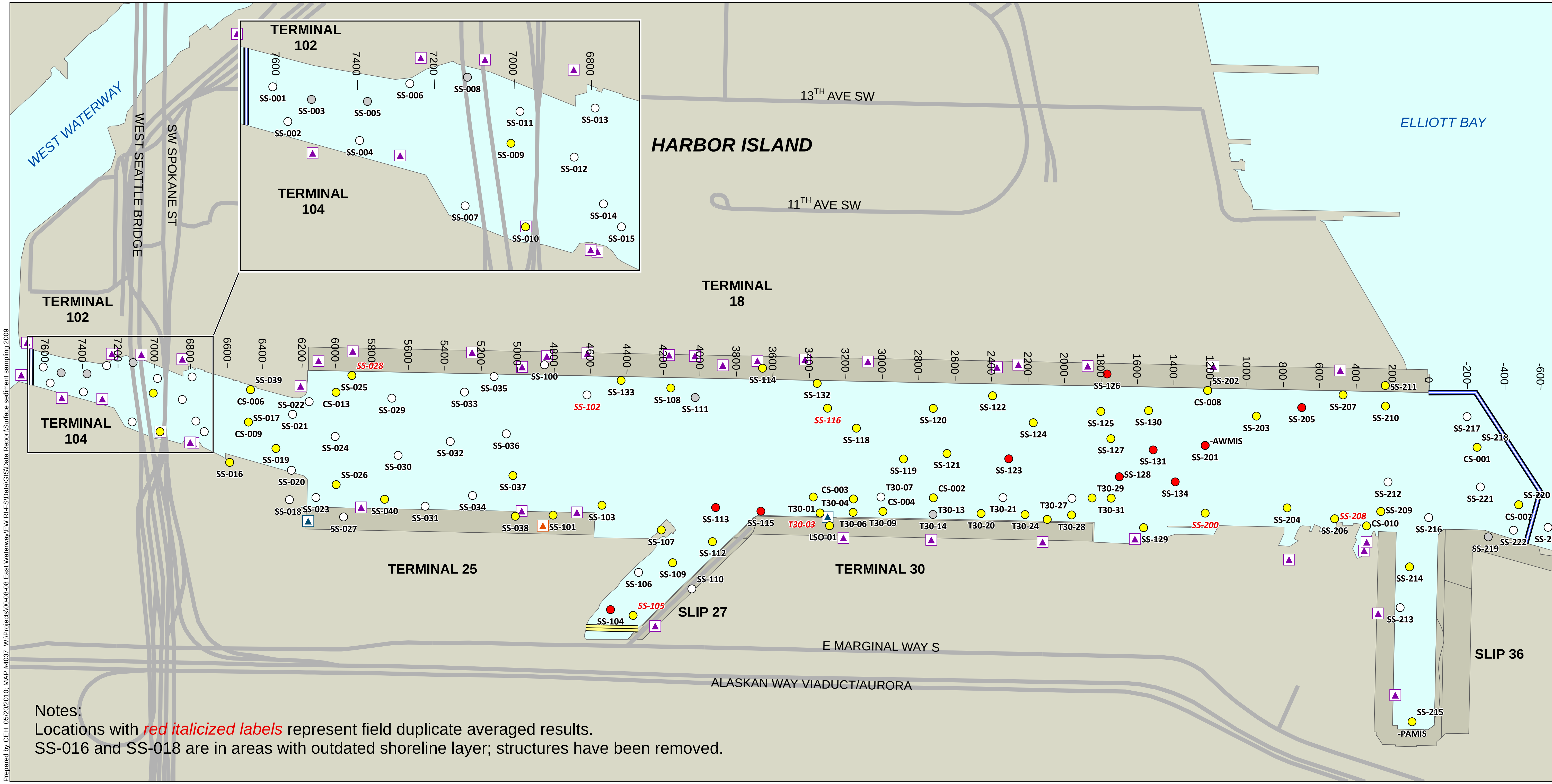
Notes:
Locations with *red italicized labels* represent field duplicate averaged results.
SS-016 and SS-018 are in areas with outdated shoreline layer; structures have been removed.

SQS/CSL Categories for Bis(2-ethylhexyl) phthalate in Surface Sediment
- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- ≤ SQS, detect
- ≤ SQS, non-detect

- CSO
- Storm Drain
- CSO/Storm Drain
- Dock/Pier
- Road
- Slip 27 Bridge
- East Waterway Study Area Boundary

0 600
Scale in feet

Map 4-5
BEHP Concentrations in Surface Sediment Samples Based on SMS Comparisons
Surface Sediment Draft Data Report
East Waterway Study Area



Notes:
Locations with *red italicized labels* represent field duplicate averaged results.
SS-016 and SS-018 are in areas with outdated shoreline layer; structures have been removed.

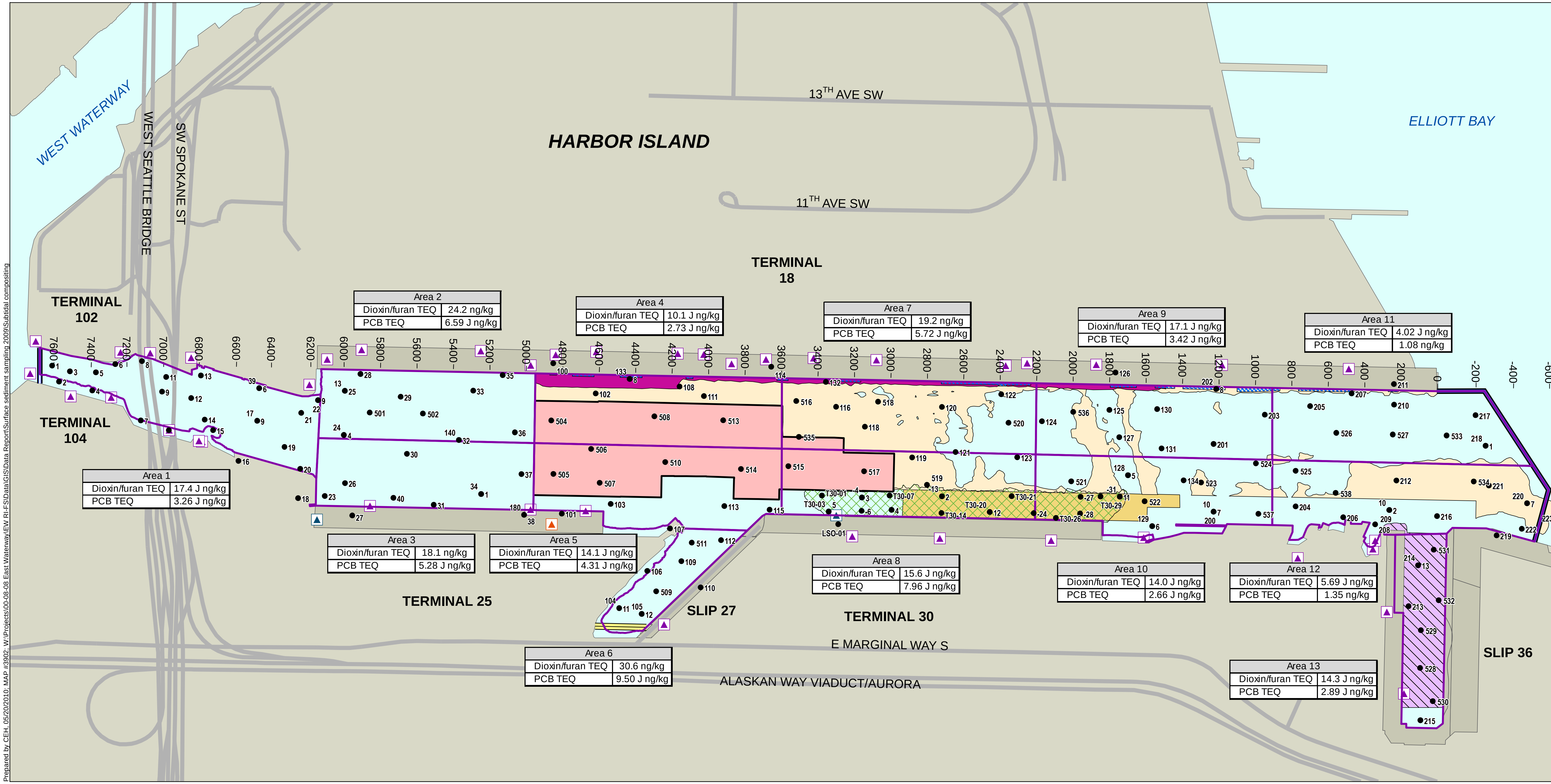
SQS/CSL Categories for Total Polychlorinated Biphenyls in Surface Sediment

- > CSL, detect
- > SQS and ≤ CSL, detect
- ≤ SQS, detect
- ≤ SQS, non-detect

- CSO
- Storm Drain
- CSO/Storm Drain
- Dock/Pier
- Road
- Slip 27 Bridge
- East Waterway Study Area Boundary

0 600
Scale in feet

Map 4-6
Total PCB Concentrations in Surface Sediment Samples Based on SMS Comparisons
Surface Sediment Draft Data Report
East Waterway Study Area



Prepared by CEH, 05/20/2010; MAP #3902; W:\Projects\00-08-08 East Waterway\EW RI-FS\Data\GIS\Data Report\Surface sediment sampling 2009\Subtidal compositing

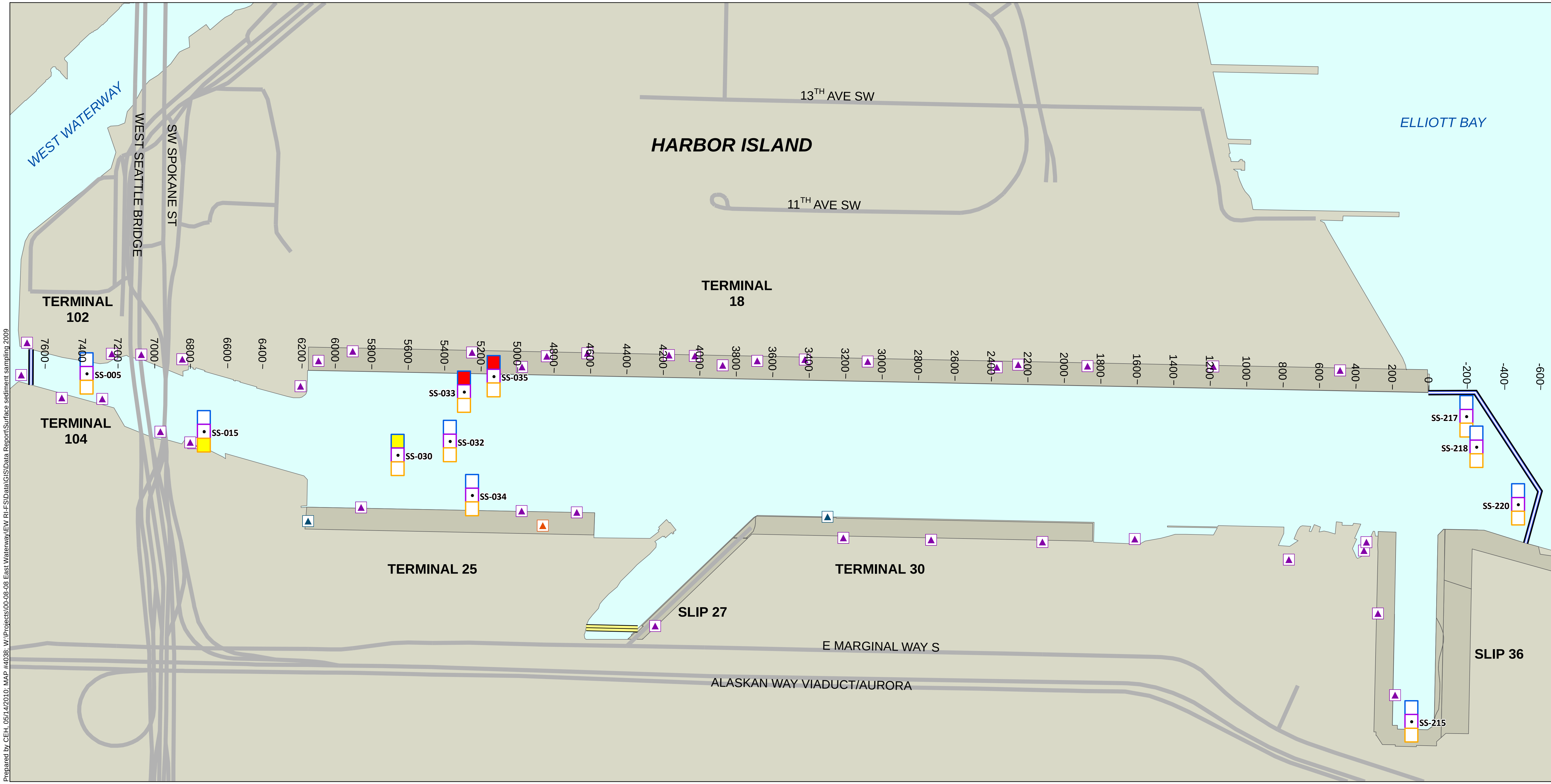
- Subtidal Composite Sampling Location
- Subtidal Composite Area with Dioxin TEQ
- CSO
- Storm Drain
- CSO/Storm Drain
- Dock/Pier
- Road
- Slip 27 Bridge
- East Waterway Study Area Boundary

Dredge Events (Completion Date)

- Terminal 18 Maintenance Dredging (Completed 2009, -51 MLLW)
- Terminal 30 Maintenance Dredging (Completed 2009, -51 MLLW)
- Terminal 18 Dredging, Berths 2 through 5 (Completed 2006, -51 MLLW)
- Slip 36 Dredging (Completed 2005, -40 MLLW)
- Phase 1 Removal Action Boundary (Completed 2005, -51 MLLW)
- Stage 1 Navigational Dredging (Completed 2000, -51 MLLW)
- Terminal 30 Berth Dredging (Completed 2002, -44 MLLW)

0 600
Scale in feet

Map 4-7
Dioxin and Furan TEQs and PCB Congener TEQs in Surface Sediment
Surface Sediment Draft Data Report
East Waterway Study Area



Prepared by CEH, 05/14/2010; MAP #4038; W:\Projects\00-08-08 East Waterway\EW RI-FS\Data\GIS\Data Report\Surface sediment sampling 2009

Toxicity Test Results

- Amphipod
- Bivalve Larvae
- Polychaete
- > CSL
- > SQS and ≤ CSL
- ≤ SQS

- CSO
- Storm Drain
- CSO/Storm Drain
- Dock/Pier
- Road
- Slip 27 Bridge
- East Waterway Study Area Boundary

0 600
Scale in feet

Map 4-8
Surface Sediment Toxicity Testing Results Relative to SMS
Surface Sediment Draft Data Report
East Waterway Study Area