City of Bremerton

Sediment Monitoring Study Report

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The technical material and data contained in this document were prepared under the supervision and direction of the undersigned, whose seal as a professional engineer licensed to practice as such, is affixed below.

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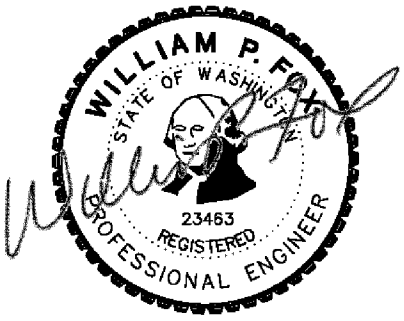

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LIST OF ACRONYMS

CEG	Cosmopolitan Engineering Group
COC	Chain of Custody
CSS	Combined Sewer System
DGPS	Differential Global Positioning System
DNR	Washington State Department of Natural Resources
DW	Dry Weight
EDL	Estimated Detection Limit

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EIM	Environmental Information Management System
EIMS	Environmental Information Management System
LAET	Lowest Apparent Effects Threshold
MDL	Method Detection Limit
MRL	Method Reporting Limit
NPDES	National Pollutant Elimination Discharge System
OC	Organic Carbon
PAH	Polynuclear Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PCMP	Post Construction Monitoring Plan
PQL	Practical Quantification Limits
PSNS	Puget Sound Naval Shipyard
RI/FS	Remedial Investigations and Feasibility Studies
SAPA	Sediment Sampling and Analysis Plan Appendix
SMS	Sediment Management Standards
SQS	Sediment Quality Standards
SSAP	Sediment Sampling and Analysis Plan

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SECTION 1: INTRODUCTION

1.1 BACKGROUND

1.1.1 Washington State Sediment Quality Standards

The state of Washington has enacted a set of Sediment Management Standards (SMS) in WAC 173-204 to "reduce and ultimately eliminate adverse effects in biological resources and significant health threats to humans from surface sediment contamination…" (WAC 173-204-100[2]). The SMS include chemical concentration criteria (Table 1 in WAC 173-204-320[2]) and biological effects criteria (WAC 173-204-320[3]), known as Sediment Quality Standards (SQS), which are applicable to marine sediment in Puget Sound. The criteria define marine sediment quality assumed to not adversely affect biological resources in Puget Sound sediments. These criteria are presented in Tables 1 and 2 of the Ecology document titled *Sediment Sampling and Analysis Plan Appendix* (Ecology Publication No. 03-09-043), referred to in the remainder of this report as the SAPA. These tables are included in Appendix A.

1.1.2 Combined Sewer System

The City of Bremerton operates a combined sewer system (CSS) consisting of fifteen combined sewer overflow (CSO) outfalls, a principal wastewater treatment facility (West Plant), and a wet weather treatment facility (East Plant). The current wastewater collection system has been in operation since 1985, and, since 1992, numerous improvements have been made to the collection system and the East and West Plants under Bremerton's CSO Reduction Plan (Bremerton, 2014). Bremerton is located on the north side of Sinclair Inlet, with the Port Washington Narrows to Dyes Inlet dividing the city into east and west portions. All outfalls discharge to Sinclair Inlet or Port Washington Narrows. The CSO outfall locations are shown on Figure 1.

Other point sources in the area have been identified by the Sinclair and Dyes Inlets TMDL. These include the Puget Sound Naval Shipyard, which discharges stormwater and wastewater to Sinclair Inlet and Clear Creek, the South Kitsap Water Reclamation Facility in Port Orchard discharging to Sinclair Inlet, and stormwater discharges to Sinclair Inlet from state highways and unincorporated Kitsap County. These sources may all contribute to any sediment contamination in the area.

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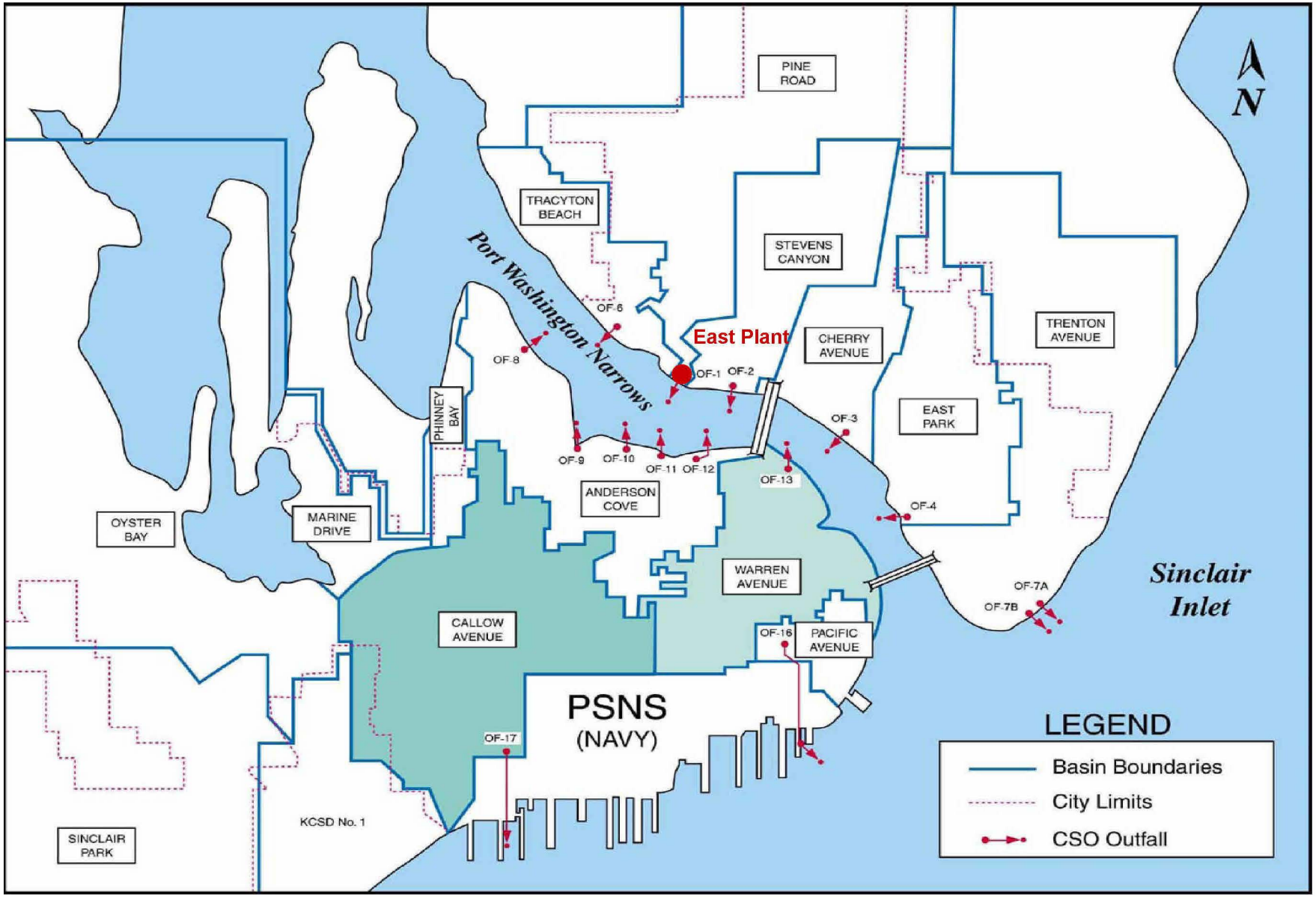

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Figure 1: City of Bremerton CSO Outfall and Treatment Plant Locations

1.1.3 Previous Sediment Quality Investigations

Long-term sediment monitoring conducted by Ecology under the Puget Sound Assessment and Monitoring Program (PSAMP) provides baseline conditions for the study area. A 2013 report on sediment conditions in the Bainbridge Basin indicates that roughly 75 percent of sediments in the survey area were likely unimpacted or had only low toxicity/exposure to contaminants. The remainder were classified as possibly or likely impacted, due mainly to adversely affected benthic communities and slightly higher toxicity. These sediments were largely concentrated in Liberty Bay, however some areas at the end of Sinclair Inlet near Gorst and the West Plant outfall also showed signs of moderate toxicity. Of the 129 chemical parameters tested, metals and PAHs were frequently detected in samples, particularly arsenic, copper, lead, and zinc in Sinclair Inlet. PCBs were also detected in Sinclair Inlet; however, only Mercury consistently exceeded the SMS criterion (Ecology, 2013), and only in Sinclair Inlet near the Naval Shipyard. USGS is leading remedial investigations and feasibility studies (RI/FS) for mercury in Sinclair Inlet sediments, centered around the Puget Sound Naval Shipyard (PSNS) and adjacent to the West Plant outfall.

1.2 PURPOSE

Ecology issued NPDES Permit No. WA0029289 to the City of Bremerton on June 21, 2013. Condition S10 of the permit requires the City to conduct sediment monitoring at the treatment plants and selected CSO outfall locations. This monitoring is required in order to determine baseline conditions near historic CSO outfalls and treated East and West Plant discharges. Additionally, Special Condition S11.d specified that the City must develop a *Post Construction Monitoring Plan* (PCMP) to verify the effectiveness of CSO controls, which have been completed under WAC 173-245. This plan and the accompanying *Sediment Sampling and Analysis Plan* (SSAP) were approved in November 2014. The approved SSAP established sediment monitoring of the areas surrounding three CSO outfalls (OF-6, OF-7, and OF-13) and both treatment plant outfalls. An addendum to the SSAP proposed additional sampling at a fourth CSO outfall discharge location (OF-12), which was incorporated into the sampling schedule in summer 2015.

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This report presents the results of the sediment sampling conducted in summer 2015, and satisfies Condition S10.B of the NPDES permit. Upon approval of this report, the results presented in the following sections will be entered into Ecology's Environmental Information Management System (EIMS) data base. This report will also be submitted to Washington Department of Natural Resources (DNR) to establish baseline sediment chemistry for the City's aquatic land leases for the outfalls.

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SECTION 2: SAMPLE COLLECTION

2.1 OVERVIEW

The Bremerton SSAP (CME, 2014) described sample collection/handling procedures and analytical methods in accordance with protocol outlined in the SAPA. Ecology approved the SSAP in November 2014.

Sediment sample collection was performed as described in the SSAP in July and August 2015. Sampling notes/observations were recorded in a field notebook during the study. Typical field notes include the following:

- General information such as field personnel, start and end time, weather, and other miscellaneous observations
- Station coordinates
- Number of sample casts, water depth to sediment surface, time of sample collection, sample identification name
- General observations of sample makeup; including color, texture, odor, and organic debris

2.2 FIELD STAFF

Sediments were collected by Lauren Fox (sampler) and Bill Fox (winch operator) of Cosmopolitan Marine Engineering (CME). Jay Fox piloted the sample vessel for the August sampling effort and assisted with sample site location. Lauren Fox was the primary field sampler, and led all sample collection and handling activities.

2.3 SAMPLING SCHEDULE

Sediment samples were collected over two two-day periods in summer 2015. The sampling schedule was arranged to allow for sample collection at intertidal or shallow subtidal stations at

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low tide on July 29 and 30, and at high slack at deeper stations from a sampling vessel on August 17 and 18. The stations sampled during these two sampling efforts were selected according to their accessibility at either high or low tide. The intertidal or shallow subtidal stations sampled in July were: OF6-1, 6-2, 6-3, 12-1, 12-3, 13-1, 13-2, and 13-3. The deeper stations sampled in August were: WP-1, 2, 3, 4, 5, EP-1, 2, 3, 4, 5, OF7-1, 7-2, 7-3, and 12-2.

2.4 SAMPLING LOCATIONS

Sediment sampling sites were proposed at six outfalls discharging from the City's combined sewer system. Five samples were collected at each of the City's two treatment plant outfalls and three samples were collected at each of the four CSO outfalls, for a total of 22 stations.

Figure 2 shows the locations of the outfalls sampled. Figures of the target sampling stations at each location are included in Appendix C. Actual sample site latitudes, longitudes and water depth at time of collection are provided in Table 1. Sample stations were located in the field using a hand-held Differential Global Positioning System (DGPS) unit.

Table 1 WWTP Outfall Sampling Station Coordinates and Water Depth

Station	N 48°	W 122°	Depth (ft)
WP-1	32.773'	40.223'	34
WP-2	32.787'	40.19'	35
WP-3	32.779'	40.181'	38
WP-4	32.79'	40.182'	35
WP-5	32.804'	40.147'	33
EP-1	34.873'	38.389'	35
EP-2	34.875'	38.35'	24
EP-3	34.86'	38.346'	27
EP-4	34.877'	38.337'	30
EP-5	34.874'	38.296'	32
OF6-1	35.15'	38.777'	1
OF6-2	35.14'	38.77'	3
OF6-3	35.137'	38.755'	1
OF7-1	34.078'	36.441'	44
OF7-2	34.082'	36.429'	52
OF7-3	34.092'	36.415'	55
OF12-1	34.703'	38.273'	2

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Table 1 WWTP Outfall Sampling Station Coordinates and Water Depth

Station	N 48°	W 122°	Depth (ft)
OF12-2	34.721’	38.273’	24
OF12-3	34.701’	38.247’	5
OF13-1	34.65’	37.815’	1
OF13-2	34.644’	37.812’	0
OF13-3	34.635’	37.797’	0

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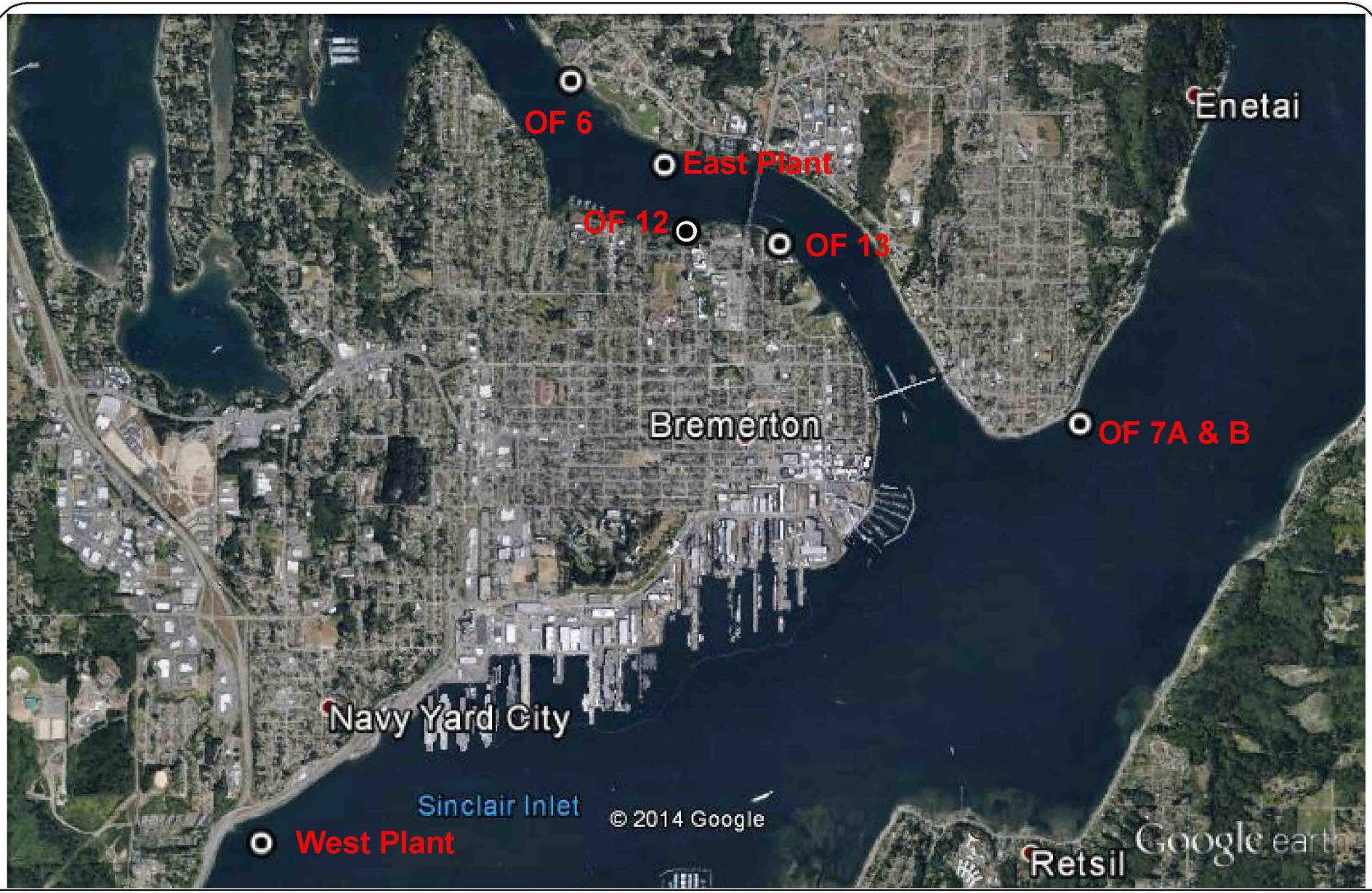

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Figure 2: Sediment Sampling Locations

2.5 SAMPLE COLLECTION AND COMPOSITING

Sediment samples were collected via two methods - hand-collected where the sample site was located above the water level, or with a surface sediment sampler (0.05 m^2 stainless steel Ponar sampler) deployed from a research vessel with a power winch or deployed manually where collection occurred at low tide. Water was carefully withdrawn from the sediment sampler using a turkey baster to minimize loss of fines. Sediments for all samples were collected using stainless steel spoons and bowls that had been decontaminated following the procedure outlined in the SSAP. Minimum sediment sample size required for the analytical tests are listed in Table 9 of the SAPA (see Appendix B). Observations for each sample site are provided in Section 2.6.

Several modifications to the proposed sampling were made during the course of the sampling activities due to sediment character and equipment difficulties at various sites, mainly those located in or near Port Washington Narrows. Currents through this area are very strong, resulting in a rocky bottom washed relatively clean of fines at several of the points identified for sampling in the SSAP. Nearly all of the sample sites proposed for stations OF12, OF7, and East Plant required several casts with the grab sampler, and frequently resulted in failed casts where the sampler did not fully close or contained only pebbles and cobbles. Where this was the case, samples were collected for particle size only. At one location, OF7-1, sufficient sediment was obtained to collect samples for sediment chemistry, however the full volume was not obtained and no particle size sample was collected for this site.

2.6 SAMPLE OBSERVATIONS

Table 2 below summarizes sample cast information for each sample station, including sample date, time, number of casts required, and notes regarding sample appearance. Full field notes and pictures are included in Appendix C.

Table 2 Sediment Sample Observations

Station	Date	Time	# of Casts	Comments
WP-1	8/17/15	10:45	1	Black-brown, strong organic odor, cohesive silt, no organic debris
WP-2	8/17/15	10:32	1	Black-brown cohesive silt, sulfuric/organic odor, little to no organic matter
WP-3	8/17/15	10:02	1	Black cohesive silt, ~1mm green top layer, strong organic & diesel

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Table 2 Sediment Sample Observations

Station	Date	Time	# of Casts	Comments
				odor, eel grass
WP-4	8/17/15	11:02	1	Black-brown cohesive silt, organic odor, small amount of eel grass, shell hash, & tube worms
WP-5	8/17/15	11:21	1	Black-brown cohesive silt, ~2mm black top layer, organic/sulfuric odor, small amount of organic debris
EP-1	8/18/15	8:09	3	Unable to obtain sufficient fine-grained sediments required for sediment chemistry - **grain size only**
EP-2	8/17/15	NA	11	Grab sampler failed to close on 6 of 11 casts, contained only rocks or water on 5 other casts. **No sample taken.**
EP-3	8/17/15	12:39	9	Unable to obtain sufficient fine-grained sediments required for sediment chemistry - **grain size only**
EP-4	8/17/15	13:05	7	Unable to obtain sufficient fine-grained sediments required for sediment chemistry - **grain size only**
EP-5	8/18/15	8:40	11	Unable to obtain sufficient fine-grained sediments required for sediment chemistry - **grain size only**
OF6-1	7/30/15	10:19	1	Cohesive dark gray sand, ~2-3mm brown-green top layer, slight briny odor, small amount shell hash & tube worms, no cobbles/pebbles. Grab sampler deployed by hand.
OF6-2	7/30/15	10:39	1	Cohesive dark gray sand (darker than other two at OF6), no brown-green top layer, slight sulfuric odor, cobbles & shell hash, some plant matter. Grab sampler deployed by hand.
OF6-3	7/30/15	9:57	1	Cohesive dark gray sand, ~1mm brown-green top layer, slight briny odor, pebbles & small amount of shell hash. Grab sampler deployed by hand.
OF7-1	8/18/15	9:52	11	Brown sand, briny odor, organic debris & shell hash. Sulfide sample collected from cast #5, dioxins & metals samples homogenized from casts #2, 4, 8, & 9. Unable to obtain sufficient fine-grained sediments required for grain size – **sediment chemistry only.**
OF7-2	8/18/15	9:07	2	Brown sand, briny odor, small amount tube worms & shell hash. Full volume of sample obtained from 3 casts & homogenized.
OF7-3	8/18/15	10:45	6	Brown sand, briny odor, small amount organic debris, tube worms & shell hash. Sample site modified to 30' offshore after sampler failed to close at original site. Sulfide sample collected from cast #3, dioxins & metals samples collected from cast #5, particle size homogenized from casts #5 &6.
OF12-1	7/30/15	11:53	4	Medium brown cohesive sand, no odor, cobbles/pebbles & shell hash. Sample site relocated further offshore to visible sandy patch, grab sampler deployed by hand. Full sample volume obtained from cast #4.
OF12-2	8/17/15	14:12	7	Grab sampler failed to close on six of seven casts, GPS died after cast #4, sample site located visually from markers on shore. Unable to obtain full volume required for sediment chemistry – **grain size only**.
OF12-3	7/29/15	11:27	4	Sand, slight briny odor, small rocks & shell hash. Grab sampler deployed by hand, full volume of sample obtained from cast #4.
OF13-1	7/29/15	10:00	1	Sand/gravel, slight briny odor, large amount of marine life. Sample hand-collected using spoon brought slowly to surface to minimize loss of fines.
OF13-2	7/29/15	10:33	1	Sand/gravel, slight briny odor, large amount of marine life. Sample

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Table 2 Sediment Sample Observations

Station	Date	Time	# of Casts	Comments
				hand-collected from beach.
OF13-3	7/29/15	9:33	1	Sand/gravel, large amounts of shell hash, no odor. Sample hand collected from beach.

2.7 SAMPLE HANDLING AND DELIVERY

Composited samples were placed in the laboratory-prepared sample jars and hand delivered to ALS Environmental in Kelso, Washington, per SSAP protocol. Samples were placed in the cooler on ice immediately upon collection and remained so until delivery to ALS the next day. Chain of Custody (COC) forms are provided in Appendix D.

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SECTION 3: LABORATORY METHODS AND ANALYTES

Sediment samples were analyzed by ALS Environmental in Kelso, WA using testing protocol outlined in the SAPA (Ecology, 2008). Sediment samples for all sites but EP-1, 3, 4, 5, and OF12-2 were analyzed for the 47 SQS chemicals, dioxins and furans, and conventional sediment variables, with the exception of OF7-1 which was not analyzed for grain size. The remaining samples, which were unable to obtain sufficient fines for chemical analysis, were analyzed for grain size only.

Samples OF13-1, 13-2, 13-3, 6-1, 6-2, 6-3, 12-1, 12-3, and certain parameters for samples WP-2 and WP-3 required dilution due to relatively high levels of non-target background components. This resulted in elevated detection limits for several parameters which, though reported by the lab as undetected, exceeded SQS criteria. Table 3 summarizes the analytes and associated SQS criteria, sample preparation, cleanup, and analytical methods, and target Practical Quantification Limits (PQLs). Case narrative, laboratory results and QA/QC procedures are included in Appendix D.

The principal quality issue arising from the laboratory analysis pertained to detection limits. From the case narrative:

> "**Elevated Detection Limits:**
>
> The detection limit was elevated for all samples except sample Batch QC. The sample extract was diluted prior to instrumental analysis due to relatively high levels of non-target background components. The extract was highly colored and viscous, which indicated the need to perform a dilution of 5 or 10 prior to injection into the instrument. Clean-up of the extract was performed within the scope of the method, but did not eliminate enough of the background components to prevent dilution. The reporting limits were increased by 5 or 10 to reflect the dilution."

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Table 3 Laboratory Methods and Analytes Summary

Chemical Parameter	Sediment Quality Standards (SQS)	Recommended Sample Preparation Methods	Recommended Sample Cleanup Methods	Recommended Analytical Methods	Target Practical Quantitation Limits[1][2]
METALS	**(mg/kg dry weight, ppm)**				**(mg/kg dry weight)**
Arsenic	57	PSEP/3050B	–	6010B/6020/7061A	19
Cadmium	5.1	PSEP/3050B	–	6010B/6020/7131A	1.7
Chromium	260	PSEP/3050B	–	6010B/6020/7191	87
Copper	390	PSEP/3050B	–	6010B/6020	130
Lead	450	PSEP/3050B	–	6010B/6020	150
Mercury	0.41	–	–	7471A/245.5	0.14
Silver	6.1	PSEP/3050B	–	6010B/6020	2
Zinc	410	PSEP/3050B	–	6010B/6020	137
NONIONIZABLE ORGANIC COMPOUNDS	**(mg/kg organic carbon[3], ppm OC)**				**(µg/kg dry weight or as listed)**
Aromatic Hydrocarbons					
Total LPAH[4]	370				
Naphthalene	99	3540C/3550B/3545	3640A/3660B	8270C/1625C	700
Acenaphthylene	66	3540C/3550B/3545	3640A/3660B	8270C/1625C	433
Acenaphthene	16	3540C/3550B/3545	3640A/3660B	8270C/1625C	167
Fluorene	23	3540C/3550B/3545	3640A/3660B	8270C/1625C	180
Phenanthrene	100	3540C/3550B/3545	3640A/3660B	8270/1625C	500
Anthracene	220	3540C/3550B/3545	3640A/3660B	8270C/1625C	320
2-Methylnaphthalene	38	3540C/3550B/3545	3640A/3660B	8270C/1625C	223
Total HPAH[5]	960				
Fluoranthene	160	3540C/3550B/3545	3640A/3660B	8270C/1625C	567
Pyrene	1,000	3540C/3550B/3545	3640A/3660B	8270C/1625C	867
Benz[a]anthracene	110	3540C/3550B/3545	3640A/3660B	8270C/1625C	433
Chrysene	110	3540C/3550B/3545	3640A/3660B	8270C/1625C	467
Total benzofluoranthenes[6]	230	3540C/3550B/3545	3640A/3660B	8270/1625C	1067
Benzo[a]pyrene	99	3540C/3550B/3545	3640A/3660B	8270C/1625C	533
Indeno[1,2,3-c,d]pyrene	34	3540C/3550B/3545	3640A/3660B	8270C/1625C	200
Dibenzo[a,h]anthracene	12	3540C/3550B/3545	3640A/3660B	8270C/1625C	77
Benzo[g,h,i]perylene	31	3540C/3550B/3545	3640A/3660B	8270C/1625C	223

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Table 3 Laboratory Methods and Analytes Summary

Chemical Parameter	Sediment Quality Standards (SQS)	Recommended Sample Preparation Methods	Recommended Sample Cleanup Methods	Recommended Analytical Methods	Target Practical Quantitation Limits[(1)(2)]
Dioxin and Furans as 2,3,7,8-TCDD TEQs				EPA 1613B	
CHLORINATED BENZENES					**(µg/kg dry weight or as listed)**
1,2-Dichlorobenzene	2.3	3540C/3550B/3545	3640A/3660B	8270C/1625C	35
1,4-Dichlorobenzene	3.1	3540C/3550B/3545	3640A/3660B	8270C/1625C	37
1,2,4-Trichlorobenzene	0.81	3540C/3550B/3545	3640A/3660B	8270C/1625C	31
Hexachlorobenzene	0.38	3540C/3550B/3545	3640A/3660B	8270C/1625C	22
PHTHALATE ESTERS					**(µg/kg dry weight or as listed)**
Dimethyl phthalate	53	3540C/3550B/3545	3640A/3660B	8270C/1625C	24
Diethyl phthalate	61	3540C/3550B/3545	3640/A3660B	8270C/1625C	67
Di-n-butyl phthalate	220	3540C/3550B/3545	3640A/3660B	8270C/1625C	467
Butyl benzyl phthalate	4.9	3540C/3550B/3545	3640A/3660B	8270C/1625C	21
Bis[2-ethylhexyl]phthalate	47	3540C/3550B/3545	3640A/3660B	8270C/1625C	433
Di-n-octyl phthalate	58	3540C/3550B/3545	3640A/3660B	8270C/1625C	2067
MISCELLANEOUS					**(µg/kg dry weight or as listed)**
Dibenzofuran	15	3540C/3550B/3545	3640A/3660B	8270C/1625C	180
Hexachlorobutadiene	3.9	3540C/3550B/3545	3640A/3660B	8270C/1625C	11
N-nitrosodiphenylamine	11	3540C/3550B/3545	3640A/3660B	8270C/1625C	28
Total PCBs	12	3540/3550	3640A/3660B	8082	6
IONIZABLE ORGANIC COMPOUNDS	**(µg/kg dry weight, ppb)**				**(µg/kg dry weight or as listed)**
Phenol	420	3540C/3550B/3545	3640A/3660B	8270C/1625C	140
2-Methylphenol	63	3540C/3550B/3545	3640A/3660B	8270C/1625C	63
4-Methylphenol	670	3540C/3550B/3545	3640A/3660B	8270C/1625C	223
2,4-Dimethylphenol	29	3540C/3550B/3545	3640A/3660B	8270C/1625C	29
Pentachlorophenol	360	3540C/3550B/3545	3640A/3660B	8270C/1625C	120
Benzyl alcohol	57	3540C/3550B/3545	3640A/3660B	8270C/1625C	57
Benzoic acid	650	3540C/3550B/3545	3640A/3660B	8270C/1625C	217

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Table 3 Laboratory Methods and Analytes Summary

Chemical Parameter	Sediment Quality Standards (SQS)	Recommended Sample Preparation Methods	Recommended Sample Cleanup Methods	Recommended Analytical Methods	Target Practical Quantitation Limits[(1)(2)]
CONVENTIONAL SEDIMENT VARIABLES					
Ammonia	–	–	–	Plumb (1981)	100 mg/L
Grain size	–	–	–	Plumb (1981)	1%
Total solids	–	–	–	PSEP	0.1% (wet wt)
Total organic carbon (TOC)	–	–	–	9060	0.1%
Total sulfides	–	–	–	Plumb (1981)9030B	10 (mg/kg)

(1) To achieve the recommended practical quantitation limits for organic compounds, it may be necessary to use a larger sample size approximately (100 g), a smaller final extract volume for gas chromatography/mass spectrometry analyses (0.5 mL), and one of the recommended sample cleanup methods as necessary to reduce interference, using different analytical methods with better sensitivity. Detection limits are on a dry-weight basis unless otherwise indicated. For sediment samples with low TOC, it may be necessary to achieve even lower detection limits for certain analytes in order to compare the TOC-normalized concentrations with applicable numerical criteria.

(2) The target practical quantitation limits are based on a value equal to one third of the 1988 dry weight lowest apparent effects threshold value (LAET, Barrick et al 1988) except for the following chemicals: 1,2-dichlorobenzene, 1,2,4-trichlorobenzene, hexachlorobenzene, hexachlorobutadiene, n-nitrosodiphenylamine, 2-methylphenol, 2,4-dimethylphenol, and benzyl alcohol, for which the recommended maximum detection limit is equal to the full value of the 1988 dry weight LAET.

(3) The listed values represent concentrations in parts per million "normalized" on a total organic carbon basis. To normalize to total organic carbon, the dry-weight concentration for each parameter is divided by the decimal fraction representing the percent total organic carbon content of the sediment.

(4) The total LPAH criterion under the SMS represents the sum of the concentrations of the following LPAH compounds: naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. The total LPAH criterion is not the sum of the corresponding criteria listed for the individual LPAH compounds.

(5) The total HPAH criterion under the SMS represents the sum of the concentrations of the following HPAH compounds: fluoranthene, pyrene, benz[a]anthracene, chrysene, total benzofluoranthenes, benzo[a]pyrene, indeno[1,2,3-c,d]pyrene, dibenzo[a,h]anthracene, and benzo[g,h,i]perylene. The total HPAH criterion is not the sum of the corresponding criteria listed for the individual HPAH compounds.

(6) The total benzofluoranthenes criterion represents the sum of the concentrations of the b, j, and k isomers of benzofluoranthene.

Notes: Where laboratory analysis indicates a chemical is not detected in a sediment sample, the detection limit shall be reported with U (Undetected) qualifier code and shall be at or below the Marine Sediment Quality Standards (SQS) chemical criteria (Table 1). Where the result is an estimated concentration that is less than the MRL but greater than or equal to the MDL, the detection limit shall be reported with a J flag. Where chemical criteria in Table 1 represent the sums of individual compounds (e.g., total LPAHs and total HPAHs), isomers (e.g., total benzofluoranthenes), or groups of congeners (e.g., total PCBs), the following methods shall be applied: (i) Where chemical analyses identify an undetected value for every individual compound/isomer/ congener, then the single highest detection limit shall represent the sum of the respective compounds/isomers/congeners; and (ii) Where chemical analyses detect one or more individual compound/isomers/ congeners, only the detected concentrations will be added to represent the group sum.

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SECTION 4: SEDIMENT CHEMISTRY RESULTS

This section presents analytical results for the baseline conditions with comparisons to regulatory criteria. The laboratory analytical results and quality control report are provided in Appendix D.

Where appropriate, laboratory results are presented with qualifiers. When data is qualified with a "U," the analyte was not detected above the Method Detection Limit (MDL). Comparison of undetected analytes to SQS criteria assumes the MDL concentration. When data is qualified with a "J," the analyte was detected at a concentration between the MDL and the Method Reporting Limit (MRL). Concentration results for these analytes are estimates provided by the laboratory. Results flagged with a "D" indicate the result is from a dilution of 5 or 10, in which case the reporting limits were elevated proportionally.

4.1 CONVENTIONAL PARAMETERS

The analytical results for the sediment grain size and other conventional parameters are summarized below. Sediment conventional analyses included total solids, grain size distribution, Total Organic Carbon (TOC), ammonia nitrogen, and total sulfides. Conventional parameters are monitored because these parameters affect the bioavailability and/or toxicity of pollutants.

4.1.1 Total Solids and Grain Size

Total solids are the inorganic and organic particles remaining after sediment samples have been dried. This parameter is used to convert the chemical concentrations from a wet weight to dry weight (DW) basis for uniformity. Table 4 summarizes the total solids values and grain size analyses for each sample site. As discussed in Section 2.5, grain size varied widely from site to site, and in some cases was the sole parameter analyzed.

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Table 4 Total Solids & Grain Size Distribution Summary

Parameter	Sample											
	6-1	6-2	6-3	7-1	7-2	7-3	12-1	12-2	12-3	13-1	13-2	13-3
Total Solids (%)	79.1	72.7	81.2	77.3	75.5	72.5	83.0	81.0	84.6	74.3	74.4	80.7
Grain Size												
Gravel (>2.00mm)	1.08	7.69	4.01	NA	2.34	0.1	49.2	88.7	25.5	21.5	27.8	38.0
Sand (0.0625mm to 2.00mm)	95.5	84.6	90.0	NA	91.3	91.0	53.1	5.03	73.7	71.1	62.1	54.9
Fines	1.48	4.40	1.85	NA	6.25	8.53	1.60	0.40	1.59	3.31	4.30	1.52

Parameter	WP-1	WP-2	WP-3	WP-4	WP-5	EP-1	EP-3	EP-4	EP-5
Total Solids (%)	28.2	29.1	47.7	31.2	24.8	95.0	95.6	94.5	94.7
Grain Size									
Gravel (>2.00mm)	0.00	3.84	1.53	0.83	0.00	92.3	98.8	102.9	89.7
Sand (0.0625mm to 2.00mm)	2.97	21.1	50.1	12.9	1.92	0.29	0.39	0.31	2.31
Fines	99.4	78.7	48.0	90.2	102.2	0.48	0.30	0.15	0.57
Silt (0.0039mm to 0.0625mm)	67.5	48.3	29.6	56.3	65.7	0.00	0.10	0.06	0.01
Clay (<0.0039mm)	31.9	30.5	18.4	34.0	36.4	0.48	0.20	0.09	0.56

Note: No grain size testing was conducted at Station 7-1, but was visually confirmed as majority sand similar to 7-2 and 7-3

4.1.2 Ammonia, Sulfides, and Total Organic Carbon

Ammonia was detected at all sampling sites, ranging widely from 2.94 to 96.2 mg/kg DW. Sulfides were also detected at all sites, in concentrations ranging from 0.4 to 1520 mg/kg DW.

TOC is a measure of the amount of particle and non-particle organic carbon contained in a sample. Chemical concentrations tend to be higher in sediments with elevated organic content. The TOC is measured to convert some of the organic parameters from a dry weight basis to an organic carbon basis for comparisons to the SQS criterion for that parameter.

For eight of the samples, TOC was lower than 0.5%. Per PSEP 1997, in this case it is not appropriate to compare carbon-normalized concentrations to the SQS, as even background concentrations may exceed standards when OC-normalized. Instead, dry-weight concentrations are compared to the lowest apparent effects threshold (LAET) (PTI, 1988). Results of the sampling are therefore presented in two separate tables in this report, one containing sample concentrations which have been carbon-normalized (Table 6) and one for samples requiring dry weight comparisons (Table 7).

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Table 5 Laboratory Results: TOC, Total Sulfides, Total Solids, and Ammonia

Parameter	Sampling Site							
	13-1	**13-2**	**6-2**	**WP-1**	**WP-2**	**WP-3**	**WP-4**	**WP-5**
Total Sulfides (mg/kg dry weight)	12.9	63.5	333	1390	1360	1520	610	900
Ammonia (mg/kg dry weight)	19.9	10.1	13.1	96.2	22.7	9.60	18.6	44.9
TOC (percent dry)	0.71	0.57	2.00	4.49	8.43	3.87	5.57	3.85
	13-3	**12-1**	**12-3**	**6-1**	**6-3**	**7-1**	**7-2**	**7-3**
Total Sulfides (mg/kg dry weight)	0.67	5.24	0.40	35.6	53.0	6.71	36.1	40.8
Ammonia (mg/kg dry weight)	4.06	6.84	2.94	3.06	6.47	5.10	5.65	4.94
TOC (percent dry)	0.22	0.41	0.33	0.24	0.23	0.41	0.28	0.34

4.2 METALS

The eight standard metals listed in the SMS include arsenic, cadmium, chromium, copper, lead, mercury, silver, and zinc. All eight metals were detected at most sample sites at concentrations above either the method detection or method reporting limit. The only metal that exceeded SQS, and only at the West Plant sites, was mercury. All other stations met all metal SQS.

Mercury concentrations at all five West Plant sites exceeded the SQS criterion. This result is expected since sediments in Sinclair Inlet are on the 303(d) list for mercury, and the West Plant outfall is the only sediment sampling site in this study that lies within Sinclair Inlet.

There have been a number of investigations conducted in Sinclair Inlet since the 1990s to assess and remedy the mercury contamination, including Ecology's PSAMP/ENVVEST project and ongoing RI/FS work by USGS (http://pubs.usgs.gov/of/2009/1285/). The sediment concentrations measured near the West Plant outfall are all within the lower half of the range of concentrations from the studies cited in the USGS report.

Metals concentrations for each sampling site are provided in Tables 6 and 7.

4.3 ORGANICS

The organic compounds regulated under the SMS include polynuclear aromatic hydrocarbons (PAHs), chlorinated benzenes, phthalates, polychlorinated biphenyls (PCBs), acid/alcohol (ionic) compounds, and miscellaneous non-ionic compounds.

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Organic compounds are generally normalized to organic carbon for comparison with SMS chemical criteria[1]. Sediment data are measured and reported by the analytical laboratory in µg/kg DW and must be converted to an organic carbon (OC) basis for comparison to the SQS. To convert chemical concentrations expressed as µg/kg DW to mg/kg OC requires application of the following equation:

$$mg/kg\ OC = (\mu g/kg\ DW / TOC) * 0.001$$

Where TOC = Percent total organic carbon of sediment sample expressed as a decimal.

Tables 6 and 7 present laboratory results in dry weight units for metals and ionizable organic compounds. The laboratory results for nonionizable organic compounds converted to mg/kg OC are provided in Table 6 for stations with TOC > 0.5 percent, and Table 7 for stations with TOC < 0.5 percent.

[1] With the exception of seven ionizable organic compounds or where TOC is <0.5%, see Section 4.3.6 and 4.1.2.

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Table 6 Metals and Organics, Organic Carbon-Normalized

Parameter	Criterion	Sampling Station															
	SQS	OF13-1		OF13-2		OF6-2		WP-1		WP-2		WP-3		WP-4		WP-5	
METALS	**mg/kg, dry weight**																
Arsenic	57	2.2	J	1.8	J	1.8	U	11.7		12.9		12.9		14.0		12.1	
Cadmium	5.1	0.1	U	0.13	J	0.12	J	1.6		2.41		1.41		2.47		1.12	
Chromium	260	12.3		11.5		14.1		58.4		67.2		44.2		69.6		56.0	
Copper	390	9.6		13.7		7.7		129		147		113		158		120	
Lead	450	9.8		11.5		7.7		66.3		79.1		77.2		107		59.7	
Mercury	0.41	0.031		0.043		0.027		**0.784**		**0.882**		**1.04**		**1.04**		**0.742**	
Silver	6.1	0.3	U	0.2	U	0.3	J	1.5		4.1		3.2		4.3		1.0	J
Zinc	410	34.3		45.1		38.6		159		207		271		229		140	
NON-IONIZABLE ORGANIC COMPOUNDS	**mg/kg, organic carbon (1)**																
Dilution Factor		10		10		10		1		varies		varies		1		1	
Aromatic Hydrocarbons																	
Total LPAH(2)	370	27.183		18.246		83.000		0.851		4.081		16.966		2.338		1.000	
Naphthalene	99	4.085	U	5.088	JD	1.500	JD	0.116	U	0.463		0.171	J	0.084	U	0.153	U
Acenaphthylene	66	4.930	JD	4.561	U	1.300	U	0.102	U	0.202	J	0.362		0.165	J	0.143	J
Acenaphthene	16	4.507	U	5.614	U	6.000	D	0.127	U	0.178	J	0.388		0.093	U	0.169	U
Fluorene	23	4.648	U	5.789	U	5.000	D	0.131	J	0.320		0.698		0.197	J	0.174	U
Phenanthrene	100	16.901	D	13.158	D	55.000	D	0.557		1.661		10.078		1.239		0.545	
Anthracene	220	5.352	JD	5.614	U	15.500	D	0.163	J	0.546		4.910		0.413		0.312	J
2-Methylnaphthalene	38	3.944	U	4.912	U	1.400	U	0.111	U	0.712		0.362		0.323		0.148	U
Total HPAH(3)	960	250.141		97.719		279.750		7.617		12.147		150.879		13.035		11.065	
Fluoranthene	160	49.296	D	16.140	D	70.000	D	1.114		1.779		33.592	D	2.334		1.506	
Pyrene	1000	61.972	D	17.368	D	55.000	D	1.158		2.728	D	25.323		2.334		1.532	
Benz[a]anthracene	110	21.127	D	10.175	JD	25.000	D	0.713		1.661	DX	16.021		1.346		0.987	
Chrysene	110	21.127	D	10.702	JD	28.000	D	0.846		1.423	D	13.953		1.400		1.091	
Total benzofluoranthenes(4)	230	33.239	D	19.123	D	41.500	D	1.403		1.661	X	24.031		2.388		2.130	
Benzo[a]pyrene	99	25.352	D	10.351	JD	26.000	D	0.958		1.163		15.504		1.598		1.351	

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Table 6 Metals and Organics, Organic Carbon-Normalized

Indeno[1,2,3-c,d]pyrene	34	18.310	D	7.018	JD	16.000	D	0.757		0.700		10.594		1.257		1.117	
Dibenzo[a,h]anthracene	12	4.225	U	5.263	U	3.750	D	0.118	U	0.190	J	2.300		0.305		0.286	J
Benzo[g,h,i]perylene	31	19.718	D	6.842	JD	14.500	D	0.668		0.842		9.561		0.073		1.065	
Chlorinated Benzenes																	
1,2-Dichlorobenzene	2.3	**3.380**	**U**	**4.211**	**U**	1.200	U	0.096	U	0.050	U	0.065	U	0.070	U	0.127	U
1,4-Dichlorobenzene	3.1	**3.521**	**U**	**4.386**	**U**	1.250	U	0.100	U	0.664		2.196		0.341		0.132	U
1,2,4-Trichlorobenzene	0.81	**3.662**	**U**	**4.561**	**U**	**1.300**	**U**	0.102	U	0.142	J	0.070	U	0.180	J	0.138	U
Hexachlorobenzene	0.38	**4.648**	**U**	**5.789**	**U**	**1.650**	**U**	0.131	U	0.068		0.090	U	0.095	U	0.174	U
Phthalate Esters																	
Dimethyl phthalate	53	5.634	U	7.018	U	4.550	D	0.158	U	0.082	U	0.109	U	0.269	J	0.210	U
Diethyl phthalate	61	5.211	U	6.491	U	1.850	U	0.147	U	0.522		0.101	U	0.108	U	0.195	U
Di-n-butyl phthalate	220	6.761	U	8.421	U	2.400	U	0.423	J	1.542		0.801		0.521	J	0.390	J
Butyl benzyl phthalate	4.9	**5.211**	**U**	**6.491**	**U**	1.850	U	0.147	U	**53.381**	**D**	3.618		3.411		1.662	
Bis[2-ethylhexyl]phthalate	47	12.535	U	24.561	JD	**150.000**	**DX**	9.577		**100.830**	**D**	**46.512**	**D**	10.592		1.896	J
Di-n-octyl phthalate	58	4.507	U	5.614	U	24.500	D	0.127	U	1.661		0.088	U	0.093	U	0.169	U
Miscellaneous																	
Dibenzofuran	15	4.789	U	5.965	U	2.400	JD	0.156	J	0.070	U	0.235	J	0.099	U	0.179	U
Hexachlorobutadiene	3.9	**4.225**	**U**	**5.263**	**U**	1.500	U	0.118	U	0.062	U	0.083	U	0.086	U	0.158	U
N-nitrosodiphenylamine	11	4.507	U	5.614	U	1.600	U	0.127	U	0.065	U	0.088	U	0.093	U	0.169	U
Total PCBs	12	0.408	U	0.509	U	10.0		1.158		2.112		8.010		1.526		0.522	
IONIZABLE ORGANIC COMPOUNDS	**µg/kg, dry weight**																
Phenol	420	31.0	U	31.0	U	31.0	U	5.5	U	62.0		3.3	U	5.0	U	6.3	U
2-Methylphenol	63	41.0	U	41.0	U	41.0	U	7.3	U	7.1	U	4.3	U	6.6	U	8.3	U
4-Methylphenol	670	45.0	U	45.0	U	45.0	U	8.0	U	48.0		65.0		7.2	U	9.1	U
2,4-Dimethylphenol	29	**63.0**	**U**	**63.0**	**U**	**63.0**	**U**	12.0	U	11.0	U	6.6	U	11.0	U	13.0	U
Pentachlorophenol	360	53.0	U	53.0	U	53.0	U	9.4	U	9.1	U	5.5	U	8.5	U	11.0	U
Benzyl alcohol	57	49.0	U	49.0	U	49.0	U	8.7	U	8.4	U	5.1	U	7.9	U	9.9	U
Benzoic acid	650	**960**	**U**	**960**	**U**	**960**	**U**	170	U	170	U	100	U	160	U	200	U

Blue font indicates parameter was undetected in the sample

Green font indicates parameter was detected at a concentration above the MDL but below the MRL

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Table 6 Metals and Organics, Organic Carbon-Normalized

Red font indicates parameter was detected at a concentration above both the MDL and MRL

Bolded underlined font indicates the measured concentration exceeded SQS criterion

(1) The listed values represent concentrations in parts per million "normalized" on a TOC basis. To normalize to TOC, the dry-weight concentration for each parameter is divided by the decimal fraction representing the percent TOC content of the sediment.

(2) The total LPAH criterion under the SMS represents the sum of the concentrations of the following LPAH compounds: naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. 2-Methylnaphthalene is not included in the LPAH definition under the SMS, but is included in the LPAH definition under the DMMP. The total LPAH criterion is not the sum of the corresponding criteria listed for the individual LPAH compounds.

(3) The total HPAH criterion under the SMS represents the sum of the concentrations of the following HPAH compounds: fluoranthene, pyrene, benz[a]anthracene, chrysene, total benzofluoranthenes, benzo[a]pyrene, indeno[1,2,3-c,d]pyrene, dibenzo[a,h]anthracene, and benzo[g,h,i]perylene. The total HPAH criterion is not the sum of the corresponding criteria listed for the individual HPAH compounds.

(4) The total benzofluoranthenes criterion represents the sum of the concentrations of the b, j, and k isomers of benzofluoranthene.

Notes: Where laboratory analysis indicates a chemical is not detected in a sediment sample, the detection limit shall be reported with U (Undetected) qualifier code and shall be at or below the Marine SQS chemical criteria (Table 6). Where the result is an estimated concentration that is less than the MRL but greater than or equal to the MDL, the detection limit shall be reported with a J flag. Chemical concentrations resulting from a dilution are marked with a D flag. Where chemical criteria in Table 5 represent the sums of individual compounds (e.g., total LPAHs and total HPAHs), isomers (e.g., total benzofluoranthenes), or groups of congeners (e.g., total PCBs), the following methods shall be applied: (i) Where chemical analyses identify an undetected value for every individual compound/isomer/congener, then the single highest detection limit shall represent the sum of the respective compounds/isomers/congeners; and (ii) Where chemical analyses detect one or more individual compound/isomers/ congeners, only the detected concentrations will be added to represent the group sum.

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Table 7 Metals and Organics, Dry-Weight Concentrations

Parameter	Criterion	Sampling Station															
	SQS/LAET	OF13-3		OF12-3		OF12-1		OF6-1		OF6-3		OF7-1		OF7-2		OF7-3	
METALS	**mg/kg, dry weight**																
Arsenic	57	2.1	U	2.1	U	2	U	2.3	J	1.5	U	2.7	J	1.9	J	3.0	
Cadmium	5.1	0.1	U	0.1	U	0.1	U	0.1	U	0.08	U	0.11	J	0.07	J	0.2	
Chromium	260	10.1		16		15.2		13.7		15.4		17.1		10.3		13.1	
Copper	390	16.9		13		9.1		6.4		5.9		8.1		4.3		6.3	
Lead	450	44		7.9		7.1		7.6		10.4		9.1		4.6		6.7	
Mercury	0.41	0.014	J	0.02		0.019		0.017		0.015	J	0.064		0.065		0.061	
Silver	6.1	0.3	U	0.3	U	0.3	U	0.3	U	0.2	U	0.2	U	0.2	U	0.1	U
Zinc	410	45.7		32.8		18.9		34.2		25.5		28.6		17.4		26.0	
NON-IONIZABLE ORGANIC COMPOUNDS																	
Dilution Factor		5		10		10		5		5		1		1		1	
Aromatic Hydrocarbons																	
Total LPAH[(1)]	5200	0.109		0.248		0.229		0.142		0.186		0.035		0.029		0.032	
Naphthalene	2100	0.015	U	0.029	U	0.029	U	0.015	U	0.015	U	0.003	U	0.003	U	0.003	U
Acenaphthylene	1300	0.013	U	0.042	JD	0.033	JD	0.013	U	0.013	U	0.003	U	0.004	J	0.003	J
Acenaphthene	500	0.016	U	0.032	U	0.032	U	0.016	U	0.016	U	0.003	U	0.003	U	0.003	U
Fluorene	540	0.017	U	0.033	U	0.033	U	0.017	U	0.017	U	0.003	U	0.003	U	0.003	U
Phenanthrene	1500	0.018	U	0.052	JD	0.042	JD	0.051	D	0.095	D	0.015		0.006	J	0.008	
Anthracene	960	0.016	U	0.032	U	0.032	U	0.016	U	0.016	JD	0.005	J	0.007		0.009	
2-Methylnaphthalene	670	0.014	U	0.028	U	0.028	U	0.014	U	0.014	U	0.003	U	0.003	U	0.003	U
Total HPAH[(2)]	12000	0.182		1.603		1.155		0.562		0.772		0.138		0.145		0.101	
Fluoranthene	1700	0.019	U	0.190	D	0.140	D	0.130	D	0.190	D	0.021		0.024		0.019	
Pyrene	2600	0.019	U	0.240	D	0.260	D	0.089	D	0.160	D	0.026		0.027		0.022	
Benz[a]anthracene	1300	0.018	U	0.130	D	0.100	D	0.047	D	0.058	D	0.013		0.015		0.011	
Chrysene	1400	0.021	U	0.120	D	0.100	D	0.053	D	0.074	D	0.016		0.016		0.010	
Total benzofluoranthenes[(3)]	3200	0.037	U	0.213	D	0.175	D	0.096	D	0.114	D	0.019		0.022		0.009	

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Table 7 Metals and Organics, Dry-Weight Concentrations

Benzo[a]pyrene	1600	0.018	U	0.180	D	0.140	D	0.055	D	0.068	D	0.015		0.016		0.012	
Indeno[1,2,3-c,d]pyrene	600	0.016	U	0.110	D	0.100	D	0.042	D	0.050	D	0.013		0.011		0.007	J
Dibenzo[a,h]anthracene	230	0.015	U	0.300	U	0.030	U	0.015	U	0.015	U	0.005	J	0.003	U	0.003	U
Benzo[g,h,i]perylene	670	0.019	U	0.120	D	0.110	D	0.035	D	0.043	D	0.010		0.011		0.008	
Chlorinated Benzenes																	
1,2-Dichlorobenzene	35	0.012	U	0.024	U	0.024	U	0.012	U	0.012	U	0.002	U	0.002	U	0.002	U
1,4-Dichlorobenzene	110	0.013	U	0.025	U	0.025	U	0.013	U	0.013	U	0.003	U	0.003	U	0.003	U
1,2,4-Trichlorobenzene	31	0.013	U	0.026	U	0.026	U	0.013	U	0.013	U	0.003	U	0.003	U	0.003	U
Hexachlorobenzene	22	0.017	U	0.033	U	0.033	U	0.017	U	0.017	U	0.003	U	0.003	U	0.003	U
Phthalate Esters																	
Dimethyl phthalate	71	0.020	U	0.040	U	0.040	U	0.020	U	0.020	U	0.004	U	0.004	U	0.004	U
Diethyl phthalate	200	0.019	U	0.037	U	0.037	U	0.019	U	0.019	U	0.004	U	0.004	U	0.004	U
Di-n-butyl phthalate	1400	0.024	U	0.048	U	0.048	U	0.024	U	0.024	U	0.005	U	0.005	U	0.005	U
Butyl benzyl phthalate	63	0.019	U	0.037	U	0.037	U	0.019	U	0.019	U	0.004	U	0.004	U	0.004	U
Bis[2-ethylhexyl]phthalate	1300	0.045	U	0.089	U	0.089	U	0.079	JD	0.840	JD	0.009	U	0.009	U	0.009	U
Di-n-octyl phthalate	6200	0.016	U	0.032	U	0.032	U	0.016	U	0.016	U	0.003	U	0.003	U	0.003	U
Miscellaneous																	
Dibenzofuran	540	0.017	U	0.034	U	0.034	U	0.017	U	0.017	U	0.003	U	0.003	U	0.003	U
Hexachlorobutadiene	11	0.015	U	0.030	U	0.030	U	0.015	U	0.015	U	0.003	U	0.003	U	0.003	U
N-nitrosodiphenylamine	28	0.016	U	0.032	U	0.032	U	0.016	U	0.016	U	0.003	U	0.003	U	0.003	U
Total PCBs	130	0.019	P	0.003	Ui	0.008	Ui	0.003	U	0.003	U	0.002	U	0.002	U	0.002	U
IONIZABLE ORGANIC COMPOUNDS	**µg/kg, dry weight**																
Phenol	420	16.0	U	57.0	JD	31.0	U	16.0	U	16.0	U	3.1	U	11.0	J	3.1	U
2-Methylphenol	63	21.0	U	41.0	U	41.0	U	21.0	U	21.0	U	4.1	U	4.1	U	4.1	U
4-Methylphenol	670	23.0	U	45.0	U	45.0	U	23.0	U	23.0	U	4.5	U	4.5	U	4.5	U
2,4-Dimethylphenol	29	32.0	U	63.0	U	63.0	U	32.0	U	32.0	U	6.3	U	6.3	U	6.3	U
Pentachlorophenol	360	27.0	U	53.0	U	53.0	U	27.0	U	27.0	U	5.3	U	5.3	U	5.3	U
Benzyl alcohol	57	25.0	U	49.0	U	49.0	U	25.0	U	25.0	U	4.9	U	4.9	U	4.9	U
Benzoic acid	650	480	U	960	U	960	U	480	U	480	U	96	U	96	U	96	U

Blue font indicates parameter was undetected in the sample

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Table 7 Metals and Organics, Dry-Weight Concentrations

Green font indicates parameter was detected at a concentration above the MDL but below the MRL

Red font indicates parameter was detected at a concentration above both the MDL and MRL

Bolded underlined font indicates the measured concentration exceeded SQS criterion

(1) The total LPAH criterion under the SMS represents the sum of the concentrations of the following LPAH compounds: naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. 2-Methylnaphthalene is not included in the LPAH definition under the SMS, but is included in the LPAH definition under the DMMP. The total LPAH criterion is not the sum of the corresponding criteria listed for the individual LPAH compounds.

(2) The total HPAH criterion under the SMS represents the sum of the concentrations of the following HPAH compounds: fluoranthene, pyrene, benz[a]anthracene, chrysene, total benzofluoranthenes, benzo[a]pyrene, indeno[1,2,3-c,d]pyrene, dibenzo[a,h]anthracene, and benzo[g,h,i]perylene. The total HPAH criterion is not the sum of the corresponding criteria listed for the individual HPAH compounds.

(3) The total benzofluoranthenes criterion represents the sum of the concentrations of the b, j, and k isomers of benzofluoranthene.

Notes: Where laboratory analysis indicates a chemical is not detected in a sediment sample, the detection limit shall be reported with U (Undetected) qualifier code and shall be at or below the Marine SQS chemical criteria (Table 6). Where the result is an estimated concentration that is less than the MRL but greater than or equal to the MDL, the detection limit shall be reported with a J flag. Chemical concentrations resulting from a dilution are marked with a D flag. Where chemical criteria in Table 5 represent the sums of individual compounds (e.g., total LPAHs and total HPAHs), isomers (e.g., total benzofluoranthenes), or groups of congeners (e.g., total PCBs), the following methods shall be applied: (i) Where chemical analyses identify an undetected value for every individual compound/isomer/congener, then the single highest detection limit shall represent the sum of the respective compounds/isomers/congeners; and (ii) Where chemical analyses detect one or more individual compound/isomers/ congeners, only the detected concentrations will be added to represent the group sum.

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4.3.1 Polynuclear Aromatic Hydrocarbons (PAHs)

Most of the SMS low and high-molecular weight PAH (LPAH and HPAH) compounds were detected at all sampling sites but OF13-3, but all in concentrations well below the corresponding SQS or LAET criteria.

4.3.2 Chlorinated Benzenes

The SMS chlorinated benzene compounds (1,2-dichlorobenzene, 1,4-dichlorobenzene, 1,2,4-trichlorobenzene, hexachlorobenzene) were detected at only three sites, WP-2, 3, and 4. However, due to elevated detection levels resulting from dilutions prior to analysis by the lab, the results for samples OF13-1 and 2 exceeded the SQS criteria for all four chlorinated benzenes, and the results for sample OF6-2 exceeded the criteria for 1,2,4-trichlorobenzene and hexachlorobenzene, though all parameters were undetected in the samples.

4.3.3 Phthalate Esters

Of the six phthalate compounds, four (dimethyl phthalate, diethyl phthalate, di-n-butyl phthalate and di-n-octyle phthalate) were detected at low levels at OF6-2 and all five West Plant sites. Butyl benzyl phthalate was also detected at all West Plant sites but WP-1, and in the case of WP-2 at a level exceeding the SQS. It was undetected in the samples from OF13-1 and 2, however elevated detection levels due to sample dilution resulted in these samples exceeding the SQS criterion. Bis[2-ethylhexyl]phthalate was detected at levels exceeding the MDL or MRL at sample sites OF13-2, 6-1, 6-2, 6-3, and all West Plant sites. Concentrations exceeded the SQS criterion at sites OF6-2, WP-2, and WP-3. Concentrations from all three of these sites resulted from dilution of the sample before analysis.

4.3.4 Miscellaneous Non-Ionic Organic Compounds

Of the other non-ionizable organic compounds, only dibenzofuran and polychlorinated biphenyls (PCBs) were detected at any site. Dibenzofuran was detected in concentrations below the MRL at sites OF6-2, WP-1, and WP-3. PCBs were detected at all West Plant sites and at sites OF6-2 and 13-3. None of these results exceeded the corresponding SQS or LAET criterion.

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4.3.5 Polychlorinated Biphenyls (PCBs)

PCBs generally occur as mixtures of congeners; the most common of these mixtures being the Aroclors. Per WAC 173-204-320, where Aroclors are detected, the reported result is the sum of all detected concentrations; where all values are undetected the result reported assumes the single highest MDL value for a single Aroclor. Aroclors were detected in seven of the sixteen samples that were analyzed for sediment chemistry, but none at levels exceeding the SQS or LAET criterion.

4.3.6 Ionizable Organic Compounds

Of the ionizable organic compounds, only phenol and 4-methylphenol were detected in the samples, phenol at sites WP-2, OF12-3, and 7-2 and 4-methylphenol at sites WP-2 and 3. Reported concentrations were well below SQS limits. Due to elevated detection levels resulting from dilution of some samples before analysis, several sample results exceeded SQS criteria for 2,4-dimethylphenol and benzoic acid, though they were undetected by the laboratory. These sites were OF13-1, 2, 3, 6-1, 2, 3, 12-1 and 12-3 (6-1, 3 and 13-3 exceeded the criterion for 2,4-dimethylphenol only). No other ionizable organic compounds were detected in any of the samples. MDL values for the remaining ionizable organic compounds meet their respective SQS criteria.

4.4 DIOXINS AND FURANS

Dioxins and furans are common names for a family of toxic compounds that are formed as unintentional byproducts of most forms of combustion and several industrial chemical processes. There are 210 different dioxins and furans. All dioxins have the same basic chemical structure. Furans are similar, but have a different structure. The different dioxins and furans vary widely in toxicity. The one considered most toxic is referred to as 2,3,7,8-tetrachlorodibenzo-p-dioxin, or simply TCDD.

The SMS do not include SQS criteria for dioxins and furans. However, the SSAP proposed sample analysis for dioxin and furan congeners to establish baseline concentrations for future comparison. Lab results for dioxin and furans, in units of ng/kg dry weight, are summarized in Table 8. Undetected values ("U") assume an estimated detection limit (EDL) provided by the laboratory. Results flagged with a 'K' indicate an ion abundance ratio between the primary and

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secondary ions outside of theoretical acceptance limits. The result reported in these cases is an estimated maximum possible concentration.

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Table 8 Laboratory Results: Dioxins and Furans

Parameter	Sampling Station															
	WP-1		WP-2		WP-3		WP-4		WP-5		OF7-1		OF7-2		OF7-3	
Dioxin Congeners (ng/kg DW)																
2,3,7,8-TCDD	0.322	U	0.963	U	0.561	JK	1.98	U	0.416	U	0.0799	U	0.112	U	0.106	U
1,2,3,7,8-PeCDD	1.11	J	3.59	JK	1.69	JK	4.08	U	0.929	U	0.166	U	0.364	U	0.183	U
1,2,3,4,7,8-HxCDD	1.19	J	3.57	J	2.36	J	1.98	U	0.996	J	0.111	U	0.103	U	0.235	JK
1,2,3,6,7,8-HxCDD	5.4	J	21.6		23.3		18.6	K	3.52	J	0.628	J	0.667	J	0.493	JK
1,2,3,7,8,9-HxCDD	2.7	J	9.61		6.25		7.08	J	2.01	JK	0.39	BJK	0.386	BJ	0.271	BJ
1,2,3,4,6,7,8-HpCDD	92		428		530		710		56.8		6.44		8.4		5.1	
OCDD	770		3890		5800		6040		437		43.5		55		35.2	
Total Tetra-Dioxins	3.89		8.16		4.4		4.69		0.416	U	0.0799	U	0.491	J	0.106	U
Total Penta-Dioxins	3.82	J	19.5		4.58	J	4.08	U	0.929	U	0.166	U	0.364	U	0.183	U
Total Hexa-Dioxins	51.4		178		129		215		32.2		0.628	J	9.34		4.31	
Total Hepta-Dioxins	272		1140		1160		2550		174		15.2		28.6		13.7	
Furan Congeners (ng/kg DW)																
2,3,7,8-TCDF	1.5	J	5.38		3.3		3.1	U	1.2	U	0.26	U	0.371	U	0.263	U
1,2,3,7,8-PeCDF	0.446	U	1.71	JK	0.763	U	2.47	U	0.59	U	0.163	U	0.214	U	0.134	U
2,3,4,7,8,-PeCDF	2	J	5.71	JK	5.33		2.56	U	0.607	U	0.608	JK	0.225	U	0.26	J
1,2,3,4,7,8-HxCDF	2.13	J	4.92	J	4.97	J	3.91	JK	1.16	JK	0.569	J	0.281	JK	0.2	JK
1,2,3,6,7,8-HxCDF	1.27	JK	3.38	JK	2.91	J	2.74	JK	0.824	J	0.377	J	0.172	J	0.147	JK
1,2,3,7,8,9-HxCDF	0.2	U	1.09	JK	0.844	J	0.859	U	0.233	U	0.177	BJK	0.115	BJK	0.0624	BJK
2,3,4,6,7,8-HxCDF	1.69	JK	5.25	J	3.84	J	3.65	J	1.26	JK	0.462	J	0.307	JK	0.153	JK
1,2,3,4,6,7,8-HpCDF	20.6		62.7		64.7	P	43.5		12.9	P	3.25		1.75	BJ	1.34	BJ
1,2,3,4,7,8,9-HpCDF	2.27	JK	3.68	J	4.02	J	5.9	JK	0.824	JK	0.664	J	0.226	U	0.117	U
OCDF	38.2		102		132		109		21.4		22.1		2.23	BJ	3.12	BJ
Total Tetra-Furans	4.6		11.4		12.9		5.36	U	1.2	U	0.26	U	12.7		0.777	
Total Penta-Furans	19.1		34.2		45.9		20.6		10.1		4.74		13.5		1.95	J
Total Hexa-Furans	23.1		83.7		90.1		48		13.1		4.89		3.51		1.53	J
Total Hepta-Furans	52.7		170		210		130		32.6		7.61		2.63	J	3.55	
TEQ (ng/kg)	4.69		17		16.4		13		1.82		0.566		0.311		0.31	

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Table 8 Laboratory Results: Dioxins and Furans

Parameter	Sampling Station															
	OF13-1		OF13-2		OF13-3		OF12-1		OF12-3		OF6-1		OF6-2		OF6-3	
Dioxin Congeners (ng/kg DW)																
2,3,7,8-TCDD	0.194	U	0.226	U	0.638	U	0.197	U	0.199	U	0.232	U	0.651	U	0.156	U
1,2,3,7,8-PeCDD	0.228	U	0.2	U	0.818	U	0.196	U	0.253	U	0.266	U	0.578	U	0.174	U
1,2,3,4,7,8-HxCDD	0.162	U	0.237	U	0.501	U	1.18	J	0.192	U	1.22	J	0.428	U	0.21	U
1,2,3,6,7,8-HxCDD	0.433	BJK	0.713	BJ	0.484	U	2.13	J	0.553	BJ	2.48	J	0.691	BJK	0.327	BJK
1,2,3,7,8,9-HxCDD	0.147	U	0.374	BJ	0.448	U	1.23	JK	0.24	BJK	1.72	J	0.388	U	0.187	U
1,2,3,4,6,7,8-HpCDD	9.28	B	14.4	B	14.9	B	88.1		7.12	B	70		16.4	B	6.85	B
OCDD	54.8	B	117	B	65.3	B	265		41.7	B	225		137	B	45.7	B
Total Tetra-Dioxins	0.194	U	0.226	U	0.638	U	0.197	U	0.199	U	0.232	U	0.651	U	0.156	U
Total Penta-Dioxins	0.228	U	0.2	U	0.818	U	1.27	J	0.563	J	0.266	U	0.578	U	0.174	U
Total Hexa-Dioxins	1.65	J	2.83	J	3.17		31.5		4.12		38.7		5.51		0.879	J
Total Hepta-Dioxins	25.4		37.1		29.9		181		18.7		179		48.7		17.5	
Furan Congeners (ng/kg DW)																
2,3,7,8-TCDF	0.239	U	0.265	U	0.882	U	0.297	U	0.423	U	0.571	U	0.615	U	0.343	U
1,2,3,7,8-PeCDF	0.2	U	0.177	U	0.514	U	0.193	U	0.178	U	0.24	U	0.526	U	0.169	U
2,3,4,7,8,-PeCDF	2.39	J	0.178	U	0.505	U	0.193	U	0.182	U	0.245	U	0.514	U	0.168	U
1,2,3,4,7,8-HxCDF	0.191	JK	0.153	U	0.419	U	0.295	J	0.31	J	0.497	JK	0.271	U	0.128	U
1,2,3,6,7,8-HxCDF	0.466	J	0.217	BJ	0.404	U	0.214	BJ	0.313	BJK	0.145	U	0.265	U	0.126	U
1,2,3,7,8,9-HxCDF	0.0978	U	0.134	U	0.403	U	0.111	U	0.144	U	0.146	U	0.251	U	0.115	U
2,3,4,6,7,8-HxCDF	1.2	J	0.392	J	0.424	U	0.354	JK	0.567	J	0.403	JK	0.276	U	0.13	U
1,2,3,4,6,7,8-HpCDF	2.7	J	3.7	B	1.53	BJ	2.69	BJ	1.9	BJ	3.44	B	3.07	BJ	1.83	BJ
1,2,3,4,7,8,9-HpCDF	0.2	U	0.303	BJ	0.62	U	0.314	BJ	0.215	U	0.907	BJK	0.525	U	0.24	U
OCDF	7.32	B	10.6	B	5.59	BJ	7.63	B	5.8	BJ	7.5	B	8.96	B	6.79	
Total Tetra-Furans	7.91		0.824		0.882	U	0.963		4.99		0.757		0.615	U	1.02	
Total Penta-Furans	31.6		5.13		3.4		5.68		17.9		1.26	J	2.01	J	0.804	J
Total Hexa-Furans	15.4		5.72		2.25	J	4.66		8.34		3.27		1.82	J	1.33	J
Total Hepta-Furans	10.6		13.9		7.5		10.8		8.01		16.1		12.2		7.6	
TEQ (ng/kg)	1.08		0.392		0.186		1.53		0.303		1.45		0.308		0.135	

Blue font indicates the parameter was undetected, green font indicates the parameter was detected at a concentration above the MDL but below the MRL, red font indicates the parameter was detected at a concentration above both the MDL and MRL

U = Undetected, J= Estimated concentration, K= Ion abundance ratio outside theoretical limits. Reported result is an estimate.

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SECTION 5: SUMMARY AND CONCLUSIONS

Sampling of the sediments at selected treatment plant and CSO outfalls in Bremerton was performed in July and August 2015. Sampling activities were conducted according to the protocols outlined in a SSAP dated October 2014 and approved by Ecology in November 2014.

Sediment samples were collected from six stations (21 samples total, see discussion in Section 2.5) for the analysis of sediment chemical constituents and conventional parameters. This sediment study was performed to fulfill Ecology and NPDES requirements.

Sample results which exceeded SQS criteria are summarized in Table 9. Blue font indicates the parameter was not detected in the sample, red font indicates a concentration above both the method detecting and reporting limits. Results which were undetected in the sample exceeded SQS criteria due to elevated detection levels resulting from dilutions.

Ecology utilizes the Environmental Information Management (EIM) System database for storing sediment quality information. This database is used by federal, state, and other public and private institutions for storing and providing access to sediment test data. Cosmopolitan Marine Engineering will enter the data collected from this study into the EIM database at the time of report submittal.

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Table 9 Sample Results Exceeding SQS Criteria

Parameter	SQS Criterion	CSL Criterion	Sample Site				
			WP-1	WP-2	WP-3	WP-4	WP-5
METALS (mg/kg, dry weight)							
Mercury	0.41	0.59	0.784	0.882	1.04	1.04	0.742
Phthalate Esters							
Butyl benzyl phthalate	4.9	64		53.4[1]			
Bis[2-ethylhexyl]phthalate	47	78		100.8[2]			
Parameter	**SQS Criterion**	**CSL Criterion**	**Sample Site**				
			12-1	**12-3**	**13-3**	**6-1**	**6-3**
IONIZABLE ORGANIC COMPOUNDS (µg/kg, dry weight)							
2,4-Dimethylphenol	29	29	63	63	32	32	32
Benzoic acid	650	650	960	960			

Parameter	SQS Criterion	CSL Criterion	Sample Site		
			13-1	13-2	6-2
NON-IONIZABLE ORGANIC COMPOUNDS (mg/kg, organic carbon)					
Dilution Factor			10	10	10
Chlorinated Benzenes					
1,2-Dichlorobenzene	2.3	2.3	3.38	4.21	
1,4-Dichlorobenzene	3.1	9	3.52	4.39	
1,2,4-Trichlorobenzene	0.81	1.8	3.66	4.56	1.3
Hexachlorobenzene	0.38	2.3	4.65	5.79	1.65
Phthalate Esters					
Butyl benzyl phthalate	4.9	64	5.21	6.49	
Bis[2-ethylhexyl]phthalate	47	78			150
Miscellaneous					
Hexachlorobutadiene	3.9	6.2	4.23	5.26	
IONIZABLE ORGANIC COMPOUNDS (µg/kg, dry weight)					
2,4-Dimethylphenol	29	29	63	63	63
Benzoic acid	650	650	960	960	960

[1] Dilution factor of 5
[2] Dilution factor of 10

The sediment sampling stations and chemistry results can be split up into three distinct categories, which are discussed below:

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5.1 GRAVEL STATIONS

As revealed in Table 4, all of the East Plant sediment stations (EP-1, EP-2, EP-3, EP-4 and EP-5) and the offshore station at OF-12 (12-2) consisted of over 90 percent gravel content. A photo of the most successful grab sample at Station EP-3 is shown below in Figure 3.

Figure 3 Photo of Sediment Grab Sample at Station EP-3

The EP stations and the offshore 12-2 station are located in very swift tidal currents, with average daily maximum current speeds exceeding 1.1 meter/second (NOAA Tidal Current Predictions, Port Washington Narrows). As shown in the Hjulstrom Diagram in Figure 4 below, the maximum current speed and observed grain size (pebbles) are wholly consistent.

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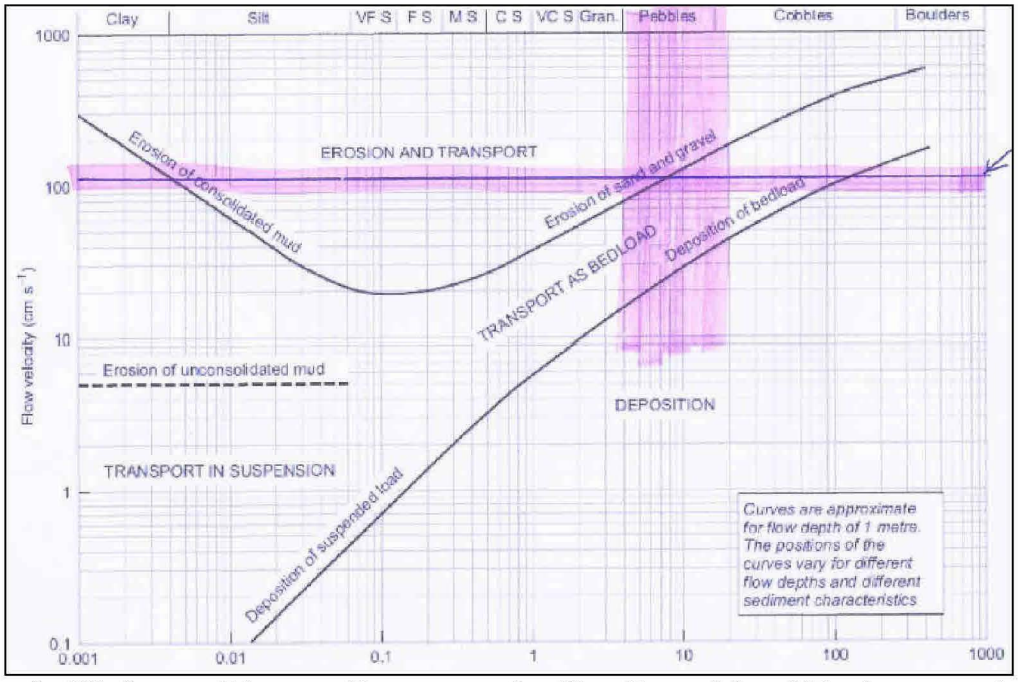

Figure 4 Hjulstrom Diagram Demonstrating Non-Depositional Environment in Port Washington Narrows Stations EP and 12-2 for Sand and Finer Grades

It is not feasible to sample chemistry for the stations consisting predominantly of gravel. These sites are clearly not depositional environments, and therefore no further sediment sampling should be required at these locations.

5.2 MUD STATIONS

Per Table 4, all of the West Plant sediment sampling stations consisted predominantly of fine-grained particles (though WP-3 alone had some fine sand), and would commonly be categorized as typical bay mud. Total organic carbon content of 4-8% and total sulfides exceeding 500 mg/kg are consistent with this characterization. A typical photo of a WP sediment sample is shown in Figure 5.

Per Table 9, the West Plant sediment samples met all SQS with the exception of mercury and, in the case of WP-2, two phthalates.

Phthalates are not typically associated with WWTP discharges. However, they are commonly associated with stormwater or CSO discharges, which have occurred in the vicinity of the West Plant Outfall. Additional investigation may be required to confirm the high phthalate concentrations at WP-2 and assess potential sources.

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Figure 5 Photo of Sediment Grab Sample at Station WP-4

Figure 6 shows the range of mercury concentrations observed at the five West Plant Outfall stations with other sediment data in Sinclair Inlet provided in the USGS (2009) report. The observed mercury concentrations are in the middle of the range of other sediment stations in Sinclair Inlet. Remediation of the sediments in Sinclair Inlet, including those around the West Plant Outfall, will come from the RI/FS being conducted by USGS.

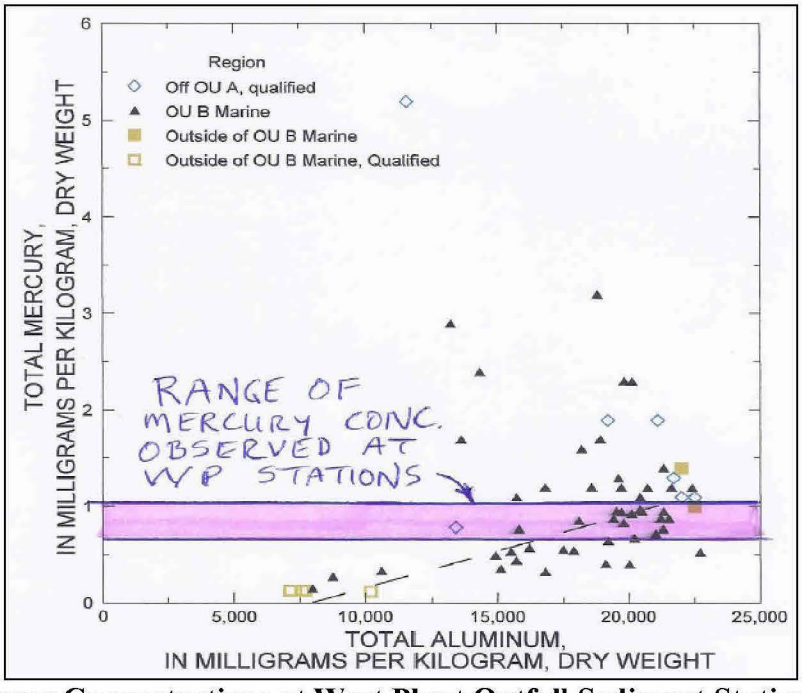

Figure 6 Mercury Concentrations at West Plant Outfall Sediment Stations Compared to USGS (2009) Sediment Mercury Data in Sinclair Inlet

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5.3 SAND STATIONS

The remaining stations (OF-6, OF-7, OF-13, and OF-12) were all predominantly sand or sand and gravel. All of these stations had percent fines below 10 percent (see Table 4). Typical photos of sediment samples are shown in Figure 7.

Station 6-1

Station 12-3

Figure 7 Photos of Sediment Grab Samples with High Sand Content

These stations all had very low concentrations of sulfides, ammonia and TOC compared to mud samples, and typically no odor. The TOC of all but three of these stations fell below the 0.5 percent threshold for carbon normalization, and are thus compared to LAET dry weight criteria, as described in Section 4.1.2.

The only detected compound at any sand station that exceeded SQS or LAET criteria was bis[2-ethylhexyl]phthalate at Station 6-2. Station 6-2 is located straight offshore of the CSO Outfall OF-6 and a municipal storm drain. Station 6-2 also had the highest TOC of all sand stations at 2.0 percent, approximately three times higher than the next highest sand station, suggesting there is some organic input from the CSO and/or stormwater outfalls.

The only quality issue with the laboratory analysis was the aforementioned elevated reporting limits for the sand stations (see Section 3). As a result, there are a number of non-detected compounds at sand stations where the detection level exceeded SQS or LAET criteria, shown in blue type in Table 9. Although there is no reason to suspect that any of the sand stations would exceed criteria, Ecology may require resampling at all or some of these stations. Measures to

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reduce the detection levels by eliminating laboratory dilutions should be investigated and coordinated between the analytical laboratory and Ecology laboratory experts.

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SECTION 6: REFERENCES

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