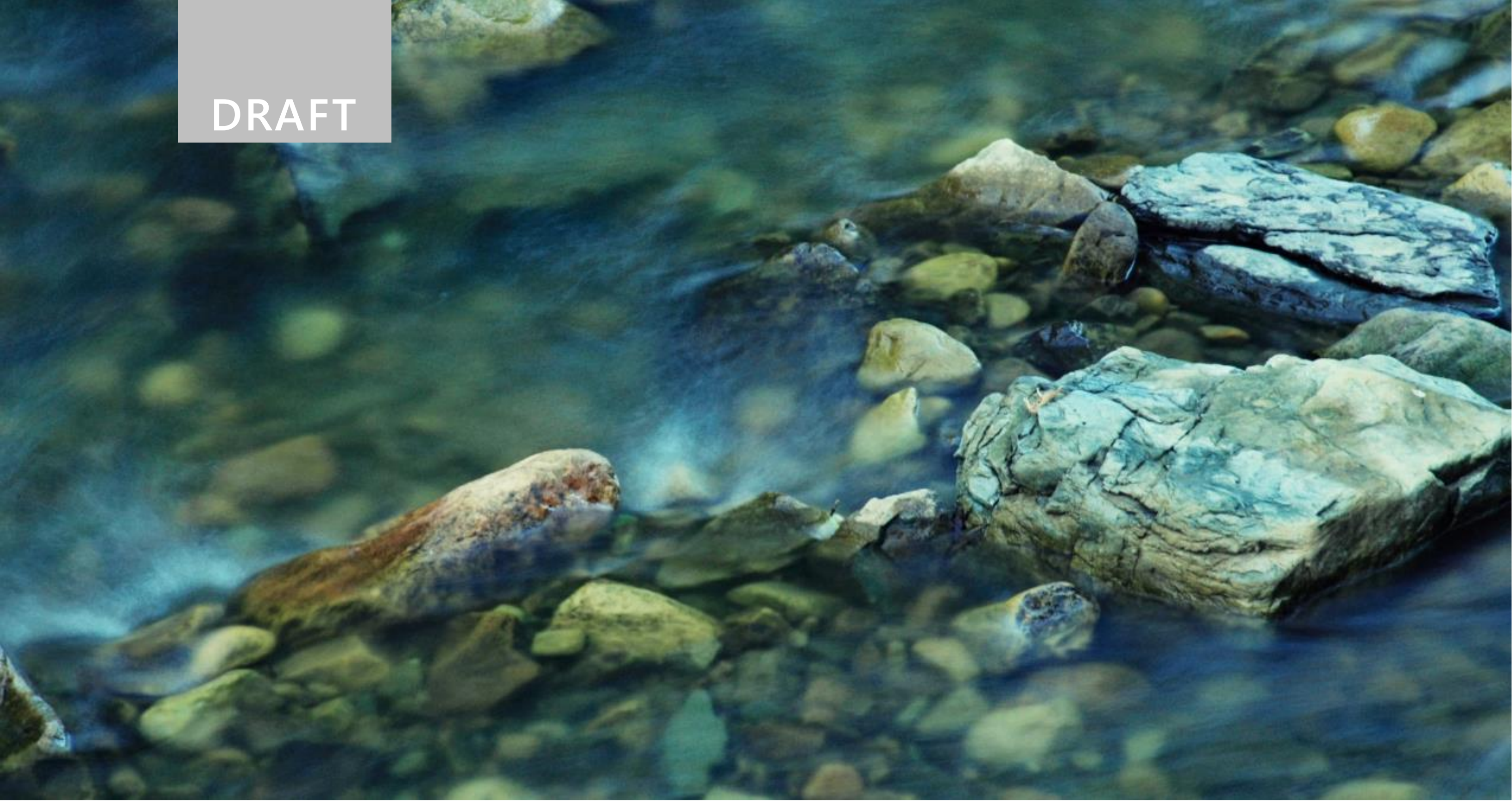
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February 2021
Port Gamble Bay Cleanup Project

2020 Post-Construction Monitoring Report

Prepared for OPG Port Gamble, LLC and Rayonier, Inc.

February 2021
Port Gamble Bay Cleanup Project

2020 Post-Construction Monitoring Report

Prepared for
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ABBREVIATIONS

µg/kg	micrograms per kilogram
ARI	Analytical Resources, Inc.
CAP	*Port Gamble Bay Cleanup Action Plan*
Carr Ref	Carr Inlet Reference
CD	*Port Gamble Bay Cleanup Consent Decree 13-2-02720-0*
cm	centimeter
CoC	chemical of concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CRM	certified reference material
DGT	diffusive gradient thin sheet
EcoAnalysts	EcoAnalysts, Inc.
Ecology	Washington State Department of Ecology
EMNR	enhanced monitored natural recovery
eTrac	eTrac, Inc.
Gravity	Gravity Consulting
H_2S	hydrogen sulfide
mg/kg	milligrams per kilogram
mg/L	milligram per liter
MNR	monitored natural recovery
Monitoring Report	*Port Gamble Bay Cleanup 2020 Post-Construction Monitoring Report*
MTCA	Model Toxics Control Act
NAD83	North American Datum of 1983
ng/kg	nanograms per kilogram
OMMP	*Port Gamble Bay Cleanup Operations, Maintenance, and Monitoring Plan*
PAH	polycyclic aromatic hydrocarbon
ppt	part per thousand
PR/OPG	Pope Resources, LP/OPG Properties, LLC
QC	quality control
Rayonier	Rayonier, Inc.
SCO	sediment cleanup objective
Seton	Seton Construction
Site	Port Gamble Bay
SMA	sediment management area
SMP	*Port Gamble Bay Cleanup Shellfish Monitoring Plan*
SMS	Sediment Management Standards
SU	standard units

SWAC	surface-weighted average concentration
TEQ	toxicity equivalence
WAC	Washington Administrative Code

1 Introduction

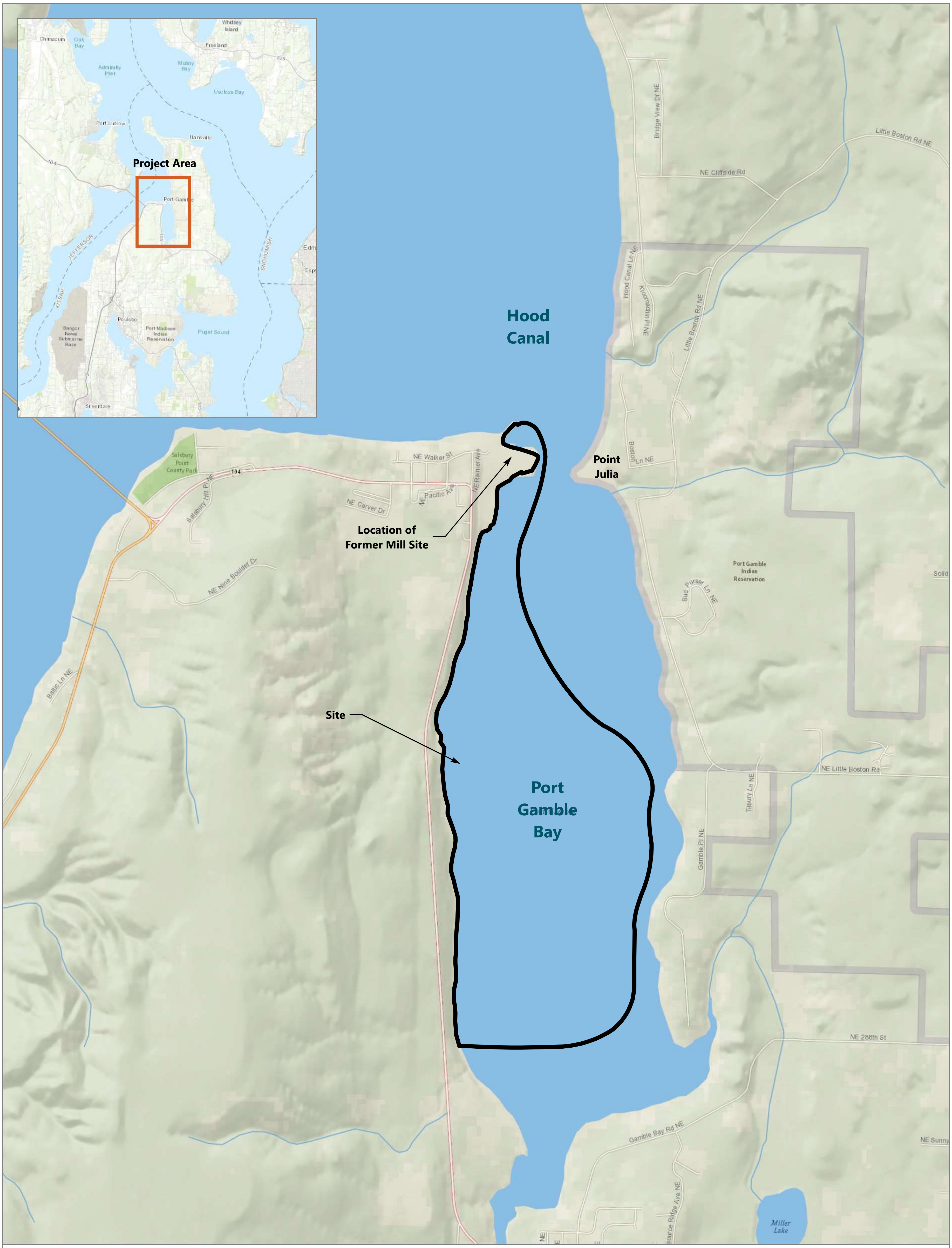
This *2020 Post-Construction Monitoring Report* (Monitoring Report) summarizes surface sediment monitoring of engineered caps, enhanced monitored natural recovery (EMNR), and monitored natural recovery (MNR) areas in Port Gamble Bay ("Site"; Figure 1). Post-construction monitoring was initiated in 2018 to verify the protectiveness of the Site cleanup remedy. The 2020 monitoring data presented in this report were collected approximately 3 years after completion of remedial construction, allowing for post-construction stabilization of environmental conditions at the Site.

This Monitoring Report was prepared in accordance with the *Operations, Maintenance, and Monitoring Plan, Port Gamble Bay Cleanup Project* (OMMP; Anchor QEA 2018a), which describes monitoring and adaptive management of engineered caps and surface sediment natural recovery throughout the Site. The OMMP builds on the accompanying *Engineering Design Report, Port Gamble Bay Cleanup Project* (Anchor QEA 2015), which describes the approach and performance requirements for sediment cleanup actions at the Site, as set forth in the *Cleanup Action Plan, Port Gamble Bay* (CAP; Ecology 2013). The CAP is an exhibit to the *Port Gamble Bay Consent Decree (CD) 13-2-02720-0* between the Washington State Department of Ecology (Ecology) and Pope Resources, LP/OPG Properties, LLC (PR/OPG), entered in December 2013.

In May 2020, PR/OPG merged with Rayonier, Inc. (Rayonier). The actions described in this Monitoring Report were performed by PR/OPG and Rayonier under Ecology oversight, consistent with CD requirements.

Implementation of the OMMP was also performed consistent with the requirements of the Model Toxics Control Act (MTCA), Chapter 70.105D in the Revised Code of Washington, as administered by Ecology under the MTCA Cleanup Regulation, Chapter 173-340 of the Washington Administrative Code (WAC), and the Sediment Management Standards (SMS) Chapter 173-204 WAC.

The monitoring, surveying, and inspection activities summarized in this Monitoring Report were conducted by Anchor QEA on behalf of PR/OPG. The project team also included Analytical Resources, Inc. (ARI), for chemical analyses; EcoAnalysts, Inc. (EcoAnalysts), for bioassay analyses; eTrac, Inc. (eTrac), for upland and bathymetric surveying; Gravity Consulting (Gravity) for sediment sample collection; Laboratory Data Consultants for data validation; and Seton Construction, Inc. (Seton), for cap repairs.



LEGEND:

▭ Site

0 2,000

Feet

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ANCHOR QEA

Figure 1
Site Vicinity Map

2020 Post-Construction Monitoring Report Port Gamble Bay Cleanup

1.1 Purpose and Scope of Monitoring Activities

As set forth in the CAP (Ecology 2013), the objectives of sediment cleanup actions implemented in Port Gamble Bay are summarized as follows:

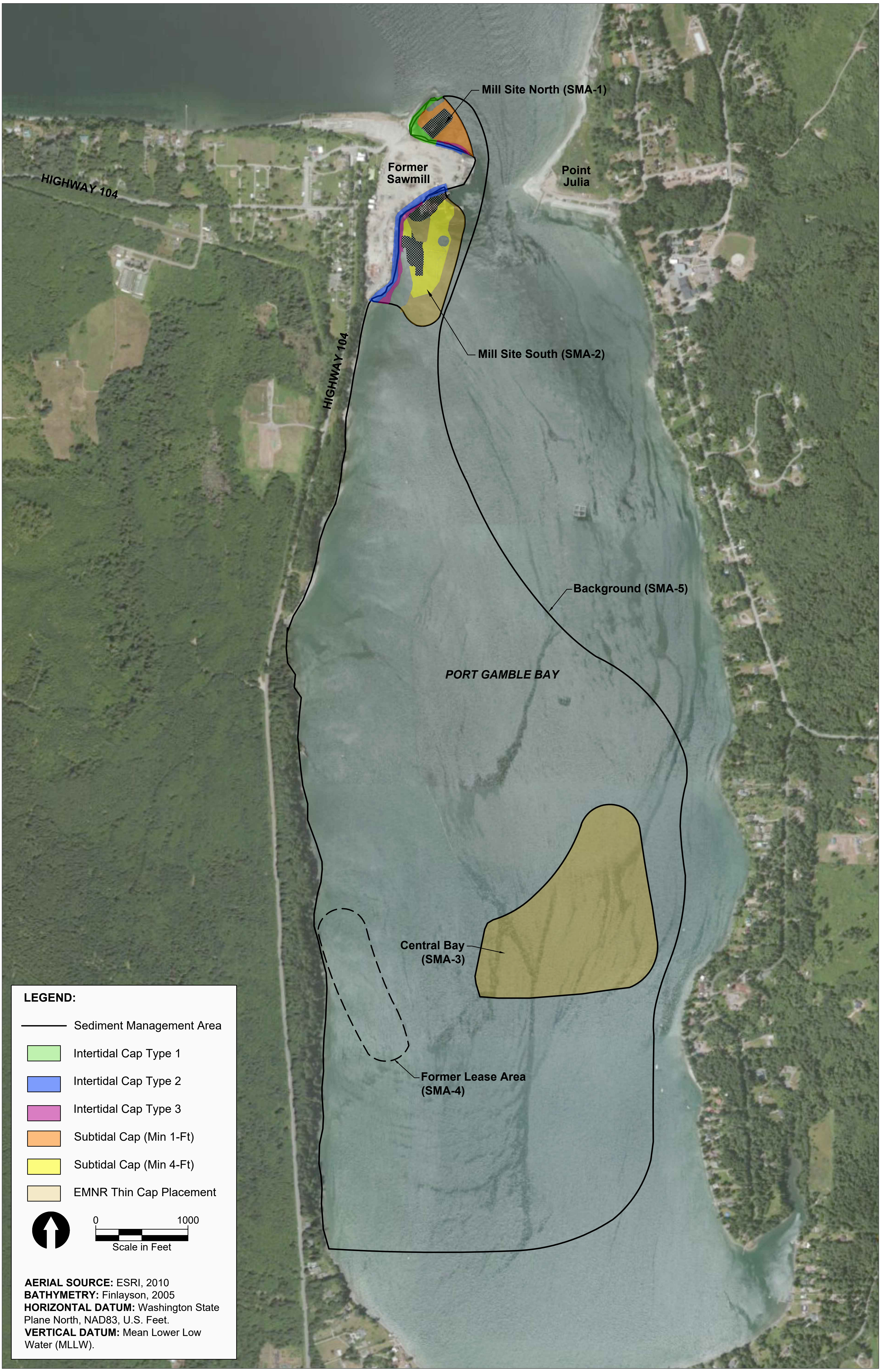
- Eliminate, reduce, or otherwise control to the extent practicable risks to benthic organisms in localized areas of Port Gamble Bay through exposure to sediments or porewater containing deleterious wood debris breakdown products such as hydrogen sulfide (H_2S) that exceed SMS sediment cleanup objective (SCO) biological criteria.
- Eliminate, reduce, or otherwise control to the extent practicable Port Gamble Bay-wide human health risks from ingestion of seafood containing carcinogenic polycyclic aromatic hydrocarbons (cPAHs) as measured by toxicity equivalence (TEQ) exceeding natural background concentrations.
- Eliminate, reduce, or otherwise control to the extent practicable human health risks in localized areas of Port Gamble Bay from ingestion of seafood containing dioxin/furan TEQ and/or cadmium concentrations that exceed natural background concentrations.

Between September 2015 and January 2017, the in-water construction phase of the Port Gamble Bay Cleanup project was successfully completed by PR/OPG (Anchor QEA 2017). Construction activities included the following (Figure 2):

- Removal and off-site disposal of 8,592 decayed piling, nearly all of which were creosote treated; 99.9% of the piling were successfully removed without breaking
- Removal and off-site disposal of 110,000 cubic yards of wood debris and sediment
- Removal and off-site disposal of 1.3 acres of overwater and derelict structures
- Improvement of 3,485 linear feet of shoreline
- Placement of 10 acres of clean engineered caps in sediment management area (SMA)-1 and SMA-2
- Placement of 68 acres of clean EMNR layers in SMA-1, SMA-2, and SMA-3 to manage dredging residuals and reduce sediment toxicity

Post-construction monitoring began in 2018 (Year-1 following completion of construction) as described in the Port Gamble Bay Cleanup Year-1 Post Construction Monitoring Report – 2018 (Anchor QEA 2019a). The 2018 monitoring focused on the SMA-1 and SMA-2 caps and included sediment surveys and sediment quality confirmation monitoring at sentinel and nearshore wood debris cap locations to verify cap integrity and protectiveness. Informed by the Year-1 monitoring, a small area (approximately 0.08 acre) of the upper intertidal SMA-2 cap was proactively repaired in 2018. Sediment bioassays performed at all SMA-1 and SMA-2 engineered cap monitoring stations met the SCO biological standard for the Site in 2018.

The CAP (Ecology 2013) anticipated that source control (e.g., removal of approximately 8,500 decayed creosote-treated piling), along with sediment removal, capping, and EMNR actions as previously summarized, would accelerate natural recovery processes throughout the rest of the 730-acre Site. Specifically, the CAP anticipated that bay-wide surface sediment concentration of chemicals of concern (CoCs), including cPAHs, dioxins/furans, and cadmium, would be reduced to cleanup levels within 10 years following completion of construction (i.e., by approximately 2027). Confirmatory MNR and EMNR sampling to verify bay-wide recovery trends began in 2020, as summarized in this Monitoring Report. The data presented in this Monitoring Report will inform Ecology's forthcoming (2022) 5-year review of the effectiveness of remedial actions at the Site, consistent with MTCA and SMS requirements.



AERIAL SOURCE: ESRI, 2010
BATHYMETRY: Finlayson, 2005
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

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Filepath: K:\Projects\0388-Pope Resources\2020 Long Term Monitoring\0388-RP-003 OMMP-Capping.dwg Figure 2

Figure 2
Capping and EMNR Areas

1.2 Report Organization

Subsequent sections of this Monitoring Report describe the 2020 (Year-3) post-construction monitoring activities and data. The remainder of this Monitoring Report is organized as follows:

- **Section 2 – Cap Surveys and Sampling:** This section describes surveying, inspection, and sediment quality confirmation monitoring activities.
- **Section 3 – Data Quality Assessment:** This section summarizes sediment chemical data quality, including sample completeness, quality control (QC) measures, and data validation.
- **Section 4 – Cap Physical Integrity and Adaptive Management:** This section summarizes surveys to confirm cap integrity as well as implemented adaptive management measures.
- **Section 5 – Sentinel Cap Protectiveness:** This section summarizes chemistry and bioassay data at sentinel monitoring stations to confirm cap protectiveness.
- **Section 6 – Nearshore Wood Debris Cap Protectiveness:** This section summarizes porewater H_2S and bioassay data in nearshore wood debris areas to confirm cap protectiveness.
- **Section 7 – Natural Recovery:** This section summarizes surface sediment and shellfish tissue recovery monitoring data and updated recovery projections.
- **Section 8 – Recommendations:** This section summarizes the recommended scope of future monitoring.
- **Section 9 – References:** This section lists the references cited in this Monitoring Report.

2 Cap Surveys and Sampling

2020 (Year-3) cap monitoring in SMA-1 and SMA-2 included the following:

- Physical integrity performance monitoring (Section 2.1)
- Sediment quality confirmation monitoring at sentinel cap monitoring stations (Section 2.2)
- Sediment quality confirmation monitoring in nearshore capped wood debris areas (Section 2.3)
- Natural recovery sediment quality monitoring (Section 2.4)

Table 1 summarizes sample collection and analyses performed on the surface sediment samples. Field data collection forms are included in Appendix A.

Table 1
2020 Surface Sediment Sampling Coordinates and Analyses

Station ID	SMA Composite or Transect ID	Station Coordinates (Washington NAD83 North Zone)		Analyses			
		Easting	Northing	Site CoCs	H_2S	Larval Bioassay	Full Suite Bioassay
SMA1-ST1	SMA1-ST (Sentinel)	1211456.8	317493.6	X	—	X	—
SMA1-ST2		1211631.6	317616.9				
SMA1-ST3		1211710.4	317374.3				
SMA1-ST4		1211702.8	317283.9				
SMA1-ST5		Not collected					
SMA1A-IT1	SMA1A-IT (Sentinel)	1211539.3	317657.7	X	—	X	—
SMA1A-IT2		1211394.9	317525.6				
SMA1A-IT3		1211361.4	317394.0				
SMA1A-IT4		1211655.6	317219.1				
SMA1A-IT5		Not collected					
SMA2A-IT1	SMA2A-IT (Sentinel)	1211599.9	316644.1	X	—	X	—
SMA2A-IT2		1211401.0	316579.2				
SMA2A-IT3		1211352.9	316503.8				
SMA2A-IT4		1211231.3	316419.2				
SMA2A-IT5		1211186.2	316282.6				
SMA2A-ST1	SMA2A-ST (Sentinel)	1211482.5	316243.8	X	—	X	—
SMA2A-ST2		1211592.3	316373.9				
SMA2A-ST3		1211791.4	316463.9				
SMA2A-ST4		1211512.1	316013.4				
SMA2A-ST5		1211733.8	316185.7				

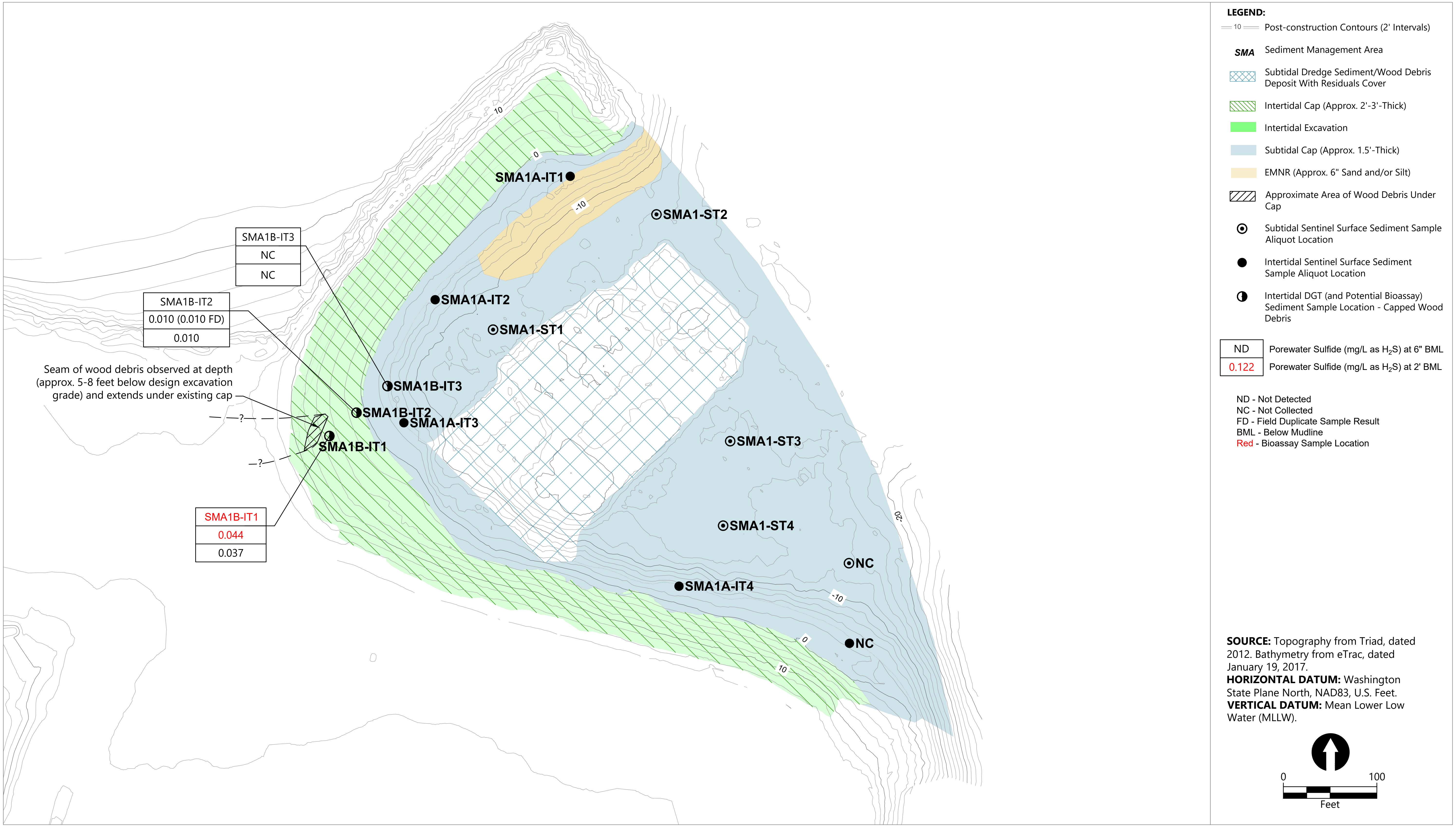
Station ID	SMA Composite or Transect ID	Station Coordinates (Washington NAD83 North Zone)		Analyses			
		Easting	Northing	Site CoCs	H_2S	Larval Bioassay	Full Suite Bioassay
SMA2B-IT1	SMA2B-IT (Sentinel)	1211167.0	316123.3	X	—	X	—
SMA2B-IT2		1211178.5	315958.9				
SMA2B-IT3		1211165.0	315736.2				
SMA2B-IT4		1211114.8	315619.9				
SMA2B-IT5		1211062.9	315501.0				
SMA2B-ST1	SMA2B-ST (Sentinel)	1211304.1	315848.3	X	—	X	—
SMA2B-ST2		1211662.0	315810.1				
SMA2B-ST3		1211511.2	315741.1				
SMA2B-ST4		1211336.2	315446.0				
SMA2B-ST5		1211565.9	315512.3				
SMA1B-IT1-0-6	SMA-1 Transect 1 (Nearshore Cap)	1211281.7	317379.8	—	X	—	X
SMA1B-IT1-24				—	X		
SMA1B-IT2-0-6		1211310.7	317404.8	—	X	—	—
SMA1B-IT2-24				—	X		
SMA1B-IT3-0-6		1211343.9	317433.2	—	—	—	—
SMA1B-IT3-24				—	—		
SMA2C-IT1-0-6	SMA-2 Transect 1 (Nearshore Cap)	1211398.5	316652.6	—	X	—	X
SMA2C-IT1-24				—	X		
SMA2C-IT2-0-6		1211406.1	316640.4	—	X	—	—
SMA2C-IT2-24				—	—		
SMA2C-IT3-0-6		1211412.0	316630.8	—	X	—	—
SMA2C-IT3-24				—	—		
SMA2C-IT4-0-6	SMA-2 Transect 2 (Nearshore Cap)	1211415.6	316663.1	—	X	—	X
SMA2C-IT4-24				—	X		
SMA2C-IT5-0-6		1211423.1	316651.0	—	X	—	—
SMA2C-IT5-24				—	X		
SMA2C-IT6-0-6		1211429.0	316641.3	—	—	—	—
SMA2C-IT6-24				—	X		

Station ID	SMA Composite or Transect ID	Station Coordinates (Washington NAD83 North Zone)		Analyses			
		Easting	Northing	Site CoCs	H_2S	Larval Bioassay	Full Suite Bioassay
SMA2C-IT7-0-6	SMA-2 Transect 3 (Nearshore Cap)	1211432.6	316673.6	—	X	—	X
SMA2C-IT7-24				—	X		
SMA2C-IT8-0-6		1211440.1	316661.5	—	X	—	—
SMA2C-IT8-24				—	X		
SMA2C-IT9-0-6		1211446.0	316651.9	—	—	—	—
SMA2C-IT9-24				—	—		
BW-15	Natural Recovery	1212504.4	308613.1	X	—	X	—
PGSS-77A		1211300.1	314626.1	X	—	—	—
PGSS-70A		1210998.2	313614.8	X	—	—	—
BW-01		1211478.3	312626.5	X	—	—	—
BW-04		1212481.3	310620.2	X	—	—	—
BW-19		1212455.1	307656.7	X	—	—	—
BW-21		1212473.4	305746.4	X	—	—	—
PGSS-29		1210491.7	308615.3	X	—	—	—
PGSS-8		1211002.4	305613.3	X	—	—	—
BW-18		1210994.7	307610.4	X	—	—	—
PGST-1		1211636.5	311079.8	X	—	—	—
PGST-5		1212129.5	309869.5	X	—	—	—

Notes:
CoCs include cPAHs, dioxins/furans, and cadmium.
X: Analysis performed
—: Analysis not performed

2.1 Physical Integrity Surveys

Physical integrity monitoring of SMA-1 and SMA-2 (Figure 2) was conducted in 2020 to verify the continued stability of constructed caps. This monitoring included visual inspection, topographic survey, and high-resolution hydrographic survey (i.e., multi-beam bathymetric survey). Bathymetric and topographic survey data were used to evaluate the cap thicknesses by comparing measured surface elevations (3 years after construction) with as-built conditions immediately following completion of construction. SMA-1 and SMA-2 cap areas are depicted in Figures 3 and 4, respectively.



SOURCE: Topography from Triad, dated 2012. Bathymetry from eTrac, dated January 19, 2017.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

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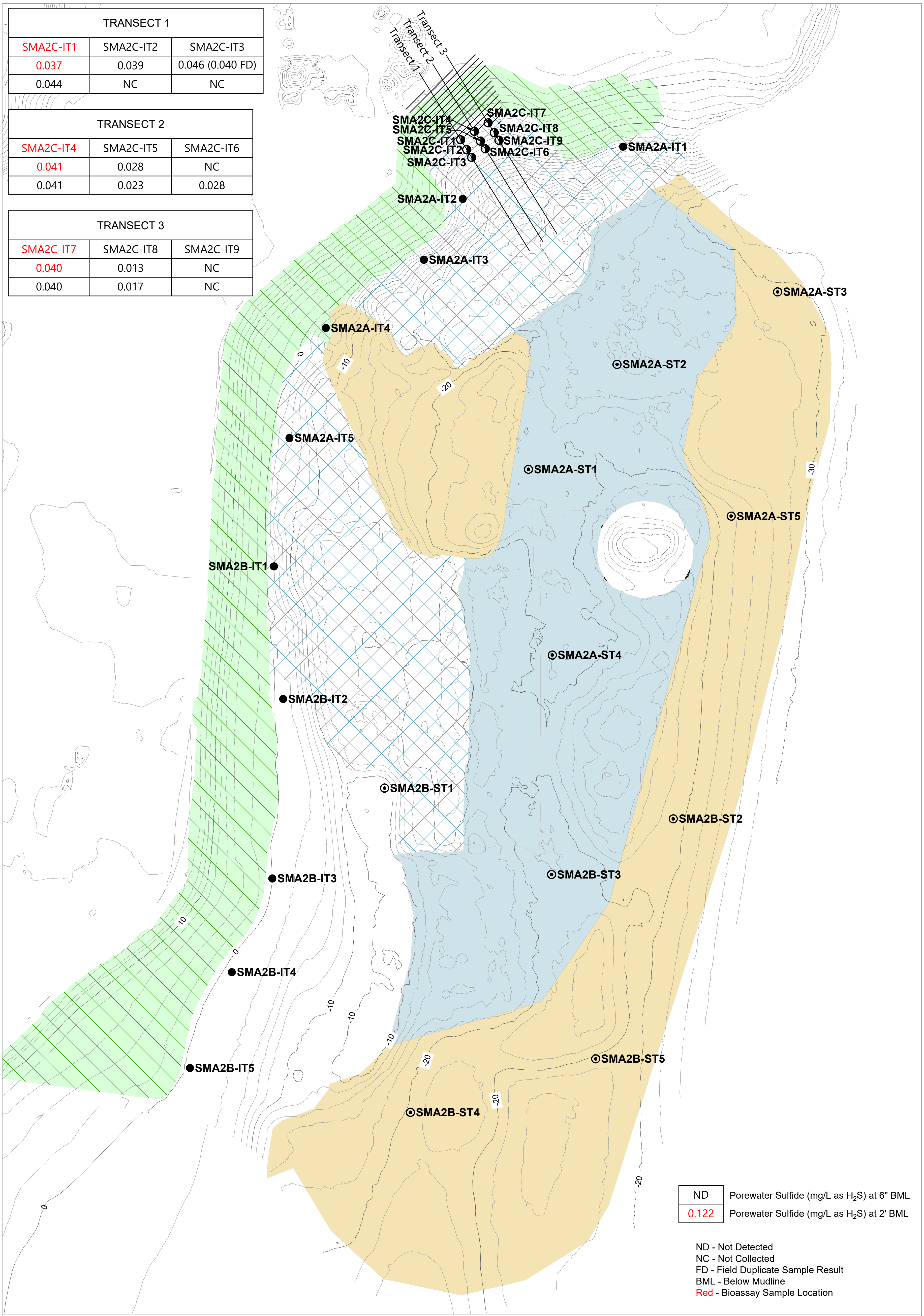
Filepath: K:\Projects\0388-Pope Resources\2020 Long Term Monitoring\0388-RP-004 MAF Porewater XS.dwg Figure 3

Figure 3
SMA-1 Sediment Sampling Stations

2020 Post-Construction Monitoring Report
Port Gamble Bay Cleanup



TRANSECT 1		
SMA2C-IT1	SMA2C-IT2	SMA2C-IT3
0.037	0.039	0.046 (0.040 FD)
0.044	NC	NC

TRANSECT 2		
SMA2C-IT4	SMA2C-IT5	SMA2C-IT6
0.041	0.028	NC
0.041	0.023	0.028

TRANSECT 3		
SMA2C-IT7	SMA2C-IT8	SMA2C-IT9
0.040	0.013	NC
0.040	0.017	NC

ND	Porewater Sulfide (mg/L as H_2S) at 6" BML
0.122	Porewater Sulfide (mg/L as H_2S) at 2' BML

ND - Not Detected
NC - Not Collected
FD - Field Duplicate Sample Result
BML - Below Mudline
Red - Bioassay Sample Location

SOURCE: Topography from Triad, dated 2012. Bathymetry from eTrac, dated January 19, 2017.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

LEGEND:

10	Post-construction Contours (2' Intervals)
SMA	Sediment Management Area
▨	Subtidal Dredge Sediment/ Wood Debris Deposit With Residuals Cover
▨	Intertidal Cap (Approx. 2'-3'-Thick)
🟩	Intertidal Excavation
■	Sand Cap (Approx. 4'-Thick)
■	EMNR (Approx. 6" Sand and/or Silt)
▨	Approximate Area of Wood Debris Under Cap
⊙	Subtidal Sentinel Surface Sediment Sample Aliquot Location
●	Intertidal Sentinel Surface Sediment Sample Aliquot Location
◑	Intertidal DGT (and Potential Bioassay) Sediment Sample Location - Capped Wood Debris

0 120
Feet

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Filepath: K:\Projects\0388-Pope Resources\2020 Long Term Monitoring\0388-RP-004 MAF Porewater XS.dwg Figure 4

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Figure 4
SMA-2 Sediment Sampling Stations
2020 Post-Construction Monitoring Report
Port Gamble Bay Cleanup

Bathymetric and topographic surveys were performed by eTrac using multi-beam survey equipment in subtidal and lower intertidal areas to characterize mudline elevations; light detection and ranging laser scan equipment was used in the upper portions of the intertidal caps. The multi-beam surveys were conducted by a licensed surveyor and met or exceeded the accuracy standards of ±0.2 foot set forth in the OMMP (Anchor QEA 2018a). Topographic surveys of upper intertidal cap areas not included in the bathymetric survey were performed by a licensed surveyor and also met or exceeded the accuracy standards of ±0.1 foot set forth in the OMMP.

Following completion of the bathymetric and topographic surveys, eTrac-licensed surveyors integrated the bathymetric and topographic elevation contours into a single set of elevation contours. These contours were integrated using computer-aided drafting. Isopach comparison of 2017 post-construction versus 2020 (Year 3) cap surface elevations are depicted in Figure 5. While most of the cap areas exhibited net accretion over this 3-year period, localized zones of apparent settlement or erosion were identified. These areas were investigated further during a follow-on low-tide visual inspection as discussed in Section 4.

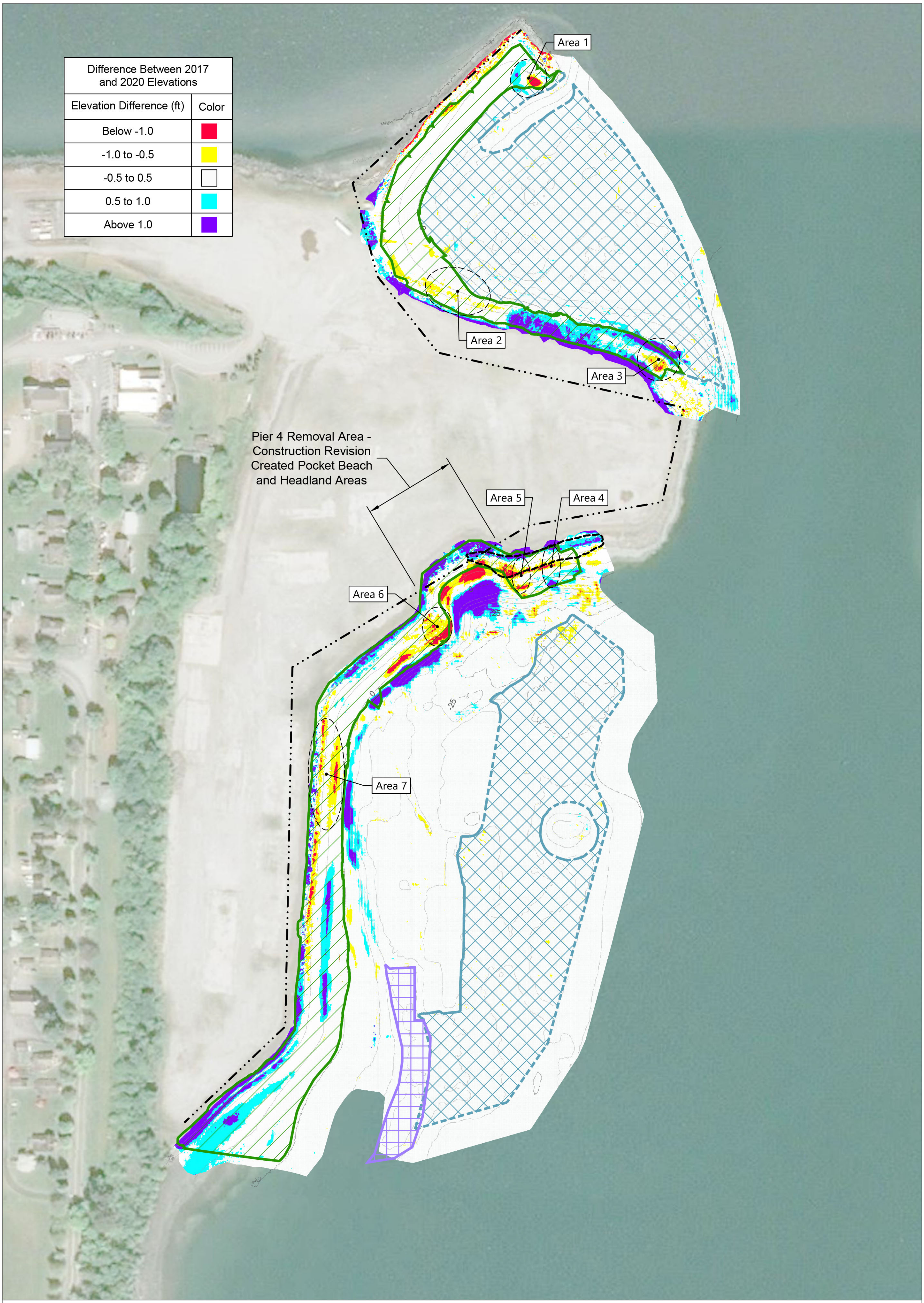
2.2 Sentinel Cap Sampling

Surface sediment quality monitoring was conducted at six sentinel intertidal and subtidal stations in SMA-1 and SMA-2, in accordance with the OMMP (Anchor QEA 2018a). Sampling was conducted in September 2020 during daylight low-tide intertidal sampling windows. Samples were collected using a Van Veen-type hydraulic power grab sampler deployed from a winch line on the Gravity sampling vessel.

SMA-1 intertidal and subtidal sentinel cap monitoring stations comprised a four-point composite, as depicted in Figure 3. While the OMMP targeted five individual composite sample locations for each of these cap areas, one sample from each area (at locations closest to the channel to Port Gamble Bay with relatively high currents) did not contain fine-grained sediment. Only cap armor rock material was recovered during attempts to collect sediment samples at these two locations (Figure 3).

Samples at each SMA-2 intertidal and subtidal sentinel cap monitoring station comprised a five-point composite, as identified in the OMMP and depicted in Figure 4. In addition, a discrete 0- to 10-centimeter (cm) grab sample from location BW-15 within SMA-3 (Figure 6) was collected and submitted for larval bioassay analysis.

Sentinel cap performance monitoring data are presented in Section 5.



Difference Between 2017 and 2020 Elevations	
Elevation Difference (ft)	Color
Below -1.0	🟥
-1.0 to -0.5	🟨
-0.5 to 0.5	☐
0.5 to 1.0	🟦
Above 1.0	🟪

SOURCE: Bathymetry from eTrac, dated January 19, 2017, and June 30, 2020. Aerial from ESRI
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

LEGEND:

- Year 1 Monitoring Survey Contours (5' and 25' Interval)
- Original Designed Shoreline Orientation
- Shoreline Cap Repair Area
- Intertidal Cap (Approx. 2'-3'-Thick)
- Sand Cap (Approx. 4'-Thick)
- Eelgrass Bench

0 200
Feet

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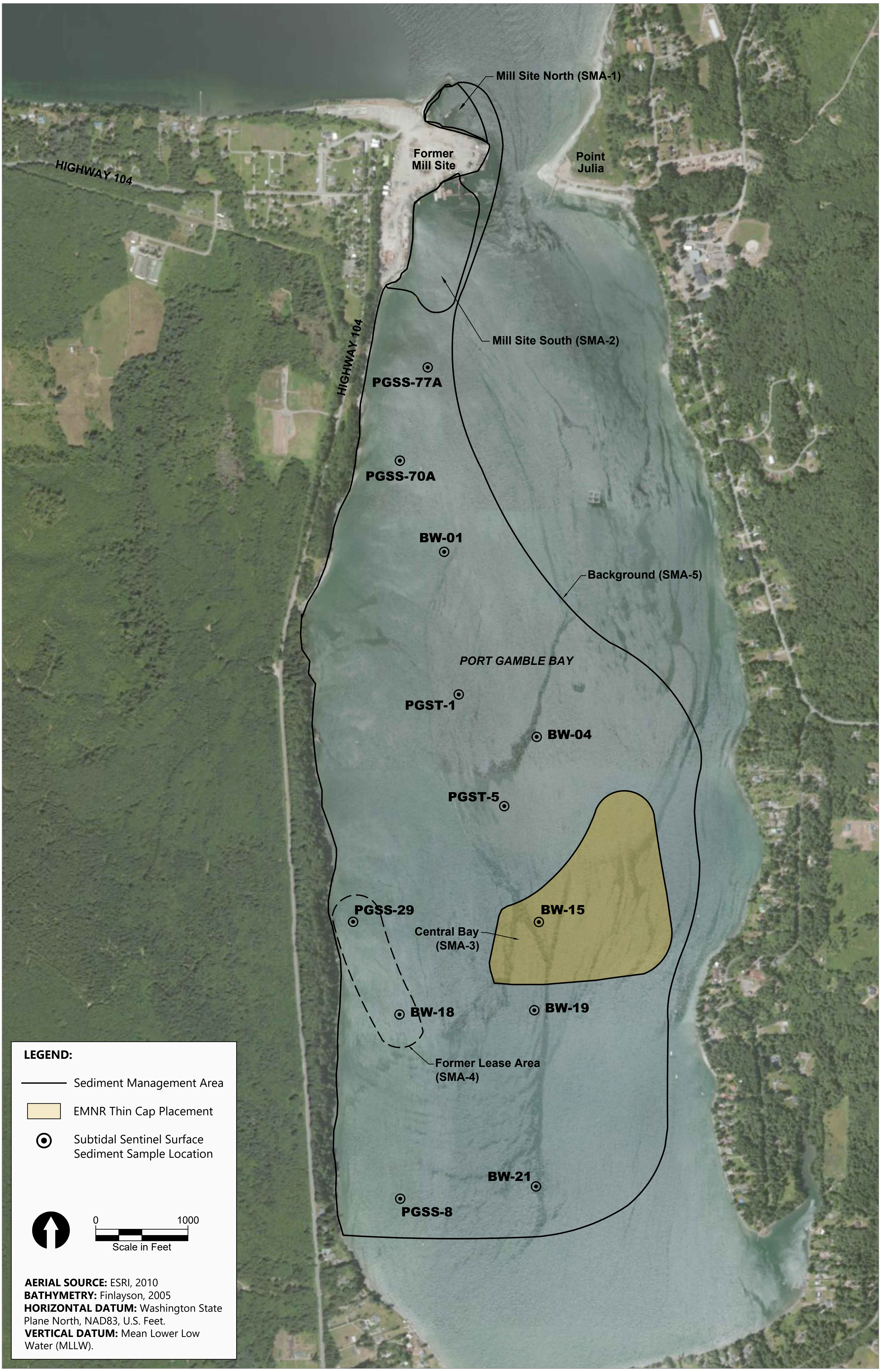
Filepath: K:\Projects\0388-Pope Resources\2020 Long Term Monitoring\0388-RP-005 Post-work Monitoring.dwg Figure 5

ANCHOR QEA

Figure 5
Isopach Comparison - Post-Construction vs. Year-3

2020 Post-Construction Monitoring Report
Port Gamble Bay Cleanup



AERIAL SOURCE: ESRI, 2010
BATHYMETRY: Finlayson, 2005
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

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Filepath: K:\Projects\0388-Pope Resources\2020 Long Term Monitoring\0388-RP-002 Sediment Sampling.dwg Figure 6

Figure 6
Bay-wide Surface Sediment Sampling Stations

2.3 Nearshore Cap Sampling

Surface sediment quality monitoring was conducted within the two areas where nearshore wood debris deposits were capped along the shoreline (i.e., within the North Basin of SMA-1 and the Former Pier 4 Area of SMA-2). Sampling was conducted in September 2020. Nearshore sediment wood debris cap sampling locations are depicted in Figures 3 and 4.

Sediment monitoring in nearshore wood debris cap locations consisted of an initial phase of passive in situ diffusive gradient thin sheet (DGT) monitoring of porewater H_2S concentrations including concurrent temperature, pH, and salinity sampling. Following this initial phase of porewater monitoring, confirmatory surface sediment bioassay samples were collected.

2.3.1 Porewater H_2S Monitoring

DGT probe field deployment consisted of a DGT piston within a plastic spear, so that the DGT could be deployed to the desired depth while the piston was protected within a wire mesh chamber. DGT probes were advanced at two locations (SMA1B-IT1 and SMA1B-IT2) along a single transect in SMA-1 (Figure 3). The third location (SMA1B-IT3) shown in Figure 3 was too deep to successfully deploy the sampler. DGT probes were also deployed at three locations along three parallel transects in SMA-2 (total of nine locations; Figure 4). At each of these 12 DGT sampling locations, probes were installed at 6 and 24 inches below the mudline, for a total of four samples in SMA-1 and 18 samples in SMA-2.

Following a 24-hour deployment period, DGT probes were retrieved from the sediment, and the DGT piston assemblies were removed, rinsed with de-ionized water, and sealed in Mylar bags. As practicable, representative surface sediment (approximately 6 inches below mudline) porewater temperature, pH, and salinity measurements were collected at each DGT sampling location during retrieval of the DGTs. DGT piston assemblies were packaged with ice and shipped to Anchor QEA's environmental geochemistry laboratory in Portland, Oregon, for analysis.

Porewater H_2S concentrations were calculated based on the optical densitometry of the DGT gels and the corresponding temperature, pH, and salinity measurements, using the calibration curves and equations presented in the OMMP (Anchor QEA 2018a). Porewater sulfide monitoring data are presented in Section 6.1.

2.3.2 Surface Sediment Bioassay Sampling

Surface sediment samples for contingent bioassay analyses were collected from each of the probe locations and submitted to EcoAnalysts for archiving, pending the results of the porewater H_2S monitoring described in Section 2.3.1. Bioassays in nearshore capped wood debris areas are presented in Section 6.2.

2.4 Natural Recovery Sampling

Consistent with the OMMP, long-term natural recovery monitoring began approximately 3 years after completion of remedial construction (as part of this 2020 monitoring event). Surface sediment natural recovery sampling was conducted at 12 sentinel sediment monitoring locations throughout the Site: nine located in SMA-5, two in SMA-4, and one in SMA-3 (Figure 6). Samples were collected by Anchor QEA and Gravity using a Van Veen-type hydraulic power grab sampler deployed from a winch line on the Gravity sampling vessel. The sediment samples were collected from the 0- to 2-cm and 2- to 10-cm intervals, homogenized, and submitted for cPAH, dioxin/furan, and cadmium analysis. Surface sediment natural recovery monitoring data are discussed in Section 7.

3 Data Quality Assessment

This section provides information on data quality for sediment analytical data, including field and laboratory QC measures, data validation findings, and completeness.

3.1 Field Data Quality

All samples arrived at the laboratory within temperature requirements. Sufficient volume was provided for laboratory replicates, matrix spike, and matrix spike duplicate samples as required by the OMMP (Anchor QEA 2018a; Appendix B).

3.2 Analytical Data Quality

Data quality objectives and quality assurance procedures are provided in the OMMP (Anchor QEA 2018a). The laboratory data reports are provided in Appendix C, and the data validation report is provided in Appendix D. All data qualifiers applied to the data during final validation have been incorporated into the database for this project. All data are useable as reported or as qualified. Data qualifiers assigned during data validation include the following:

- "J" indicates the associated numerical value is an estimated concentration.
- "U" indicates a reporting limit below which the analyte was not detected.
- "UJ" indicates an approximate reporting limit below which the analyte was not detected.

The validation process resulted in some qualified data based on specified protocols or technical advisories summarized in the data validation reports, including the following:

- Some polycyclic aromatic hydrocarbon (PAH) and dioxin/furan results were detected in the method blanks due to contamination; dioxin/furan results were qualified as non-detect at the level of detection, and PAH results were qualified as non-detect at the laboratory reporting limits.
- Dioxin/furan results with estimated maximum potential concentration "EMPC" qualifiers were converted to "J" qualifiers to indicate potential presence of these compounds.
- Some PAH, cadmium, and dioxin/furan laboratory QC sample results were outside accuracy performance criteria; results were qualified "J" or "UJ" to indicate values are estimated.
- Some dioxin/furan and PAH duplicate results were outside of precision performance criteria; results were qualified "J" to indicate values are estimated.
- Calibration verifications were outside laboratory accuracy performance criteria for some dioxin/furan and PAH compounds; sample results were qualified "J" or "UJ" to indicate values are estimated.
- Eight dioxin/furan results were qualified "J" due to potential matrix interference.
- Some dioxin/furan labeled compound results were outside performance criteria; associated results were qualified "J" to indicate values were estimated.

3.3 Sediment Reference Material

Sediment reference materials were analyzed by ARI to evaluate measurement accuracy and laboratory performance for dioxin/furan, PAH, and cadmium analyses. The Puget Sound Sediment Reference Material was analyzed in association with the dioxin/furan analysis. The Sigma-Aldrich, Inc.-certified reference material (CRM) SQC017-40G was analyzed in association with the PAH analysis, and ERA CRM D106-540 was analyzed in association with the cadmium analysis. Laboratory results for all reference materials were within required acceptance criteria with the following exceptions:

- Two PAH results recovered below the CRM acceptance limits in BII0631-SRM1 and BII0571-SRM1; associated sample results were qualified "J" to indicate that values are estimated.
- For the dioxin/furan analysis, several results recovered above the PS SRM acceptance limits in BII0720-SRM1, BII0852-SRM1, BII0852-SRM2, BII0822-SRM1, and BII0823-SRM1. One result did not recover in BII0720-SRM2. Associated sample results were qualified "UJ" or "J" to indicate that values are estimated.

3.4 Sample Completeness

Data completeness includes collection of required samples in the field and laboratory analysis for target chemicals, as outlined in the OMMP (Anchor QEA 2018a). All target samples were collected and submitted for the full suite of chemical testing.

Laboratory data completeness was measured by percentage of results reported by the analytical laboratory. Data completeness levels were met at 95% for all parameters, consistent with data quality objectives specified in the OMMP (Anchor QEA 2018a).

4 Cap Physical Integrity and Adaptive Management

As discussed in Section 2.1, the isopach comparison of 2017 post-construction versus 2020 (Year 3) cap surface elevations is summarized in Figure 5. While most of the cap areas exhibited net accretion over this 3-year period, localized zones of apparent settlement and/or erosion were identified in seven upper intertidal areas of SMA-1 and SMA-2. Cap conditions in these areas were subsequently further characterized during a low-tide visual inspection performed on July 22, 2020. Following these evaluations, Anchor QEA prepared the *Port Gamble Bay Cleanup Year 3 Cap Integrity Monitoring Memorandum* (Anchor QEA 2020) describing the changes in surface elevation of the caps and providing recommendations for proactive maintenance and repairs for one small area. Sections 4.1 and 4.2 summarize the physical integrity evaluation of the cap and recommendations from the July 22, 2020, memorandum. Section 4.3 summarizes the 2020 cap repairs.

4.1 Physical Integrity Evaluation

The July 22, 2020, low-tide visual inspection revealed that all but one of the areas identified by the isopach survey comparison (Figure 5) were a result of either anticipated deformation of the slope profile consistent with the Ecology-approved remedial design, or anticipated movement of habitat substrate from the upper intertidal area to the lower intertidal area along the profile.

The one area (Area 5) that was not a result of anticipated slope deformation or down-slope migration of habitat substrate was within the upper intertidal cap area of SMA-2, near the former Pier 4. This area was within the footprint of the previous 2018 repair and was approximately 0.05 acre, including the area surrounding the repair where armor was blended/tapered to match the existing surface. The repair area is outlined in Figure 7. A photograph taken of the armor rock movement in the repair area (Area 5) during the low-tide visual inspection on July 22, 2020, is also provided in Figure 7. This area was repaired as described in Section 4.3.

Figure 7
SMA-2 Repair Area 5 and Aerial View of SMA-2 2020 Repair Area

4.2 Intertidal Cap Armor Movement and Prior Repairs

As shown in Figure 7, the shoreline orientation in the former Pier 4 area was changed during construction to facilitate excavation of unanticipated nearshore upland wood debris from that area. The original shoreline design was straight, through the Pier 4 area; the final constructed shoreline resulted in a configuration like a "pocket beach" with two headlands (i.e., corners) on either side of the Pier 4 area.

Armor layers constructed at shoreline bends and corners are generally more exposed than straight shoreline sections. This is due to refraction, which can focus wave energy on the corners. Also, armor rocks placed in corner sections have less lateral support from adjacent armor rocks in the bend (Anchor QEA 2020). For these reasons, headland areas along an armored shoreline are generally more susceptible to wave forces and thus need to be armored with larger rock than straight sections.

The 2018 repairs in this area followed available guidance documents specifying that the rock in these headland areas should be 1.3 to 1.5 times the size determined for a straight section of armored shoreline (Anchor QEA 2020). The armor rock size for the original design in this area had a median diameter of 9 inches; therefore, armor rock recommended to repair this section of the intertidal cap in 2018 was a median diameter of approximately 12 to 14 inches. The initial repair was completed in September 2018 consistent with the *Intertidal Cap Maintenance Recommendations Memorandum – Port Gamble Bay Cleanup* (Anchor QEA 2018b).

Additional cap maintenance repairs in other portions of the upper intertidal slopes were completed in September 2019. The 2019 cap maintenance repairs were completed in accordance with the *Port Gamble Bay Cleanup – Coastal Engineering Evaluation of Shoreline Erosion Memorandum* (Anchor QEA 2019b). The specified rock size for the 2019 repairs was increased from the 2018 recommendations based on the observed movement of cap armor rock. As described in the 2019 memorandum, armor rock size specified for the original cap armor (9 inches) was calculated using the largest predicted 100-year wind speed and a damage control level of "2," which allows for some movement of armor rock under storm events. This calculation (using damage control level 2) results in a smaller armor rock size, for the same input wind speed, than the calculation using a damage control level that allows for no movement of armor rock.

The armor rock size range for the slope repair described in the 2019 memorandum (Anchor QEA 2019b) was calculated using the same methodology and 100-year wind speed as the original cap design, but the damage level was changed to "0." The "0" damage level corresponds to no movement of armor rock under storm events. The stable armor rock size calculated using this methodology for zero movement results in a median diameter of approximately 18 inches. This size range was specified for the armor rock used in the 2019 shoreline maintenance.

4.3 2020 Cap Repair

Minor repairs to the upper intertidal SMA-2 cap (Figure 8) were performed on September 28, 2020, by Seton. Anchor QEA was on site during the repairs, and the work was performed in accordance with the recommendations in the *Port Gamble Bay Cleanup Year 3 Cap Integrity Monitoring Memorandum* (Anchor QEA 2020).

A total of 206 tons of imported armor rock with a median diameter of approximately 18 inches was placed within the repaired area. The armor rock was tapered down to a single layer at the edges of the repair area to avoid constructing an abrupt edge between the repair section and existing armored cap. The repair area was regraded as closely as possible to a 3:1 (horizontal to vertical) slope. Figure 8 presents a photograph of the repaired SMA-2 cap area.

Figure 8
Repaired SMA-2 Intertidal Cap

5 Sentinel Cap Protectiveness

Sentinel cap confirmation monitoring sampling was conducted from September 9 to 11, 2020, following the methods described in Section 2.2. Surface sediment/cap samples were submitted to EcoAnalysts for biological testing (larval bioassay) and ARI for analyses of Site COCs. The bioassay and chemical monitoring results are summarized in Sections 5.1 and 5.2, respectively.

5.1 Larval Bioassays

Biological testing data for surface sediment/cap samples collected from the six sentinel (intertidal and subtidal) stations in SMA-1 and SMA-2, as well as the subtidal sample collected from SMA-3, were evaluated using SMS biological criteria. The SMS bioassay evaluation uses statistical and numerical comparisons between each sediment sample and a matched reference sample. While two comparisons are identified in the SMS regulation (i.e., SCO and cleanup screening level), the SCO biological criterion is the site-specific cleanup standard for the Site. The full EcoAnalysts bioassay testing report is included as Appendix E. Table 2 summarizes larval bioassay results.

Table 2
Summary of Larval Bioassay Results

Composite Sample ID	Sediment Cleanup Objective	Cleanup Screening Level
BW-15-0-10-200908	Pass[1]	Pass
SMA1A-IT-0-10-COMP-200910	Pass	Pass
SMA1-ST-0-10-COMP-200910	Fail	Pass
SMA2A-IT-0-10-COMP-200911	Pass	Pass
SMA2A-ST-0-10-COMP-200910	Pass	Pass
SMA2B-IT-0-10-COMP-200910	Pass	Pass
SMA2B-ST-0-10-COMP-200911	Pass	Pass

Notes:
1: While this sample fails when compared with Carr Ref 12, it passes when compared to Carr Ref 52. Because both Carr Inlet reference samples are valid for comparison, this sample passes the SCO biological criterion.

Bioassay results met the SCO cleanup standard for each of the sentinel stations except for the SMA-1 subtidal composite sample (SMA1-ST-0-10-COMP-200910). Thus, SCO biological criteria are being maintained on the SMA-1 and SMA-2 intertidal caps, on the SMA-2 subtidal cap, and in the SMA-3 EMNR area.

The SCO biological criterion for the larval bioassay is a normal survivorship of 85% of Carr Inlet reference (Carr Ref) samples. The SMA-1 subtidal sample larval bioassay had a normal survivorship of 84% of the Carr Ref 52 reference, and thus marginally failed the SCO biological criterion. The SMA-1 subtidal sample had relatively low chemical concentrations (Appendix F) and did not contain visible organic materials. During the prior (2018) OMMP monitoring, the SMA-1 subtidal sample larval bioassay passed the SCO biological criterion. Consistent with similar confounding larval bioassay results at other Puget Sound areas such as Port Angeles Harbor (Floyd|Snider et al. 2020), it is likely that the 2020 SMA-1 subtidal bioassay result represents a potentially natural condition unrelated to Site releases. A follow-on confirmatory larval bioassay will be performed at this station in 2021 to verify protectiveness (Section 8).

5.2 Chemical Analyses

Composite samples from each of the six sentinel locations were analyzed for CoCs including cPAHs, dioxins/furans, and cadmium. Chemical analysis results from sentinel sediment sample locations are summarized in Appendix F; the complete analytical report is included in Appendix C.

As discussed in the CAP (Ecology 2013) and OMMP (Anchor QEA 2018a), surface sediment cleanup levels are targeted to be achieved approximately 10 years after completion of remedial construction. Because construction was completed in 2017, cleanup standards are targeted to be achieved by approximately 2027. The point of compliance for Site human health CoCs including cPAH TEQ, dioxin/furan TEQ, and cadmium is the surface-weighted average concentration (SWAC) over all subtidal areas of the Site (730 acres, including all SMAs; Figure 2) across the 0- to 10-cm depth interval. The SWAC has been updated and evaluated as part of this Monitoring Report, as discussed in Section 7.

6 Nearshore Wood Debris Cap Protectiveness

Sediment quality confirmation sampling of nearshore capped wood debris areas was conducted from September 23 to 24, 2020, following the methods described in Section 2.3. Samples were submitted to the Anchor QEA geochemical laboratory for porewater H_2S analyses, and to EcoAnalysts for biological testing (i.e., larval, polychaete, and amphipod bioassay analysis). Chemical and bioassay results are summarized in Sections 6.1 and 6.2, respectively.

6.1 Porewater H_2S Concentrations

Porewater H_2S measurements are summarized in Table 3. None of the surface (6-inch depth) or subsurface (24-inch depth) porewater H_2S sample concentrations exceeded the 0.07 milligram per liter (mg/L) risk-based benchmark discussed in the OMMP (Anchor QEA 2018a).

Table 3
Porewater Sulfide Diffusive Gradient Thin Sheet Data

Sample ID	Transect	pH (SU)	Temperature (°F)	Salinity (ppt)	Porewater H_2S (mg/L)	Bioassay Analysis
SMA1B-IT1-0-6-200924	SMA-1 Transect 1	6.64	13.5	0.22	**0.044**	Yes
SMA1B-IT1-24-200924					**0.037**	
SMA1B-IT2-0-6-200924		7.55	13.7	>2.6[1]	0.010	No
SMA1B-IT102-0-6-200924					0.010	
SMA1B-IT2-24-200924					0.010	
SMA2C-IT1-0-6-200924	SMA-2 Transect 1	6.66	14.0	0.12	**0.037**	Yes
SMA2C-IT1-24-200924					**0.044**	
SMA2C-IT2-0-6-200924		6.81	13.7	0.44	0.039	No
SMA2C-IT3-0-6-200924		6.74	13.8	>2.6[1]	0.046	No
SMA2C-IT103-0-6-200924					0.040	
SMA2C-IT4-0-6-200924	SMA-2 Transect 2	6.41	13.9	0.17	**0.041**	Yes
SMA2C-IT4-24-200924					**0.041**	
SMA2C-IT5-0-6-200924		7.01	13.4	>2.6[1]	0.028	No
SMA2C-IT5-24-200924					0.023	
SMA2C-IT6-24-200924		6.71	13.6	>2.6[1]	0.028	No
SMA2C-IT7-0-6-200924	SMA-2 Transect 3	6.50	13.8	0.16	**0.040**	Yes
SMA2C-IT7-24-200924					**0.040**	
SMA2C-IT8-0-6-200924		7.39	13.4	0.22	0.013	
SMA2C-IT8-24-200924					0.017	No

Notes:
Bold indicates triggered bioassay sample.
1. Sampling locations were likely influenced by overlying seawater.

6.2 Larval, Polychaete, and Amphipod Bioassays

Because none of the porewater H_2S samples exceeded the 0.07 mg/L risk-based benchmark, consistent with the OMMP (Anchor QEA 2018a) and as approved by Ecology, the transect samples with the lowest porewater salinity levels were submitted for confirmatory bioassays (Table 3). Sediment bioassay data were reviewed using SMS evaluation criteria as described in Section 5.1. The complete bioassay testing report is included as Appendix E.

Table 4 summarizes the bioassay results for the nearshore wood debris cap confirmation monitoring. All bioassay results met SCO biological criteria. The bioassay analyses confirmed that cleanup standards are being maintained in the nearshore areas of capped wood debris.

Table 4
Nearshore Wood Debris Cap Confirmation Monitoring – Bioassay Summary

	Sediment Cleanup Objective			Cleanup Screening Level		
Sample ID	**Amphipod**	**Polychaete**	**Larval**	**Amphipod**	**Polychaete**	**Larval**
SMA1B-IT1-0-10-200924	Pass	Pass	Pass	Pass	Pass	Pass
SMA2C-IT1-0-10-200924	Pass	Pass	Pass	Pass	Pass	Pass
SMA2C-IT4-0-10-200924	Pass	Pass	Pass	Pass	Pass	Pass
SMA2C-IT7-0-10-200924	Pass	Pass	Pass	Pass	Pass	Pass

7 Natural Recovery

This section summarizes surface sediment natural recovery monitoring data collected through 2020 and shellfish tissue monitoring data collected through 2017.

7.1 Surface Sediment

Surface sediment natural recovery confirmation monitoring sampling was conducted from September 9 to 11, 2020, following the methods described in Section 2.4. Surface sediment samples were submitted to ARI for analyses of Site CoCs. Samples from each of the 12 sentinel sediment monitoring locations (Figure 6) were analyzed for CoCs including cPAHs, dioxins/furans, and cadmium. Validated chemical analysis results from sentinel sediment sample locations are summarized in Appendix F; the complete analytical report is included in Appendix C.

As discussed in Section 5.2, the surface sediment point of compliance for Site human health CoCs including cPAH TEQ, dioxin/furan TEQ, and cadmium is the 0- to 10-cm depth SWAC over all subtidal areas of the Site (730 acres, including all SMAs; Figure 2). Using the subtidal sentinel monitoring data collected across the Site, 2020 SWACs and standard errors are summarized in Table 5. SWACs and standard errors from earlier sampling—2008 to 2011 (remedial investigation; Ecology 2012) and 2014 (pre-design investigation; Anchor QEA 2018a)—are also summarized in Table 5.

Table 5
Surface Sediment 0- to 10-cm SWAC Summary

Site CoC (units)	Cleanup Standard	2008–2011 Remedial Investigation SWAC[1]	2014 Pre-Design Investigation SWAC[1]	2020 Post-Construction SWAC[1]
Cadmium (mg/kg)	3	1.4 ±0.3	1.8 ±0.4	1.2 ±0.3
cPAH TEQ (µg/kg)	16	42 ±13	26 ±7	40 ±6
Dioxin/Furan TEQ (ng/kg)	5	3.0 ±1.1	4.6 ±0.6	4.3 ±0.9

Notes:
1. SWAC ± standard error over all subtidal areas of the Site (730 acres).

The 2020 SWACs for cadmium and dioxin/furan TEQ have remained below cleanup levels, consistent with earlier remedial investigation and pre-design investigation data (Table 5). Thus, the 2020 data confirm the protectiveness of the Site cleanup action for these CoCs.

The 2020 SWAC for cPAHs (40 ±6 µg/kg TEQ) is significantly greater than the 2014 SWAC (26 ±7 µg/kg TEQ), and approximately 2.5 times higher than the 16 µg/kg TEQ natural background cleanup standard set forth in the CAP (Ecology 2013). Moreover, the measured 2020 SWAC for cPAH is approximately 21 ±7 µg/kg TEQ greater than pre-design modeling projections for 2020 summarized in the OMMP (Anchor QEA 2018a).

The lowest surface sediment cPAH concentrations measured in 2020 were in subtidal cap and EMNR areas of SMA-1 and SMA-2, averaging 14 ±3 µg/kg TEQ in 2020 (Appendix F). These data reveal that ongoing sources of cPAHs from the Mill Site are not contributing to currently elevated surface sediment cPAH concentrations at the Site. Compared with 2014 concentrations, surface sediment cPAH concentrations were elevated across the rest of the Site (i.e., throughout SMA-3 to SMA-5), particularly in the 0- to 2-cm surface interval indicative of a recent construction-related release.

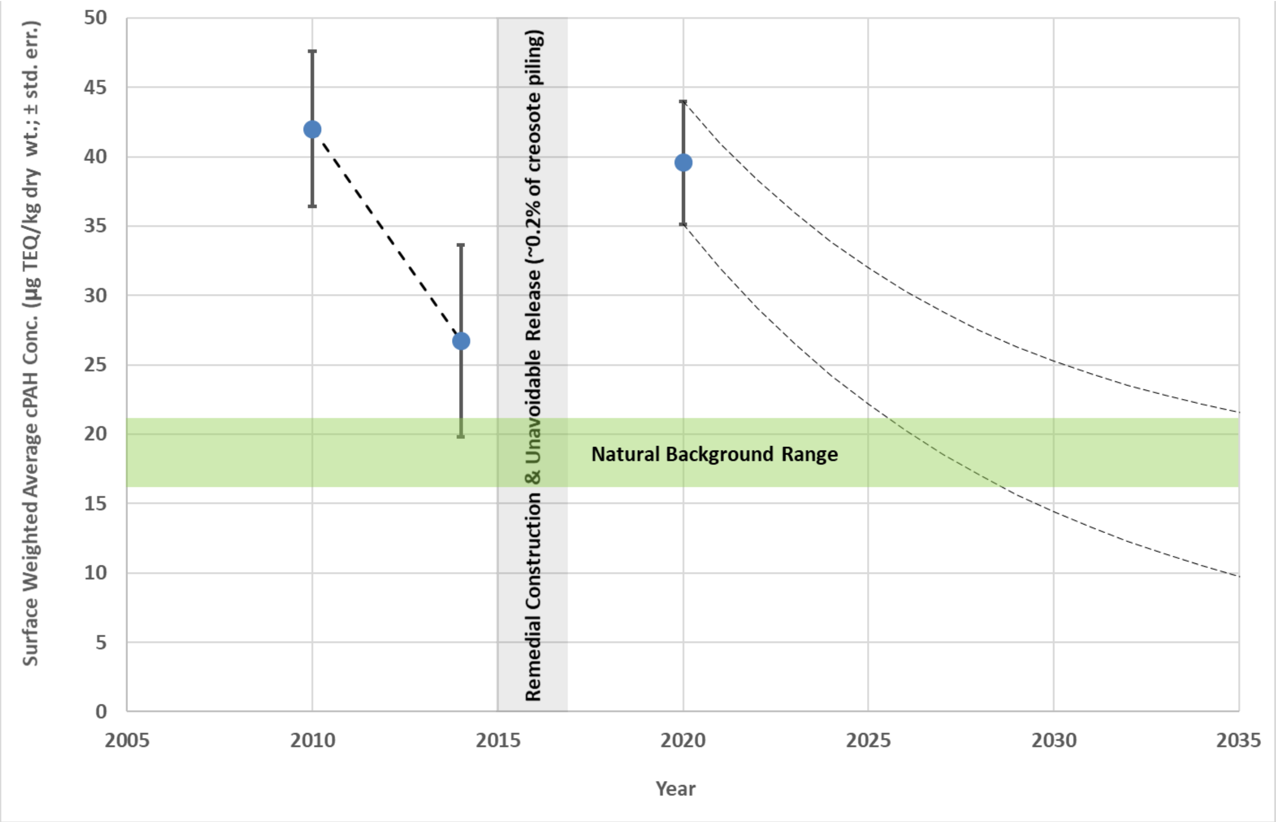
The OMMP modeling projections accounted for anticipated sediment dredging residuals consistent with current industry understanding (e.g., an unavoidable release of 2% to 10% of the dredged cPAH mass; Anchor QEA 2018a, Patmont et al. 2018). However, the OMMP projections did not address cPAHs released from creosote piling removal, as release estimates from piling removal have not been reported in the scientific literature. To assess the potential for cPAH releases, the mass of cPAH TEQ in creosote piling removed from the Site between 2015 and 2017 was calculated as follows:

- 8,500 creosote piling removed (Anchor QEA 2017)
- Average creosote pile volume = 64 cubic feet (Ecology and DOH 2012)
- Average creosote pile dry density = 0.19 gram per cubic centimeter (Parametrix 2011)
- Average creosote pile cPAH concentration = 540 mg/kg TEQ dry weight (Parametrix 2011)
- Calculated creosote pile cPAH mass removed = 1,600 kilograms TEQ

In comparison, using measured sediment density data, the apparent Site surface sediment (0- to 10-cm) cPAH SWAC increase of approximately 21 ±7 µg/kg TEQ (compared to OMMP model projections; Anchor QEA 2018a) equates to a calculated cPAH mass increase of approximately 4 ±1 kilograms TEQ. Thus, release of roughly 0.2% (4 ÷ 1,600) of the creosote pile cPAH mass removed would account for the observed increase in the 2020 SWAC (Table 5). Based on these calculations, the surface sediment cPAH concentration increase measured at the Site in 2020 is reasonably attributable to small and likely unavoidable cPAH releases from piling removal operations.

Using the same recovery modeling approach described in the OMMP (Anchor QEA 2018a), projected declines in the cPAH SWAC moving forward are summarized in Figure 9. Because observed recovery of the cPAH SWAC from data collected between 2008 and 2011 to data collected in 2014 declined faster than model projections, it is likely that cPAH recovery moving forward may also occur more rapidly than the conservative OMMP model projections depicted in Figure 9.

Figure 9
Observed and Projected Surface Sediment cPAH Recovery, Port Gamble Bay



Ecology's recent update of the Puget Sound natural background sediment cPAH concentration to 21 µg/kg TEQ (Ecology 2019), higher than the 16 µg/kg TEQ standard set forth in the CAP (Ecology 2013), is also depicted in Figure 9.

Based on the weight-of-evidence, it is probable—though still uncertain—that the site-wide cPAH SWAC will recover to natural background levels by approximately 2027 (10 years after completion of remedial construction). The next round of site-wide natural recovery monitoring to refine the recovery trend is scheduled for 2025 (Section 8).

7.2 Shellfish Tissue

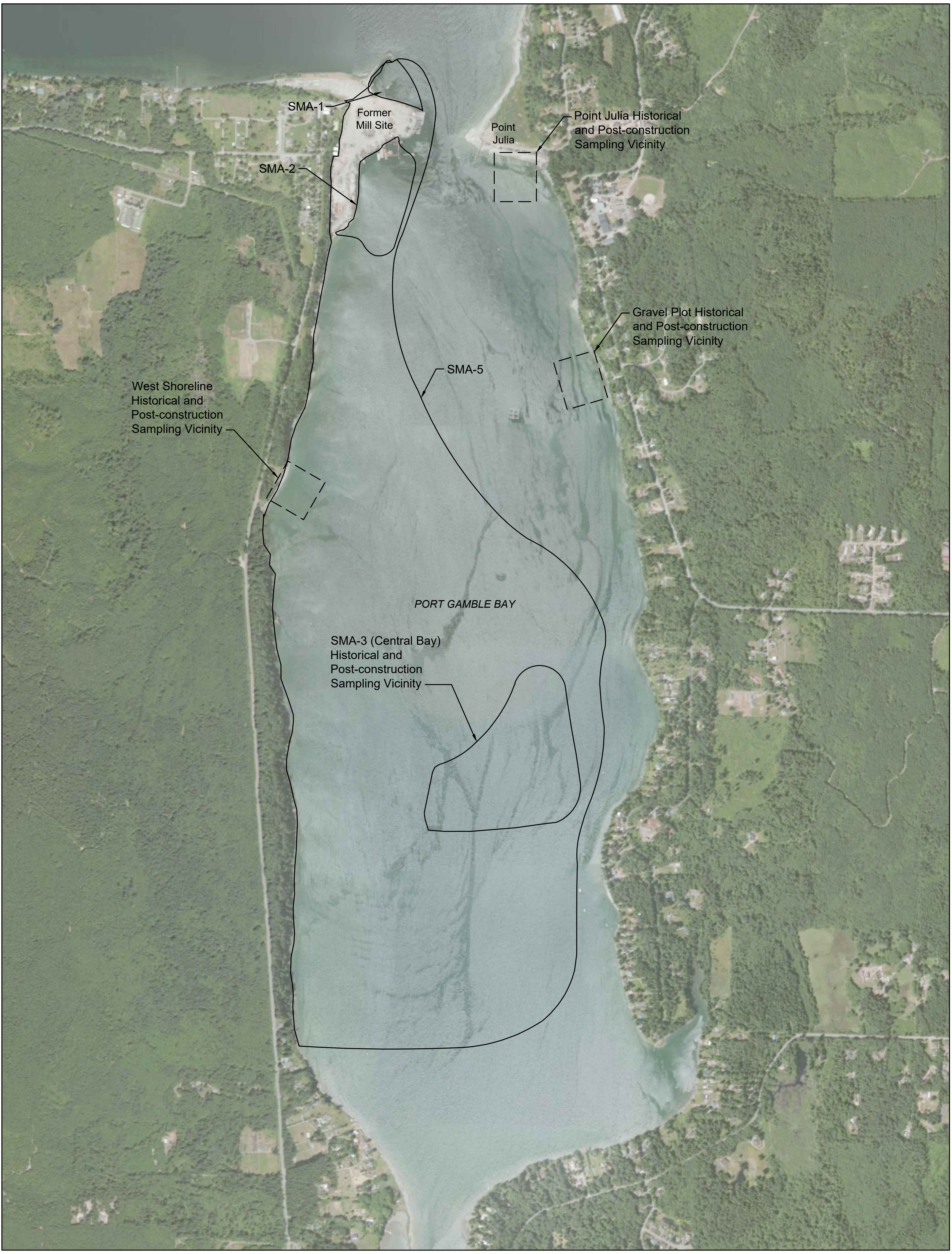
As summarized in Section 1.1, the stated objective of cPAH cleanup (source control and sediment remediation) actions set forth in the CAP (Ecology 2013) was to "*eliminate, reduce, or otherwise control to the extent practicable Port Gamble Bay-wide human health risks from ingestion of seafood containing cPAHs as measured by TEQ exceeding natural background concentrations.*" The CAP hypothesized that reducing the subtidal surface sediment cPAH concentration to natural background levels would likely proportionately reduce site-wide tissue ingestion exposures to background levels, though no quantitative site-specific evaluation was performed at the time of the CAP as currently recommended in SMS guidance (Ecology 2019).

While not an Ecology-required element of the Port Gamble Bay sediment cleanup project, in situ shellfish monitoring was performed shortly after completion of in-water construction activities (Anchor QEA and Port Gamble S'Klallam Tribe 2017). Shellfish monitoring was performed in accordance with the *Shellfish Monitoring Plan Port Gamble Bay Cleanup Project* (SMP; Anchor QEA and the Port Gamble S'Klallam Tribe 2015) as required under the Clean Water Act permit (NWS-2013-1270). Baseline shellfish monitoring locations and target species previously sampled by the Port Gamble S'Klallam Tribe between 2008 and 2012, and analyzed for CoCs by Ecology, were resampled in 2017 to provide an updated characterization of in situ shellfish tissue concentrations in Port Gamble Bay.

Post-construction shellfish sampling was performed by the Port Gamble S'Klallam Tribe in April 2017 at the four primary shellfish harvesting areas throughout Port Gamble Bay (i.e., Point Julia, Gravel Pit, and Western Shoreline intertidal areas; and subtidal areas near SMA-3; Figure 10). Shellfish sampled included cockles, Dungeness crabs, geoducks, Horse clams, Littleneck clams, Manila clams, and oysters. CoCs measured in the 2017 shellfish tissue samples included PAHs, cadmium, dioxins/furans, and polychlorinated biphenyls.

Consistent with data compiled by Ecology to inform the CAP (Ecology 2013), post-construction Port Gamble Bay shellfish tissue CoC concentrations were evaluated relative to several reference levels to provide context for data comparisons. Reference levels included pre-construction baseline (2008 to 2012) levels measured in Port Gamble Bay, as well as regional shellfish tissue levels reported in natural background, non-urban shellfish protection and harvest districts in the greater Puget Sound region. Data sources compiled for the regional non-urban comparison included the following (Anchor QEA and Port Gamble S'Klallam Tribe 2017):

- Natural background shellfish tissue concentrations reported in the Port Gamble Bay remedial investigation
- Non-urban bivalve (clams, mussels, and oysters) as well as crab/fish tissue concentrations in other relatively pristine areas of Puget Sound, including Freshwater Bay (Strait of Juan de Fuca)
- Non-urban bivalve tissue concentrations in the Holmes Harbor shellfish protection and harvest district



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Aug 03, 2017 12:23pm chewett

HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.

NOTES:

1. For in situ wild shellfish sampling, historical sampling areas were reoccupied and target species collected consisted of those previously sampled.

LEGEND:

— SMA Area

[ ] Wild Shellfish Sampling Area

0 1200

Scale in Feet

Figure 10

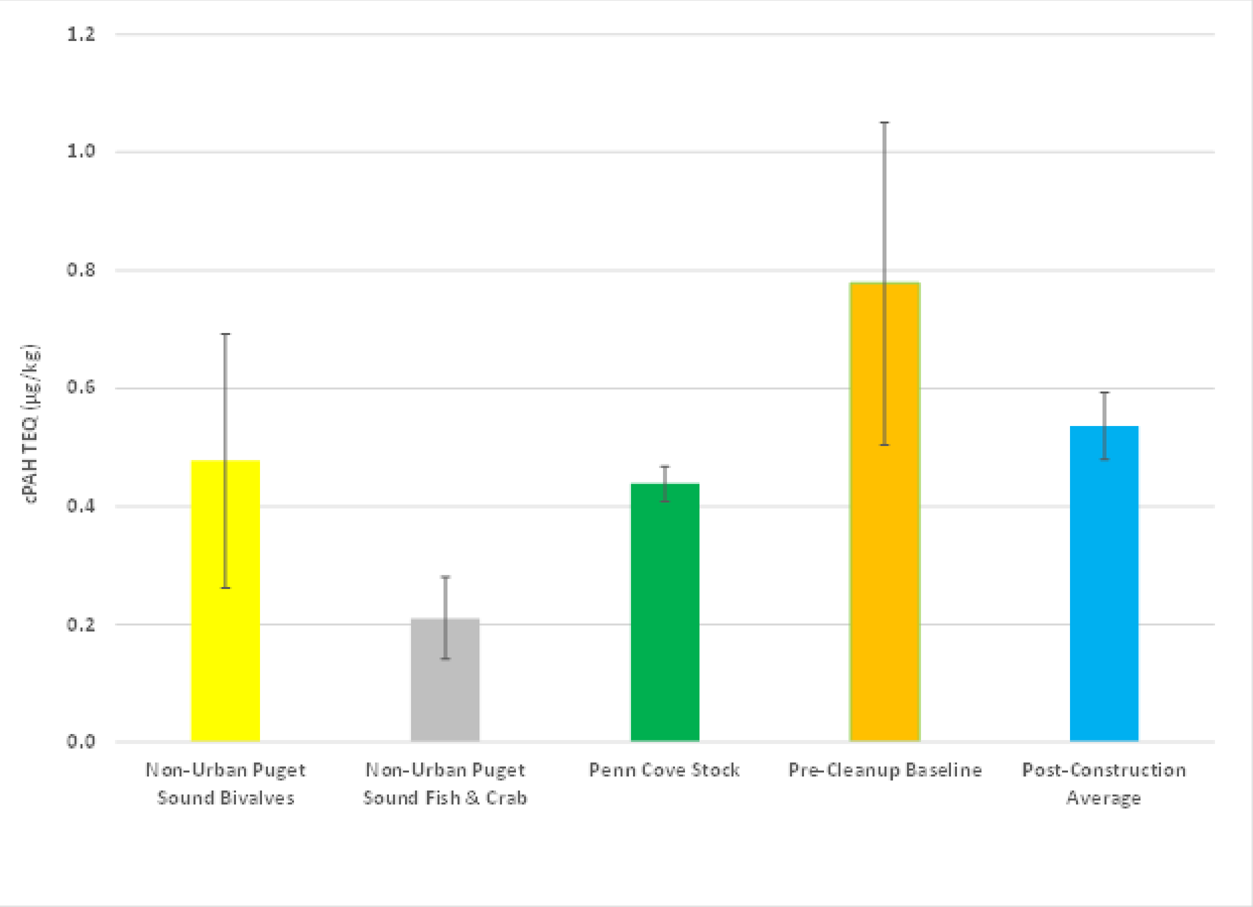
In Situ Shellfish Monitoring Areas

2020 Post-Construction Monitoring Report

Port Gamble Bay Cleanup Project

Importantly, 2017 post-construction concentrations of all CoCs in Port Gamble Bay shellfish were within the range of natural background non-urban Puget Sound bivalve levels. Tissue cPAH TEQ levels were also lower than pre-construction baseline (Figure 11). Thus, the 2017 shellfish data suggest that the human health risk reduction objectives of Port Gamble Bay cleanup actions (Ecology 2013) were successfully achieved shortly following completion of construction for all CoCs, including cPAH TEQ.

Figure 11
Pre- and Post-Construction Shellfish Tissue cPAH Concentrations, Port Gamble Bay



8 Recommendations

The 2020 (Year-3) post-construction monitoring, and adaptive management actions summarized in the preceding sections continue to verify that Port Gamble Bay cleanup actions implemented from 2015 to 2017 have either achieved, or are on track to achieve, cleanup standards and associated remedial action objectives set forth in the CAP (Ecology 2013). Informed by these data, the recommended scope of future OMMP monitoring at the Site in 2021 and 2025 includes the following:

- Year 2021:
  - As discussed in Section 7.2, to further verify that human health risk reduction objectives set forth in the CAP (Ecology 2013) have been achieved, in spring 2021 a follow-on round of in situ shellfish tissue monitoring[1] will be performed at the four SMP sampling areas depicted in Figure 10 using SMP procedures (Anchor QEA and the Port Gamble S'Klallam Tribe 2015). Because the other CoCs have already achieved background-based sediment and tissue cleanup objectives, 2021 tissue monitoring will focus solely on cPAHs.
  - As discussed in Section 5.1, to further verify the protectiveness of the SMA-1 subtidal cap, in September 2021 a surface sediment composite sample will be collected from station SMA1-ST, as well as at matched Carr Inlet reference station(s) for confirmatory larval bioassay testing using OMMP procedures (Anchor QEA 2018a).
- Year 2025:
  - To continue to verify cap integrity and protectiveness, in summer 2025 a follow-on round of monitoring will be performed using OMMP procedures (Anchor QEA 2018b) including the following:
    - Physical integrity monitoring and adaptive management (as necessary) in SMA-1 and SMA-2.
    - Surface sediment chemistry confirmation monitoring of subtidal areas of SMA-1 (one composite sample), SMA-2 (two composite samples), and SMA-3 to SMA-5 (12 discrete samples). Because the other CoCs have already achieved background-based sediment and tissue cleanup objectives, 2025 surface sediment CoC monitoring will focus solely on cPAHs.

Sampling and analysis in 2021 will be implemented following stakeholder review and Ecology approval of this Monitoring Report.

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[1] Consistent with SMS guidance (Ecology 2019; Section 13.6.2), comparison of tissue cPAH TEQ with natural background levels may be used in a weight-of-evidence approach to evaluate compliance with the surface sediment cleanup standard for cPAH TEQ (WAC 173-204-500[4][e], 173-204-560[6][b]). Based on the 2021 tissue monitoring, any proposed changes to the compliance evaluation would be described in a revised OMMP and provided for stakeholder review and public notice as part of Ecology's 5-Year review of the Port Gamble Bay cleanup remedy, scheduled for 2022.

9 References

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Anchor QEA, 2019b. *Port Gamble Bay Cleanup Project – Coastal Engineering Evaluation of Shoreline Erosion Memorandum*. Prepared for Pope Resources, LP/OPG Properties, LLC. August 2019.

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Appendix A

Field Data

ANCHOR QEA

DATE: 9/8/20

PROJECT NAME: Port Gamble OMMP LTM

PROJECT NO: 200388-01.01

DAILY SAFETY BRIEFING

PERSON CONDUCTING MEETING: C. OREIRO

HEALTH & SAFETY OFFICER: D. TEMPLETON

PROJECT MANAGER: J. CORNETTA

TOPICS COVERED:

- ☑ Emergency Procedures and Evacuation Route
- ☑ Directions to Hospital
- ☑ HASP Review and Location
- ☑ Safety Equipment Location
- ☐ Proper Safety Equipment Use
- ☐ Employee Right-to-Know/MSDS Location
- ☑ Fire Extinguisher Location
- ☑ Eye Wash Station Location
- ☐ Buddy System
- ☑ Self and Coworker Monitoring
- ☑ Lines of Authority
- ☑ Communication
- ☐ Site Security
- ☑ Vessel Safety Protocols
- ☑ Work Zones
- ☐ Vehicle Safety and Driving/Road Conditions
- ☐ Equipment Safety and Operation
- ☑ Proper Use of PPE
- ☑ Decontamination Procedures
- ☐ Other:
- ☐ Lifting Techniques
- ☑ Slips, Trips, and Falls
- ☑ Hazard Exposure Routes
- ☑ Heat and Cold Stress
- ☑ Overhead and Underfoot Hazards
- ☐ Chemical Hazards
- ☐ Flammable Hazards
- ☐ Biological Hazards
- ☑ Eating/Drinking/Smoking

WEATHER CONDITIONS: sunny, smoky

DAILY WORK SCOPE: grab sampling

SITE-SPECIFIC HAZARDS: slips, trips, + falls

SAFETY COMMENTS: Stay hydrated

ATTENDEES

PRINTED NAME	SIGNATURE
C. OREIRO	
M. Bee	Meredith B
E SLOAN	
R Trudeau	
	CO 9/8/20

Daily Log

ANCHOR QEA

Anchor QEA L.L.C.
1201 3rd Avenue, Suite 2600
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

PROJECT NAME: PG OMMP Long Term Monitoring
DATE: 9/8/20
SITE ADDRESS: Port Gamble, WA
PERSONNEL: QO, MB

WEATHER: **WIND FROM:** N | NE | E | SE | S | SW | W | NW — [✓ LIGHT] | MEDIUM | HEAVY
[✓ SUNNY] | CLOUDY | RAIN | ? — **TEMPERATURE:** °F 75 . °C
[Circle appropriate units]

TIME	COMMENTS
0730	Arrive @ Salisbury Point launch
0800	On water
0810	H & S
0920	PGSS-77A accepted #1
0950	PGSS-70 accepted #1
1018	BW-01 accepted #1 → noted on figure that BW-01 + PGST-1
1049	PGST-1 accepted #1 seemed farther apart than plotted using GPS,
1119	BW-04 accepted #1
1151	PGST-5 accepted #1
1309	BW-15 accepted #1
1340	BW-19 accepted #1
1415	Off water

Used GPS points to collect sample (from table ~~[illegible]~~ F-1-1)

QO 9/8/20

Signature:

pg 1 of 1

ANCHOR QEA

DATE: 9/9/20

PROJECT NAME: Port Gamble OMMP LTM

PROJECT NO: 200388-01.01

DAILY SAFETY BRIEFING

PERSON CONDUCTING MEETING: C. OREIRO

HEALTH & SAFETY OFFICER: D. TEMPLETON

PROJECT MANAGER: J. CORNETTA

TOPICS COVERED:

- ☑ Emergency Procedures and Evacuation Route
- ☑ Directions to Hospital
- ☑ HASP Review and Location
- ☑ Safety Equipment Location
- ☐ Proper Safety Equipment Use
- ☐ Employee Right-to-Know/MSDS Location
- ☑ Fire Extinguisher Location
- ☑ Eye Wash Station Location
- ☐ Buddy System
- ☑ Self and Coworker Monitoring
- ☐ Lines of Authority
- ☑ Communication
- ☐ Site Security
- ☐ Vessel Safety Protocols
- ☑ Work Zones
- ☐ Vehicle Safety and Driving/Road Conditions
- ☐ Equipment Safety and Operation
- ☑ Proper Use of PPE
- ☑ Decontamination Procedures
- ☐ Other:
- ☑ Lifting Techniques
- ☑ Slips, Trips, and Falls
- ☐ Hazard Exposure Routes
- ☑ Heat and Cold Stress
- ☐ Overhead and Underfoot Hazards
- ☐ Chemical Hazards
- ☐ Flammable Hazards
- ☐ Biological Hazards
- ☑ Eating/Drinking/Smoking

WEATHER CONDITIONS: sunny

DAILY WORK SCOPE: grab sampling

SITE-SPECIFIC HAZARDS: slips, trips, & falls

SAFETY COMMENTS: Stay hydrated

ATTENDEES

PRINTED NAME	SIGNATURE
C. OREIRO	
M. Bee	
E Scott	
R Trudeau	

90 9/13/20

Daily Log

ANCHOR QEA

Anchor QEA L.L.C.
1201 3rd Avenue, Suite 2600
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

PROJECT NAME: PG OMMP Long Term Monitoring

DATE: 9/9/20

SITE ADDRESS: Port Gamble, WA

PERSONNEL: CO, MB

WEATHER:

WIND FROM: N NE E SE S SW W NW [✓ LIGHT] MEDIUM HEAVY

[✓ SUNNY] CLOUDY RAIN ?

TEMPERATURE: °F 75 . °C
[Circle appropriate units]

TIME	COMMENTS
0745	~~on site~~ Arrive @ Salusbury Point
0800	on water
0805	H+S
0810	Confirmed PGST-1/BW-01 + PGST-5/BW-05 plotted differently
	from figure Called Jason Cornetta to discuss
0827	BW-21 attempt #1 over penetrated, rejected
0831	BW-21 attempt #2 accepted
0903	PGSS-8 #1 accepted
0934	BW18 #1 accepted
1003	PGSS-29 #1 accepted
1038	SMA1B-IT3, attempt #1 rejected, wood + rock in jaws
1042	SMA1B-IT3, attempt #2 rejected, wood + rock in jaws
1046	SMA1B-IT3, #3 accepted lots of rocks
1117	SMA1A-IT1 attempt #1 rejected, ~~jaws~~ CO 9/9/20 debris (seaweed, wood)
	in jaws
1121	SMA1A-IT1, attempt #2 rejected jaws not closed, not enough
	sample to collect
1124	SMA1A-IT1, attempt #3 rejected, debris in jaw sediment winnowed
	out of grab
1128	SMA1A-IT1, attempt #4 rejected, debris in jaw, large rocks
1132	SMA1A-IT1, attempt #5 accepted, debris in jaws <10cm
1150	SMA1A-IT2, attempt #1 rejected, debris in jaws, large rocks
1153	SMA1A-IT2, attempt #2 rejected, debris in jaws, large rock
1155	SMA1A-IT2, attempt #3 rejected, debris in jaws, large rock
1157	SMA1A-IT2, attempt #4 rejected, debris in jaws, large rocks
1201	SMA1A-IT2, attempt #5 rejected, debris in jaws, large rocks
1203	SMA1A-IT2, attempt #6 rejected, debris in jaws, large rocks
1206	SMA1A-IT2, attempt #7 accepted, debris in jaws, ~4cm of Sed.
1219	SMA1A-IT3 attempt #1 accepted ~8cm, all other attempts rejected
1229	SMA1A-IT3, attempt #2 rejected, debris in jaws, large rock
1232	SMA1A-IT3, attempt #3, rejected, debris in jaws, large rocks
1235	SMA1A-IT3, attempt #4, rejected, debris in jaws, large rocks

Signature:

pg 1 of 1

Daily Log

ANCHOR QEA

Anchor QEA L.L.C.
1201 3rd Avenue, Suite 2600
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

PROJECT NAME: PG OMMP Long Term Monitoring **DATE:** 9/9/20
SITE ADDRESS: Port Gamble, WA **PERSONNEL:** CO/MB

WEATHER: **WIND FROM:** N NE E SE S SW W NW LIGHT MEDIUM HEAVY
SUNNY CLOUDY RAIN ? **TEMPERATURE:** °F . °C
[Circle appropriate units]

TIME	COMMENTS
1303	SMA1A-IT4 attempt #1 rejected debris in jaws (big rock)
1305	SMA1A-IT4 attempt #2 rejected, no sediment (just big rocks)
1308	SMA1A-IT4 attempt #3 rejected, debris in jaws, large rock
1311	SMA1A-IT4 attempt #4 rejected, one rock in jaws
1312	SMA1A-IT4 attempt #5 rejected, debris in jaws, large rocks
1315	SMA1A-IT4 attempt #6 accepted debris in jaws <10cm (~5cm)
1332	SMA1A-IT5 attempt #1, rejected, debris in jaws, large rocks
1334	SMA1A-IT5 attempt #2, rejected, large rock in jaws
1336	SMA1A-IT5 attempt #3, rejected, debris in jaws, large rocks
1338	" " #4 " "
1340	" " #5 " "
1343	" " #6 " "
1345	" " #7 " "
1347	" " #8 " "
1350	Called Jason C. moving on to SMA1-ST samples, SMA2 tomorrow
1414	SMA1-ST1 attempt #1, rejected, debris in jaws, large rocks, kelp.
1416	SMA1-ST1 attempt #2, <4cm, keep, other 3 attempts rejected
1429	SMA1-ST1 attempt #3 rejected, debris in jaws, large rocks
1431	SMA1-ST1 attempt #4 rejected, " "
1441	SMA1-ST2 attempt #1 rejected, debris in jaws, rocks + kelp
1445	SMA1-ST2 attempt #2 rejected, large rock in jaws
1447	" " #3, rejected, debris in jaws, rocks + kelp
1450	" " #4, ~4cm, debris in jaws, collected a little sed ← one 16oz jar
1503	" " #5, rejected, large rocks in jaws
1508	SMA1-ST3 #1 accepted, seaweed in jaws, ~12cm
1530	SMA1-ST4 #1 rejected, winnowing + debris in jaws
1539	" " #2 accepted, wood debris in jaws. 15cm, little winnowing
1558	SMA1-ST5 #1 rejected, rocks in jaws, rocks + seaweed
1600	" "#2" "
1603	" "#3" " rocks + seaweed in jaws
1606	" " #4 rejected, large rock in jaws
1608	" "#5" "

Signature:

pg 2 of 2

1615 - off water

ANCHOR QEA

DATE: 9/10/20

PROJECT NAME: Port Gamble OMMP LTM

PROJECT NO: 200388-01.01

DAILY SAFETY BRIEFING

PERSON CONDUCTING MEETING: C. OREIRO

HEALTH & SAFETY OFFICER: D. TEMPLETON

PROJECT MANAGER: J. CORNETTA

TOPICS COVERED:

- ☑ Emergency Procedures and Evacuation Route
- ☑ Directions to Hospital
- ☑ HASP Review and Location
- ☐ Safety Equipment Location
- ☐ Proper Safety Equipment Use
- ☐ Employee Right-to-Know/MSDS Location
- ☑ Fire Extinguisher Location
- ☐ Eye Wash Station Location
- ☑ Buddy System
- ☑ Self and Coworker Monitoring
- ☑ Lines of Authority
- ☑ Communication
- ☐ Site Security
- ☑ Vessel Safety Protocols
- ☑ Work Zones
- ☐ Vehicle Safety and Driving/Road Conditions
- ☐ Equipment Safety and Operation
- ☑ Proper Use of PPE
- ☑ Decontamination Procedures
- ☐ Other:
- ☑ Lifting Techniques
- ☑ Slips, Trips, and Falls
- ☐ Hazard Exposure Routes
- ☑ Heat and Cold Stress
- ☑ Overhead and Underfoot Hazards
- ☐ Chemical Hazards
- ☐ Flammable Hazards
- ☐ Biological Hazards
- ☑ Eating/Drinking/Smoking

WEATHER CONDITIONS: sunny, hazy

DAILY WORK SCOPE: ~~sunny, hazy~~
Grab sampling

SITE-SPECIFIC HAZARDS: heat stress

SAFETY COMMENTS: Stay hydrated

ATTENDEES

PRINTED NAME	SIGNATURE
C. OREIRO	
M. Bee	
R Trudeau	
E. Sloan	

QS 9/10/20

Daily Log

ANCHOR QEA

Anchor QEA L.L.C.
1201 3rd Avenue, Suite 2600
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

PROJECT NAME: PG OMMP Long Term Monitoring
DATE: 9/10/20
SITE ADDRESS: Port Gamble, WA
PERSONNEL: CO, MB

WEATHER: **WIND FROM:** N NE E SE S SW W NW [✓ LIGHT] MEDIUM HEAVY
[✓ SUNNY] CLOUDY RAIN ? **TEMPERATURE:** °F . °C
[Circle appropriate units]

TIME	COMMENTS
0730	Arrive @ Salisbury launch
0740	on water
0745	H+S
0800	SMA2A-IT1 #1, rejected, not enough sed in grab
0803	SMA2A-IT1 #2, rejected large rock + some sed in grab
0810	" "#3, rejected, large rock in jaws
0811	" "#4 " "
0814	SMA2A-IT1 #5, offset ~15' from station, jaws not closed
	but ~12cm of sed in grab. collected volume
0832	SMA2A-IT2 #1 rejected, rocks in jaws
0835	" "#2, ~8cm recoverd. other attempts worse, collected volume
0845	" "#3, rejected, rocks in jaws
0848	" "#4, rejected ~5cm recoverd
0902	SMA2A-IT3 #1, accepted
0917	SMA2A-IT4 #1 accepted
0930	SMA2A-IT5 #1, rejected, large rock in jaws
0932	" "#2, winnowing thru middle of grab
0935	" "#3, rejected, rocks in jaws
0938	" "#4 " "
0941	" "#5 accepted, some winnowing, best sample to collect
1000	composite SMA2A-ET-COMP-200910
1027	SMA2B-IT1 #1 accepted, Rocks in jaws but had overlying water
1039	SMA2B-IT2 #1 rejected, large rocks in jaws
1040	" "#2" "
1041	" "#3" "
1043	" "#4, accepted, closed jaws but limited sediment <10cm
1057	SMA2B-IT3 #1, rejected rocks in jaws. (potato sized)
1059	" "#2 accepted
1114	SMA2B-IT4 #1, rejected, Rocks in jaws
1115	" "#2 " "
1117	" "#3 " "
1119	" "#4 " "

Signature:

pg 1 of 2

Daily Log

ANCHOR QEA

Anchor QEA L.L.C.
1201 3rd Avenue, Suite 2600
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

PROJECT NAME: PG OMMP Long Term Monitoring
DATE: 9/10/20
SITE ADDRESS: Port Gamble, WA
PERSONNEL: MB, CO

WEATHER: **WIND FROM:** N | NE | E | SE | S | SW | W | NW — LIGHT | MEDIUM | HEAVY
SUNNY | CLOUDY | RAIN | ? — **TEMPERATURE:** °F . °C [Circle appropriate units]

TIME	COMMENTS
1120	SMA2B-IT4, rejected, rocks in jaws #5
1122	SMA2B-IT4 #6 rejected
1126	" " #7 offset 20' from location, Recovered ~10cm
1137	SMA2B-IT5 #1, rejected, rocks in jaws
1141	" "#2" "
1142	" "#3" "
1144	" "#4" "
1146	" "#5 recovered ~7cm
1254	SMA2A-ST1 #1 accepted
1309	SMA2A-ST2 #1, accepted
1324	SMA2A-ST3 #1, accepted
1338	SMA2A-ST4 #1, accepted
1351	SMA2A-ST5 #1, accepted
1420	SMA2A-ST-0-10-COMP-200910 composited w/ FD
1436	SMA2B-ST1 #1, rejected, rock in jaws, winnowing
1440	SMA2B-ST1 #2, accepted.
1454	SMA2B-ST2 #1 accepted
1515	SMA2B-ST3 #1 accepted
1530	SMA2B-ST4 #1 accepted
1544	SMA2B-ST5 #1 accepted
CO 9/10/20	
1615	Off water

CO 9/11/20

Signature:

pg 1 of 2

ANCHOR QEA

qb 11

DATE: 9/~~10~~/20

PROJECT NAME: Port Gamble OMMP LTM

PROJECT NO: 200388-01.01

DAILY SAFETY BRIEFING

PERSON CONDUCTING MEETING: C.OREIRO

HEALTH & SAFETY OFFICER: D.TEMPLETON

PROJECT MANAGER: J.CORNETTA

TOPICS COVERED:

☑ Emergency Procedures and Evacuation Route
☑ Directions to Hospital
☑ HASP Review and Location
☐ Safety Equipment Location
☐ Proper Safety Equipment Use
☐ Employee Right-to-Know/MSDS Location
☑ Fire Extinguisher Location
☐ Eye Wash Station Location
☐ Buddy System
☑ Self and Coworker Monitoring

☐ Lines of Authority
☐ Communication
☐ Site Security
☑ Vessel Safety Protocols
☑ Work Zones
☐ Vehicle Safety and Driving/Road Conditions
☐ Equipment Safety and Operation
☑ Proper Use of PPE
☐ Decontamination Procedures
☐ Other:

☑ Lifting Techniques
☑ Slips, Trips, and Falls
☐ Hazard Exposure Routes
☑ Heat and Cold Stress
☐ Overhead and Underfoot Hazards
☐ Chemical Hazards
☐ Flammable Hazards
☐ Biological Hazards
☑ Eating/Drinking/Smoking

WEATHER CONDITIONS: smoky

DAILY WORK SCOPE: grab sampling

SITE-SPECIFIC HAZARDS: smoke inhalation

SAFETY COMMENTS: Stop work if air quality worsens.

ATTENDEES

PRINTED NAME	SIGNATURE
C.OREIRO	
M. Bee	
E. SLOAN	
R Trudeau	
	9/11/20
LW	

Daily Log

ANCHOR QEA

Anchor QEA L.L.C.
1201 3rd Avenue, Suite 2600
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

PROJECT NAME: PG OMMP Long Term Monitoring **DATE:** 9/11/20

SITE ADDRESS: Port Gamble, WA **PERSONNEL:**

WEATHER: **WIND FROM:** N NE E SE S SW W NW [✓ LIGHT] MEDIUM HEAVY

[✓ SUNNY] CLOUDY RAIN Smokey? **TEMPERATURE:** °F 75 . °C

[Circle appropriate units]

TIME	COMMENTS
0830	Arrive @ Salisbury launch
0845	on water
0900	H+S
0921	SMA2A-IT2 recollect #1, rejected, large rock in jaw
0923	" " #2 " "
0926	" " #3 " "
0928	" " #4, offset ~18' from location accepted.
0954	SMA2A-IT1 recollect #1, rejected, large rock in jaws
0955	" " #2 " "
0957	#3 offset ~14' from location, accepted
1017	SMA2A-IT3 recollect #1, accepted
1038	SMA2A-IT4 recollect #1, accepted
1055	SMA2A-IT5 recollect #1, accepted
1218	PGST-1 recollect #1, accepted
1243	PGST-5 recollect #1, accepted
1312	PGSS-29 recollect #1, rejected - low recovery
1315	PGSS-29 recollect #2, accepted
1335	composite SMA2A-IT-0-10-200911
1345.	PG ~~00~~ OMMP program Complete.
	9/11/20

Signature:

pg 1 of 1

Appendix B

Operations, Maintenance, and Monitoring Plan

APPENDIX F
OPERATIONS, MAINTENANCE, AND MONITORING PLAN

TABLE OF CONTENTS

List of Tables

List of Figures

List of Attachments

LIST OF ACRONYMS AND ABBREVIATIONS

µg/kg	micrograms per kilogram
CAP	*Cleanup Action Plan*
CD	Consent Decree
cm	centimeter
CoC	chemical of concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CQAP	*Construction Quality Assurance Plan*
DGT	*diffusive gradient thin sheet*
Ecology	Washington State Department of Ecology
EDR	*Engineering Design Report*
EMNR	enhanced monitored natural recovery
H_2S	hydrogen sulfide
mg/L	milligram per liter
MLLW	mean lower low water
MNR	monitored natural recovery
MTCA	Model Toxics Control Act
ng/kg	nanograms per kilogram
OMMP	*Operations, Maintenance, and Monitoring Plan*
PR/OPG	Pope Resources, LP/OPG Properties, LLC
QA	quality assurance
QAPP	*Quality Assurance Project Plan*
QC	quality control
RI/FS	remedial investigation/feasibility study
SAP	*Sampling and Analysis Plan*
SMA	sediment management area
SMS	Sediment Management Standards
SRZ	sediment recovery zone
SWAC	surface weighted average concentration
TEQ	toxicity equivalent quotient
WAC	Washington Administrative Code

1 INTRODUCTION

This *Operations, Maintenance, and Monitoring Plan* (OMMP) describes long-term monitoring and adaptive management of engineered caps in Port Gamble Bay ("Site"; Figure F-1) to ensure their long-term integrity and protectiveness, and also describes long-term monitoring to document recovery over time of sediments throughout the Site. This OMMP builds on the accompanying *Engineering Design Report* (EDR), which describes the approach and criteria for the engineering design of sediment cleanup actions at the Site, as set forth in the *Final Cleanup Action Plan* (CAP; Ecology 2013), and in accordance with the requirements of Consent Decree (CD) 13-2-02720-0 between the Washington State Department of Ecology (Ecology) and Pope Resources, LP/OPG Properties, LLC (PR/OPG), entered in December 2013. The actions described in this OMMP will be performed by PR/OPG under Ecology oversight, consistent with CD requirements.

Implementation of this OMMP will be performed consistent with the requirements of the Model Toxics Control Act (MTCA), Chapter 70.105D in the Revised Code of Washington, as administered by Ecology under the MTCA Cleanup Regulation, Chapter 173-340 of the Washington Administrative Code (WAC). Implementation of this OMMP will also comply with the Sediment Management Standards (SMS) Chapter 173-204 WAC.

1.1 Purpose and Scope of the OMMP

As described in the EDR, engineered caps have been placed over approximately 10 acres of the Site, and clean silt/sand enhanced monitored natural recovery (EMNR) layers have been placed over an additional approximately 68 acres to address thin deposits of relatively low concentration sediment as well as dredging residuals. Capping and EMNR placement was conducted over two construction seasons, beginning in fall 2015 and continuing into January 2017. The extent of remedial actions in sediment management areas (SMAs) at the Site is shown in Figure F-2.

Long-term monitoring of engineered caps installed in SMA-1 and SMA-2 will be performed to ensure their long-term integrity and protectiveness. However, EMNR layers (placed either as the primary remedy or as a post-dredge residuals management technique) do not require long-term monitoring or maintenance, consistent with CAP requirements.

As described in more detail in Section 3, the long-term monitoring of engineered caps will primarily include physical survey methods (e.g., bathymetry) to monitor the integrity, surface elevation, and thickness of the caps, beginning in Year 1 following completion of construction (cap monitoring is currently targeted to begin in 2018, continuing in Year 3 (2020), and then approximately every 5 years thereafter through 2030. Focused follow-on chemical and/or biological monitoring may be performed in targeted cap areas identified by the physical surveys to further evaluate the protectiveness of the caps. Cap repairs will be performed as needed based on the results of the monitoring. The need for and scope of long-term cap monitoring and maintenance beyond 2030 will be developed as a collaborative effort between PR/OPG and Ecology based on the results of monitoring through 2030, and may be triggered by specific storm or seismic events (e.g., a wind event with a recurrence interval of 20 years or more, or a seismic event greater than a magnitude of 5.5).

As discussed in the CAP, monitored natural recovery (MNR) is the selected remedy throughout SMA-5. Natural recovery processes are expected to result in a reduction of surface sediment concentrations throughout SMA-5 over time, particularly after ongoing sources such as decaying creosote-treated piles are removed during the remedial action. Recovery of surface sediments will be monitored after completion of remedial construction, and will continue as needed, as discussed in Section 4. A mathematical model has been developed as an evaluation tool for the MNR remedy; the model has been used to integrate Site data and forecast timeframes over which Site-wide average surface sediment concentrations will achieve sediment cleanup standards. The model can also be used as tool to evaluate progress based on future monitoring data.

Long-term performance and confirmation monitoring activities will inform Ecology’s 5-year reviews of the effectiveness of remedial actions at the Site, consistent with MTCA and SMS requirements. Sampling events will be scheduled to facilitate Ecology's 5-year reviews, beginning in approximately 2020.

Subsequent sections of this OMMP describe post-construction environmental monitoring activities that will be performed at the Site, including the details of post-construction monitoring and maintenance of capped areas to ensure the cap remains physically stable and chemically protective over time, as well as long-term surface sediment monitoring to verify that cleanup actions accelerate natural recovery processes. The overall objective of this OMMP is to confirm that remedial actions at the Site achieve the performance standards specified in the CAP.

1.2 Organization of the OMMP

The remainder of this OMMP is organized as follows:

- Section 2 – Project Roles and Responsibilities
- Section 3 – Cap Monitoring and Potential Corrective Actions
- Section 4 – Natural Recovery Sediment Quality Evaluation and Monitoring
- Section 5 – Reporting
- Section 6 – References

The accompanying *Sampling and Analysis Plan* (SAP; Attachment F-1) and *Quality Assurance Project Plan* (QAPP; Attachment F-2) specify procedures to ensure that sample collection, handling, and analysis will result in data of sufficient quality to evaluate the effectiveness of remedial actions at the Site.

2 PROJECT ROLES AND RESPONSIBILITIES

2.1 Washington State Department of Ecology

Ecology is the regulatory authority and responsible agency for overseeing and authorizing the remedial action. In this capacity, Ecology reviews monitoring plans developed during the remedial design phase and will review information described in this OMMP to ensure that the project is constructed in a manner consistent with the remedial design. Artie Kapell has been designated as the Ecology site manager to exercise project oversight for Ecology and to coordinate with PR/OPG. Ecology will make final decisions to resolve unforeseen problems, which may change the project components, or the manner in which the OMMP is undertaken.

2.2 Pope Resources, LP/OPG Properties, LLC

The operation, maintenance, and monitoring work on this project will be managed by PR/OPG and executed by PR/OPG or by one or more consultants specializing in this work. The Project Coordinator for PR/OPG is Clay Patmont of Anchor QEA, who will be responsible for implementation of the OMMP, including required monitoring, sampling, testing, and reporting. Included within this responsibility will be the monitoring or quality control (QC) activities to ensure that activities described in this OMMP are conducted in accordance with the requirements described herein. These activities may also be assigned to other consultants with the requisite expertise and experience.

3 CAP MONITORING AND POTENTIAL CORRECTIVE ACTIONS

Long-term cap monitoring in SMA-1 and SMA-2 will encompass three broad categories:

- Physical integrity performance monitoring (Section 3.1)
- Sediment quality confirmation monitoring in sentinel cap locations (Section 3.2)
- Confirmation monitoring in nearshore wood debris cap locations (Section 3.3)

Physical integrity monitoring will be conducted visually or by using a high-resolution hydrographic survey (i.e., multi-beam bathymetric survey) conducted at the start of each OMMP monitoring event. The bathymetric survey data will be used to evaluate cap thicknesses by comparing the measured surface elevation of the cap with the final as-built survey described in the *Construction Quality Assurance Plan* (CQAP; Appendix E of the accompanying EDR). Based on the results of the survey, cap areas of relatively greater erosion or settlement will be targeted as locations to conduct follow-on sediment quality monitoring, as needed. Visual inspections of the caps, at low tide and/or by divers, may also be required to further detail the physical integrity of the caps and locate potential follow-on sediment core sampling locations, as necessary.

Surface sediment quality monitoring will be conducted at designated sentinel sampling stations on the SMA-1 and SMA-2 caps, and in nearshore wood debris cap locations, one each in SMA-1 and SMA-2. Additional surface sediment sampling stations may be selected following completion and interpretation of the hydrographic survey and/or follow-on sediment core sampling, as described below.

3.1 Physical Integrity Performance Monitoring

Following the initial post-construction (as-built) surveys of engineered cap areas as described in the CQAP, long-term OMMP monitoring of the capping areas will be performed, including bathymetric surveys of SMA-1 and SMA-2 cap areas (Figure F-2). Bathymetric surveys will cover areas deeper than approximately +0 feet mean lower low water (MLLW), while intertidal areas above +0 feet MLLW will be surveyed "in the dry" using upland topographic surveying methods. The final cap areas have been delineated in as-built construction drawings. SMA-1 and SMA-2 cap areas are depicted in Figures F-3a and F-4a, respectively.

Post-construction bathymetric surveys will begin in Year 1 following completion of construction (cap monitoring is currently targeted to begin in 2018), continuing in Year 3 (2020), and then approximately every 5 years thereafter through 2030. As discussed above, the need for and scope of long-term cap monitoring beyond 2030 will be developed as a collaborative effort between PR/OPG and Ecology based on the results of monitoring through 2030, and may be triggered by specific storm or seismic events (e.g., a wind event with a recurrence interval of 20 years or more, or a seismic event greater than a magnitude of 5.5).

Survey methods will be similar between the as-built and each long-term monitoring survey to allow detailed comparisons. Changes in bathymetry will be evaluated to identify areas of net settlement, erosion, or deposition relative to post-construction conditions. A potential cap area of concern for potential settlement or erosion will be identified when the apparent total cap thickness relative to as-built conditions is less than the minimum specification defined in the EDR for the specific cap area. A potential cap area of concern may trigger visual inspection of the cap surface (Section 3.1.2) and/or sediment sampling in that area to more accurately characterize (through coring) the in-place cap layer thicknesses (Section 3.1.3).

3.1.1 Bathymetric Survey Methods

Bathymetric surveying was used during construction to verify that the target thicknesses of the engineered caps in SMA-1 and SMA-2, as defined in the EDR, were achieved at the completion of construction activities. Multi-beam bathymetric surveys will be performed, using the same surveying transects to the extent practicable, as part of long-term monitoring to identify changes in mudline elevations. Multi-beam surveys will be conducted by a licensed surveyor and will meet or exceed the accuracy standards for a USACE Navigation and Dredging Support Survey as referenced in the USACE Hydrographic Survey Manual, April 2004 Revision (USACE 2004). Additional details about bathymetric surveys are defined in the accompanying SAP in Attachment F-1.

3.1.2 Topographic Survey and Cap Surface Visual Inspection Methods

For intertidal cap areas not included in the bathymetric survey, both an upland topographic survey and concurrent visual inspection will be performed to evaluate the integrity of caps relative to as-built post-construction conditions. Topographic surveys will be performed using established control points as part of long-term monitoring to identify changes in shoreline sloping cap elevations. Topographic surveys will be conducted by a licensed surveyor and will meet or exceed the accuracy standards for a USACE Total Station Topographic Survey as referenced in the USACE Control and Topographic Surveying Manual (USACE 2007). Additional details about upland topographic surveys are defined in the accompanying SAP in Attachment F-1. Concurrent with the topographic survey, cap inspections will be performed at low tide and/or by a diver to further detail the physical integrity of the armored areas and toe of armored slope. Inspections shall include documentation of each of the following:

- Description of the cap surface conditions
- Indications of settlement, seepage, or other unanticipated conditions
- Sediment core locations may also be identified as necessary to more accurately characterize the in-place layer thickness

3.1.3 Sediment Coring Methods

Sediment cores may be performed at locations identified in the bathymetric/topographic surveys or inspections where possible cap settlement and/or erosion of cap thicknesses are below the EDR-defined cap design criteria. If necessary, cores will be advanced to a minimum depth of approximately 1 foot below the minimum required cap thickness. The cores will be processed in the uplands and visually inspected to determine the thicknesses of the cap material.

If the coring verifies the cap thickness specification in that area (e.g., reductions in cap surface elevations are primarily attributable to sub-grade settlement), no further cap monitoring in that area will be required during that event. Conversely, if the coring reveals that cap thickness specifications in that area have not been maintained, additional contingency evaluations—including surface sediment chemistry, and/or bioassay analyses, and/or cap maintenance or repair—may be performed as appropriate, subject to Ecology approval (see Section 3.2).

Detailed procedures for field sampling, location control, sample handling, and decontamination are provided in the accompanying SAP (Attachment F-1). Detailed field and laboratory quality assurance (QA) and QC criteria, including method specifications, detection limits, accuracy and precision requirements, are provided in the accompanying QAPP (Attachment F-2).

3.2 Sediment Quality Confirmation Monitoring in Sentinel Cap Locations

As discussed above, surface sediment quality monitoring will be conducted at six designated sentinel intertidal and subtidal sampling stations composed of 5-point aliquots on the SMA-1 and SMA-2 caps, as depicted in Figures F-3a and F-4a, respectively. As practicable, all sediment sampling performed under this OMMP will be conducted in September to correspond with seasonally lower dissolved oxygen levels and higher temperatures, while also optimizing daylight low-tide intertidal sampling windows and the availability of larval bioassay organisms. Samples will be collected from the 0- to 10-centimeter (cm) biologically active zone. SMS larval bioassays and analyses of Site chemicals of concern (CoCs; including carcinogenic polycyclic aromatic hydrocarbons [cPAHs], dioxins/furans, and cadmium) will be performed on the six sentinel intertidal and subtidal surface sediment samples.

Additional targeted surface sediment sampling may be performed following completion and interpretation of the bathymetric/topographic surveys and/or follow-on core sampling (see Section 3.1). The decision on whether to collect and analyze additional surface grab samples and/or sediment core samples in these area, along with the specific bioassay and/or chemical analyses, will be a collaborative decision made by PR/OPG and Ecology based on field observations.

If the larval bioassay and chemical analyses confirm that cleanup standards are being maintained, then no further cap monitoring and/or repair in that area will be required during that event. Conversely, if the larval bioassay and/or chemical analyses reveal that cleanup standards may be exceeded, further focused monitoring and/or cap maintenance/repair will be performed as appropriate (Section 3.4), subject to Ecology approval.

3.2.1 Sediment Sampling and Analysis Methods

Surface sediment samples from each sentinel sample location shown in Figure F-3a and Figure F-4a will comprise aliquots as discussed in Attachment F-1. The sample aliquots will be collected using a van Veen grab sampler or equivalent device deployed from a winch line on a sampling vessel. As practicable, sample aliquots in intertidal areas may be collected directly from the cap surface, during low tide, using hand tools (e.g., stainless-steel trowel, spoons or scoops). The sediment samples collected will be 5-point aliquots composited in the intertidal and subtidal areas and submitted for larval bioassays and/or chemical analyses. Detailed procedures for field sampling, location control, sample handling, and decontamination are provided in the SAP and QAPP included in Attachments F-1 and F-2, respectively.

3.3 Confirmation Monitoring in Nearshore Wood Debris Cap Locations

Surface sediment quality monitoring will also be conducted within two areas where buried nearshore wood debris deposits that could not be practicably removed were capped along the shoreline (i.e., within the North Basin in SMA-1 and the Former Pier 4 Area in SMA-2). As discussed in Section 3.2, as practicable, all sediment sampling performed under this OMMP will be conducted in September to correspond with seasonally lower dissolved oxygen levels and higher temperatures, while also optimizing daylight low-tide intertidal sampling windows and the availability of larval bioassay organisms. Nearshore sediment sampling locations for capped wood debris in SMA-1 and SMA-2 are depicted in Figures F-3a and F-4a, respectively.

Sediment monitoring in nearshore wood debris cap locations will consist of initial passive in situ diffusive gradient thin sheet (DGT) monitoring of porewater total free sulfide (including hydrogen sulfide [H_2S], hydrosulfide, and disulfide) concentrations. Following calculation of the H_2S fraction of the total free sulfide concentration based on concurrent temperature, pH, and salinity sampling, locations with porewater H_2S concentrations exceeding the risk-based benchmark of 0.07 milligram per liter (mg/L) will be sampled for confirmatory surface sediment bioassay analyses.

Shortly prior to sediment sampling, DGT probes will be advanced at three locations along a single transect in SMA-1 (total of three locations), and at three locations along three parallel transects in SMA-2 (total of nine locations). At each of these twelve DGT sampling locations, probes will be installed at two depth intervals, approximately 6 and 24 inches below the mudline, respectively, for a total of six sample points in SMA-1 and 18 sample points in SMA-2. If the probe encounters refusal above the 24-inch depth, two additional attempts will be conducted within approximately 3 feet of the original sample location; if all three attempts are unsuccessful, the attempts will be documented, and no deep DGT deployment will be conducted at that location.

Following an approximate 24-hour DGT deployment period, representative surface sediment (approximately 6 inches below mudline) porewater temperature, pH, and salinity measurements will be conducted at all twelve porewater sampling locations during low tide conditions (i.e., at the time the DGTs are retrieved). Surface sediment (6-inch depth) temperature, pH, and salinity will also be representative of the underlying shallow subsurface (24-inch depth) interval. Porewater H_2S concentrations will be calculated based on field optical densitometry of the DGT gels and concurrent temperature, pH, and salinity data, as described in more detail in the SAP and QAPP included in Attachments F-1 and F-2, respectively.

Bioassay sampling at discrete surface sample locations will be conducted following DGT retrieval and calculation of porewater H_2S concentrations as outlined above. Surface sediment samples for bioassay analyses will be collected at all sample locations with a surface (6-inch depth) or subsurface (24-inch depth) porewater H_2S concentration greater than 0.07 mg/L, the risk-based sediment porewater H_2S benchmark developed by Ecology for Port Gamble Bay. If all surface or shallow subsurface porewater H_2S concentrations along a transect are less than 0.07 mg/L, then a single bioassay sample will be collected from each transect (one in SMA-1 and three in SMA-2) at the transect location with the highest porewater H_2S concentration. If all porewater H_2S concentrations within a transect are below detection limits, the location along the transect with the lowest porewater salinity measurement will be selected for bioassay analysis. In any event, a minimum of one surface sediment bioassay sample will be collected from each of the four transects (one in SMA-1 and three in SMA-2).

Figures F-3b and F-4b through F4d depict cross-sections through the targeted areas in SMA-1 and SMA-2, respectively. These cross-sections show the locations of the samples relative to the capped wood debris. Bioassay samples will be collected from the 0- to 10-cm biologically active zone. A suite of SMS bioassays (two acute and one chronic) will be performed on bioassay samples.

If the bioassay analyses confirm that cleanup standards are being maintained in the capped areas of wood debris, then no further cap monitoring and/or repair in that area will be required during that event. Conversely, if the bioassay analyses reveal that cleanup standards may be exceeded, further focused monitoring and/or cap maintenance/repair will be performed as appropriate (Section 3.4), subject to Ecology approval.

3.3.1 Sediment Sampling and Analysis Methods

DGT sampling probes will be advanced along four transects (A through D; Figures F3a and F4a), within SMA-1 and SMA-2, at mudline elevations ranging from approximately +5 feet MLLW to approximately -3 feet MLLW. Probes will be installed by hand during low tide conditions to confirm proper installation. After an approximate 24-hour equilibration period, the probes will be removed. As summarized above, surface sediment bioassay sampling at targeted sample locations will be conducted following the DGT sampling. Detailed procedures for field sampling, sample processing, location control, sample handling, and decontamination are provided in the SAP and QAPP included in Attachments F-1 and F-2, respectively.

3.4 Corrective Actions

In the event that monitoring indicates that remedial action performance standards may not be achieved, PR/OPG will submit recommendations for further monitoring or corrective actions to Ecology for review, consistent with the requirements described in the CD and CAP. While bioassay standards are applied on a single sample (nearshore wood debris cap locations) or sample composite (sentinel cap locations) basis, chemical criteria (i.e., for cPAHs, dioxins/furans and cadmium) will be applied as a surface weighted average concentration (SWAC) across the entire 700-acre Site defined in the CAP and CD, consistent with SMS requirements. Chemical monitoring data collected in all SMAs (see Section 4.3) will be used to calculate the SWAC.

If monitoring data reveal that cap performance standards are not being achieved, a response plan will describe additional response actions to be taken to ensure the successful performance of the work. In conjunction with Ecology, PR/OPG will evaluate the extent and significance of the exceedance or trigger. The need for additional response actions will take into consideration all monitoring results relative to an overall assessment of the successful performance of the remedial action. Through these discussions, an appropriate course of action will be developed and implemented, as necessary. The specific problem causing the need for a contingency will dictate which additional response actions may be most appropriate. Possible additional response actions may include, but are not limited to, those listed for the following scenarios:

- Erosion of cap material
  - Perform additional monitoring to further assess erosion and to determine the extent, cause, and potential solution to the verified erosion
  - Perform additional sediment quality sampling within those erosion areas where there may be a potential for underlying material to be exposed
  - Discuss operations that might contribute to erosion and modifications to these operations that may be required to maintain remedy effectiveness
  - Place additional material with less erosion potential to supplement caps
- Sediment cleanup standard exceedance
  - Conduct confirmation biological sediment toxicity testing to confirm or refute the occurrence of adverse ecological impacts
  - Conduct a source control evaluation in coordination with Ecology (as necessary)
  - Place additional capping material

4 NATURAL RECOVERY SEDIMENT QUALITY EVALUATION AND MONITORING

As discussed in the CAP (Ecology 2013), subsurface sediment cleanup levels must be achieved 10 years after completion of remedial construction. Since construction was completed in 2017, cleanup standards are targeted to be achieved by 2027. The point of compliance for Site human health CoCs including cPAH toxicity equivalent quotient (TEQ), dioxin/furan TEQ, and cadmium is the SWAC over all subtidal areas of the Site (730 acres, including all SMAs; Figure F-1) across the 0- to 10-cm depth interval.

Long-term monitoring of surface sediment quality will be conducted as part of this OMMP to verify that natural recovery processes at the Site continue during the 10-year post-construction period to achieve sediment cleanup standards described in the CAP. Recovery of surface sediments at sentinel monitoring locations throughout the Site will be monitored beginning approximately 3 years after completion of remedial construction (long-term monitoring is currently targeted to begin in 2020) and every 5 years thereafter as needed (see Section 4.3). Baseline sampling data, natural recovery modeling, sediment sampling/analysis methods, and potential corrective actions are discussed in Sections 4.1 through 4.4.

4.1 Baseline Sampling

The remedial investigation/feasibility study (RI/FS; Ecology 2012) that formed the basis for the CAP (Ecology 2013) included extensive sampling and analysis of surface sediment CoCs throughout the Site, and thus forms the primary baseline data set for this OMMP evaluation. Most of the surface sediment baseline data were collected between 2008 and 2011 (average 2010). Baseline (2010) surface sediment cPAH and dioxin/furan TEQs are depicted in Figures F-5 and F-6, respectively. The baseline cPAH and dioxin/furan TEQ SWACs are approximately 42 μg/kg (see Section 4.2.2; above the 16 μg/kg cleanup level) and 3 nanograms per kilogram (ng/kg; below the 5 ng/kg cleanup level), respectively. (As discussed in the CAP, the baseline surface sediment cadmium SWAC is also below the cleanup level of 3 milligrams per kilogram.)

The RI/FS (Ecology 2012) also included baseline radioisotope analyses to characterize net sedimentation rates and mixing layer thicknesses in Port Gamble Bay. Representative sediment cores from central Port Gamble Bay are depicted in Figure F-7, and are consistent with recent (last 20 years) net sedimentation rates ranging from approximately 0.40 to 0.48 cm per year. The radioisotope gradients within these cores also reveal that there is relatively little sediment mixing in the 0- to 10-cm layer.

Consistent with the Ecology-approved SAP, additional surface sediment data were collected in 2014 at six representative stations across the Site to provide an early indication of recovery and to obtain data to refine model projections (see Section 4.2). Surface sediment was sectioned into 0- to 2-cm and 2- to 10-cm sub-sampling intervals, and analyzed using the same cPAH, dioxin/furan, and cadmium analytical methods used in the RI/FS. The 2014 data are summarized in Table F-1.

In areas of Port Gamble Bay that contain higher cPAH TEQs, the 0- to 2-cm layer contained significantly lower concentrations than underlying sediments, indicative of recent cPAH source controls and natural recovery processes (Figure F-8). Consistent with the radioisotope data summarized in Figure F-7, cPAH gradients within these surface sediments confirm that there is relatively little sediment mixing in the 0- to 10-cm layer. The Figure F-8 regression relationship (y-axis intercept) also suggests that current cPAH TEQs in depositing sediment at the Site likely range from approximately 5 to 10 μg/kg. As discussed in Section 4.2, the 2014 cPAH data were used to refine model inputs of cPAH natural recovery. The 2014 data also further verify that the current dioxin/furan TEQ and cadmium SWACs are below cleanup levels.

4.2 Natural Recovery Modeling

A mathematical model of sediment natural recovery was developed as an evaluation tool for the Site. The theoretical basis and framework for the model, the data and input parameters used in the model, and the results from the model predictions (i.e., timeframes over which the Site-wide SWAC will achieve the cPAH TEQ sediment cleanup standard) are presented in the subsections that follow.

4.2.1 Model Framework

Use of mathematical models to project future conditions for MNR evaluations is recommended in the U.S. Environmental Protection Agency's contaminated sediment guidance (USEPA 2005) and in various technical support documents (e.g., Magar et al. 2009). The goal of such modeling is to project changes in surface sediment concentration over time resulting from new deposition of material with lower concentration than the existing surface, as well as other processes that can result in concentration reductions, such as dilution and dispersion.

Several models are available for MNR projections, ranging in complexity and calculation methods. Most MNR models use a one-dimensional framework to simulate concentration changes in the surface sediment layer over depth and time, as a function of deposition as well as other recovery processes including bioturbation (mixing), porewater diffusion/dispersion, and groundwater/porewater advection. Example models include RECOVERY (USACE 2001), Boudreau (1997), and AQFATE (Connolly et al. 2000; Arcadis et al. 2010). Given the relatively high sediment partition coefficients of cPAHs in Port Gamble Bay (see Appendix B of the EDR), deposition and bioturbation are the driving processes in these models; dissolved phase processes are negligible. Changes in the sediment surface layer concentration over time for a model driven by these two processes depend on the following parameters:

- Starting surface sediment concentration
- Concentration in depositing sediment
- Net sedimentation rate
- Depth and rate of bioturbation
- Averaging depth of the surface layer for compliance evaluation

For the limiting case of sediment natural recovery being driven by particulate phase processes (i.e., deposition and bioturbation), analytical solutions can be developed to simulate changes in surface concentration over time based on mass balance formulations. For example, two simplified cases that bound any other more complex case (including the numerical models described previously) are as follows:

1. **Complete mixing** within the entire surface sediment layer (i.e., mixing is instantaneous and complete over the entire depth of sediment being evaluated)
2. **No mixing**, in which the surface layer being evaluated contains layers of new (lower concentration) material that “build up” atop the existing (higher concentration) surface sediment, with no interaction between layers

The mathematical equations governing these two cases are discussed in basic environmental modeling textbooks (e.g., Chapra 1997). Conceptually, these two cases can be illustrated by the diagram shown in Figure F-9, and their associated behavior in terms of change in concentration over time is shown in Figure F-10 (for an example case of a starting surface sediment concentration of 25 µg/kg with depositing sediment at a concentration of 10 µg/kg).

For the Port Gamble Bay analysis, concepts from these two bounding cases were combined to develop a modeling approach representative of the mixing regime observed at the Site. As discussed in Section 4.1, the lead-210 profile data from radionuclide cores (Figure F-7) and cPAH data from the 0- to 2-cm and 2- to 10-cm sections of sediment cores collected in 2014 (Figure F-8) indicate that there is relatively little mixing within the upper 10 cm of sediment. Thus, the MNR model developed for the Site consisted of a two-zone modeling approach to simulate the upper 10-cm compliance depth:

1. The 0- to 2-cm depth interval was assumed to be completely mixed. Mass entering the interval is a function of the rate of sediment deposition and concentration of depositing material, and mass exiting is based on the mixed concentration within the interval and the rate of deposition. The mass exiting from this 0- to 2-cm interval was used as input to the model simulation of the underlying 2- to 10-cm interval.
2. The 2- to 10-cm depth interval was assumed to have no mixing, and was discretized into computational layers. A LaGrangian solution scheme was applied in which the sediment exiting the 0- to 2-cm interval (having a concentration as per the first zone described above) via deposition was "reassigned" to the first discrete layer within the 2- to 10-cm interval, and all subsequent discrete layers within that interval were then "reassigned" to the next layer down. This process was repeated over time as new sediment continues to deposit on the surface, causing the sediments initially present within this interval of the model to be transported downward over time.

The cPAH concentrations simulated by the model were vertically averaged to calculate the 0- to 10-cm concentration for comparison to the Site cleanup standard of 16 µg/kg.

The basic model framework described above was applied to each SMA at the Site separately, and the anticipated timing of remediation activities within individual SMAs, including short-term impacts associated with dredging (i.e., residuals), were incorporated into the model.

The parameters used for the model, the approach used to simulate the effects of remediation within applicable SMAs, and the model results (i.e., predictions of the Site-wide SWAC) are described in Sections 4.2.2 and 4.2.3, respectively.

4.2.2 Model Input Parameters

Model input parameters were derived from Site sampling efforts described in previous sections. Key parameters in the model are the mixed layer depth, sedimentation rate, and cPAH TEQ in depositing sediment. These parameters and others used in the model are summarized in Table F-2 and are discussed in Sections 4.2.2.1 through 4.2.2.4.

4.2.2.1 Initial Surface Sediment cPAH Concentrations

The baseline surface sediment cPAH data collected from 2008 to 2011 were contoured using inverse-distance-weighting methods (see Figure F-5) and used to calculate the current SWAC within each SMA. These concentrations were used for the initial condition (specified to correspond to year 2010) in the model. The 2010 cPAH TEQ Site-wide subtidal sediment SWAC is approximately 42 μg/kg. SMA-specific SWACs were used in the modeling (Table F-2).

4.2.2.2 Remediation Effects on Surface Sediment Concentrations

Sediment concentrations in SMA-1 and SMA-2 were adjusted in the model to account for short-term increases in surface sediment cPAH concentrations resulting from dredging. Residuals from dredging in portions of the SMAs were conservatively assumed to affect the entire SMA. Based on dredging case studies summarized in Bridges et al. (2010), and given the volume of sediments to be dredged, the full 10-cm simulated thickness was assumed to be at the residual concentration immediately following dredging. The surface sediment cPAH concentration of the dredge residuals, and thus, the average surface sediment cPAH TEQ during dredging was set to 430 μg/kg, the average concentration within the SMA-1 and SMA-2 dredge prisms.

In addition, following the above-described increase in concentration associated with the dredge residuals, sediment concentrations were simulated in the model to reflect the post-dredge placement of engineered sediment caps, and EMNR/residual management cover layers. For the purposes of modeling, it was assumed that the post-cap/cover surface sediment cPAH TEQ in SMA-1 and SMA-2 would be 8 µg/kg over the entire 10-cm simulated thickness, corresponding to one-half the cleanup standard. The same assumption was made for the simulation of the EMNR layer in SMA-3.

The specified timeframes of these concentration changes to represent active remediation in the model were as follows:

- **SMA-1**: Linear increase in concentration to 430 µg/kg cPAH TEQ applied from November 2016 to January 2017; linear decrease to a concentration of 8 µg/kg cPAH TEQ applied in January 2017
- **SMA-2**: Linear increase in concentration to 430 µg/kg cPAH TEQ applied from November 2015 to January 2016; linear decrease to a concentration of 8 µg/kg cPAH TEQ applied in January 2016
- **SMA-3**: Linear decrease to a concentration of 8 µg/kg cPAH TEQ in January 2017 (same timeframe as SMA-1)

4.2.2.3 Net Sedimentation Rate

Radioisotope analyses conducted as part of the baseline monitoring concluded that net sedimentation rates in Port Gamble Bay are in the range of 0.40 to 0.48 cm per year (Figure F-7). The model conservatively used a net sedimentation rate at the low end of that range (0.4 cm per year).

4.2.2.4 cPAH Concentrations in Depositing Sediment

As shown in Figure F-8, the regression between surface (0- to 2-cm) and subsurface (2- to 10-cm) sediment cPAH TEQ collected in 2014 suggests that concentrations in sediment depositing from the water column are in the range of 5 to 10 µg/kg. Supplemental watershed loading-based calculations based on regional measurements of diffuse non-point sources of cPAHs in regional stormwater for different land use classifications (Herrera 2011) produce depositing sediment cPAH concentration estimates in this same range, further corroborating this input concentration range. Modeling was conducted for the two cases bounding this depositing sediment cPAH TEQ range.

4.2.3 Model Results

Model simulations were performed for each SMA separately, incorporating the remediation schedule described in the previous subsection. These simulations were conducted for two scenarios: assuming 5 and 10 μg/kg cPAH TEQ in depositing sediment. Results of the modeling for each individual SMA are shown in Figure F-11 (5 μg/kg cPAH TEQ depositing sediment) and Figure F-12 (10 μg/kg cPAH TEQ depositing sediment). These graphics illustrate the likely effects of remediation and rate of recovery in each SMA. Because the point of compliance for the 16 μg/kg cPAH TEQ cleanup standard is the SWAC over all subtidal areas of the Site, the subtidal area results were calculated as a Site-wide SWAC based on the SMA-specific results in Figures F-11 and F-12 and respective SMA areas. Figure F-13 shows the predicted decline in the Site-wide SWAC for cPAH TEQ. Based on the simulated range of depositing sediment cPAH TEQ concentration (i.e., 5 and 10 μg/kg), the predicted Site-wide SWAC is anticipated to achieve the 16 μg/kg cPAH TEQ cleanup standard between approximately 2026 and 2029.

The model developed and presented herein will be refined as additional data become available from long-term monitoring of surface sediment quality conducted as part of this OMMP to verify that natural recovery is progressing towards the cleanup standard.

4.3 Sediment Sampling and Analysis Methods

To verify model predictions and document the rate of recovery following completion of sediment cleanup actions, surface sediment samples will be collected from 12 representative sediment monitoring locations throughout the Site: nine located in SMA-5, two in SMA-4, and one in SMA-3 (see Figure F-14). As discussed above, long-term monitoring will begin approximately 3 years after completion of remedial construction (monitoring is currently targeted to begin in 2020) and every 5 years thereafter as needed (see Section 4.4). The SMA-3 to SMA-5 data will be combined with data collected in SMA-1 and SMA-2 (see Sections 3 and 4.2.3) to calculate the SWAC over all subtidal areas of the Site.

Field and analytical techniques and procedures to be used in the long-term monitoring program will be consistent with those used in the CAP (and the 2014 monitoring program) to ensure comparability of data. The accompanying SAP (Attachment F-1) and QAPP (Attachment F-2) specify procedures to ensure that sample collection, handling, and analysis will result in data of sufficient quality to evaluate the effectiveness of remedial actions at the Site.

4.4 Corrective Actions

The evaluation and implementation of corrective actions would be performed consistent with the requirements of the CD and CAP. Where monitored natural recovery does not achieve cleanup standards within 10 years following completion of remedial construction, PR/OPG will comply with sediment recovery zone (SRZ) requirements as defined under the SMS.

Following the first post-construction monitoring event (3 years after construction, anticipated in 2020), natural recovery modeling will be updated to refine projections of recovery through 2027. If the combined monitoring data in Year 3 post-construction (2020) and modeling projections summarized in Section 4.2 continue to confirm that the SWAC will be reduced to the 16 μg/kg cPAH TEQ cleanup standard by 2027, follow-on sediment recovery monitoring will be performed in Years 5 and 10 (2022 and 2027 respectively) to update and refine model projections.

Ecology will initiate a review of factors listed in SRZ criteria (WAC 173-204-590(3)) as part of a Focused Feasibility Study to evaluate remedial options including, but not limited to, implementation of a SRZ within 6 months after the first determination that the target of 16 μg/kg cPAH TEQ cleanup standard will not be met by 2027 (or 10 years after remediation). If the monitoring data indicate that MNR is not likely to achieve the cleanup level in this timeframe, the SRZ process will be initiated, including a Focused Feasibility Study for the Site including MNR and EMNR areas.

The Focused Feasibility Study will include but not be limited to the following:

- Consideration of further source controls, MNR, and EMNR to achieve cleanup standards
- Congener fingerprinting analysis to evaluate potential sources of cPAH, and to understand whether additional source controls might be necessary to achieve the 16 μg/kg cPAH TEQ cleanup standard

5 REPORTING

Subsequent to each OMMP monitoring event described in the sections above, PR/OPG's Project Coordinator will submit a detailed report to Ecology outlining the actions taken and the results, which will include survey maps and chemical analysis data. A recommendation for modifications to the scope of future monitoring efforts (e.g., reduction or elimination of cap and/or natural recovery monitoring) and/or corrective actions will be described in detail if warranted.

6 REFERENCES

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TABLES

Table F-1
Baseline Sediment Recovery Grab Sample Results

	Task	2014RemedialDesign	2014RemedialDesign	2014RemedialDesign	2014RemedialDesign	2014RemedialDesign	2014RemedialDesign	2014RemedialDesign
	Location ID	BW-01	BW-01	BW-01	BW-15	BW-15	BW-21	Bw-21
	Sample ID	BW-01-SG-0-2-140811	BW-01-SG-2-10-140811	BW-101-SG-2-10-140811	BW-15-SG-0-2-140811	BW-15-SG-2-10-140811	BW-21-SG-0-2-140811	BW-21-SG-2-10-140811
	Sample Date	8/11/2014	8/11/2014	8/11/2014	8/11/2014	8/11/2014	8/11/2014	8/11/2014
	Depth	0 to 2 cm	2 to 10 cm	2 to 10 cm	0 to 2 cm	2 to 10 cm	0 to 2 cm	2 to 10 cm
	Sample Type	N	N	FD	N	N	N	N
	Matrix	SE	SE	SE	SE	SE	SE	SE
	Site-specific Criteria							
Conventional Parameters (mg/kg)								
Total organic carbon		0.764	1.56	0.768	3.17	3.48	2.83	2.93
Total solids		63.97	71.42	69.69	24.5	29.21	20.38	24.3
Grain Size (%)								
Gravel		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Sand, very coarse		0.2	0.2	0.2	0.1 U	0.7	0.2	0.1
Sand, coarse		2	2	2	1.4	1.7	6.6	0.2
Sand, medium		21.4	21.9	22.5	2.8	2	0.9	0.5
Sand, fine		56.4	56.7	56	2	1.7	0.2	0.5
Sand, very fine		6	5.6	5.7	7.1	6.9	0.7	1.8
Silt, coarse		3.1	2.6	2.9	11.8	12.4	10.4	8.9
Silt, medium		2.7	2.1	2.1	16.6	15.6	25.7	21.1
Silt, fine		2.1	1.8	2	15.9	14.8	21.4	20.2
Silt, very fine		1.4	1.4	1.9	11.9	12.5	8.2	14.9
Total fines (Reported, not calculated)		--	--	--	--	--	--	--
Clay, coarse		1.1	1.4	1.4	8.5	10.4	5.6	9.3
Clay, medium		0.9	1.4	1	5.6	6.4	3.4	5.5
Clay, fine		2.6	2.9	2.3	16.3	14.8	16.7	17
Metals (mg/kg)								
Cadmium	3	0.6	0.6	0.6	2.3	2.3	3	3.2
Polycyclic Aromatic Hydrocarbons (µg/kg)								
2-Methylnaphthalene		8.5	7.1	8.5 J	5.3	8.1	9.8	7.1
Acenaphthene		9.4 J	10 J	13 J	5.4	7.8 J	8 J	5.9 J
Acenaphthylene		34	42	49	18	27	25	16
Anthracene		12 J	13 J	16 J	9.1	15 J	14 J	10 J
Benzo(a)anthracene		7.7 J	8 J	10 J	13	13 J	12 J	8.8 J
Benzo(a)pyrene		8	8	11	14	14	14	9.8
Benzo(b,j,k)fluoranthenes		14	15	20	29	28	26	18
Benzo(g,h,i)perylene		8.7	8.4	11	11	13	15	9.8
Chrysene		12	10	12	18	20	15	11
Dibenzo(a,h)anthracene		4.9 UJ	4.7 UJ	4.7 UJ	5 U	4.9 UJ	4.9 UJ	4.9 UJ
Fluoranthene		52 J	62 J	76 J	50	74 J	72 J	48 J
Fluorene		7.2 J	6.9 J	8.8 J	5.8	8.2 J	11 J	8.2 J
Indeno(1,2,3-c,d)pyrene		4.8 J	4.5 J	5.7	6.7	7.6	8	5.9
Naphthalene		110	120	140 J	65	91	110	78
Phenanthrene		49 J	57 J	68 J	34	57 J	59 J	40 J
Pyrene		50 J	61 J	77 J	44	69 J	70 J	46 J
cPAH TEQ (U=1/2)	16	11.02 J	11.09 J	14.93 J	19.3 J	19.305 J	18.995 J	13.425 J
Dioxin Furans (ng/kg)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)		0.392 J	0.342 J	0.334 J	0.844 J	0.458 J	0.665 J	0.705 J

Table F-1
Baseline Sediment Recovery Grab Sample Results

	Task	2014RemedialDesign	2014RemedialDesign	2014RemedialDesign	2014RemedialDesign	2014RemedialDesign	2014RemedialDesign	2014RemedialDesign
	Location ID	**BW-01**	**BW-01**	**BW-01**	**BW-15**	**BW-15**	**BW-21**	**Bw-21**
	Sample ID	**BW-01-SG-0-2-140811**	**BW-01-SG-2-10-140811**	**BW-101-SG-2-10-140811**	**BW-15-SG-0-2-140811**	**BW-15-SG-2-10-140811**	**BW-21-SG-0-2-140811**	**BW-21-SG-2-10-140811**
	Sample Date	**8/11/2014**	**8/11/2014**	**8/11/2014**	**8/11/2014**	**8/11/2014**	**8/11/2014**	**8/11/2014**
	Depth	**0 to 2 cm**	**2 to 10 cm**	**2 to 10 cm**	**0 to 2 cm**	**2 to 10 cm**	**0 to 2 cm**	**2 to 10 cm**
	Sample Type	**N**	**N**	**FD**	**N**	**N**	**N**	**N**
	Matrix	**SE**	**SE**	**SE**	**SE**	**SE**	**SE**	**SE**
	Site-specific Criteria							
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)		1.08	0.571 J	0.594 J	2.34	1.28	1.63	1.79
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)		0.771 J	0.332 J	0.378 J	1.47	1.98	1.09	1.35
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)		1.44	1.09	1.08	4.7	3.45	3.54	4.85
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)		0.993 J	0.723 J	0.716 J	3.24	2.42	2.32	3.4
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)		16.8	14	13.4	66.1	36.4	48.5	66
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)		123	104	99.7	497	257	361	345
Total Tetrachlorodibenzo-p-dioxin (TCDD)		63.1 J	18.5 J	17.3 J	64 J	52.8 J	39.3 J	67.4 J
Total Pentachlorodibenzo-p-dioxin (PeCDD)		36.9	12.3	12.9 J	46.5	67.5	30.5	67.9
Total Hexachlorodibenzo-p-dioxin (HxCDD)		27	18	18.4	76.7	87.1	53.5	150
Total Heptachlorodibenzo-p-dioxin (HpCDD)		71.8	60.5	55	276	146	178	203
2,3,7,8-Tetrachlorodibenzofuran (TCDF)		1.08	1.24 J	1.09	4.26	1.7 J	2.93	2.88 J
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)		0.597 J	0.589 J	0.455 J	1.7 J	0.84 J	1.16	1.34
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)		0.573 J	0.438 J	0.406 J	1.99	0.886 J	1.39	1.47
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)		0.474 J	0.396 J	0.364 J	1.63 J	0.876 J	1.27 J	1.27 J
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)		0.426 J	0.438 J	0.237 J	1.25	0.724 J	0.937 J	1.03
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)		0.356 J	0.186 J	0.0815 U	0.349 J	0.626 J	0.313 J	0.402 J
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)		0.523 J	0.396 J	0.235 J	1.52 J	0.8 J	1.24 J	1.21
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)		2.81	2.54	2.61	11.5	5.47	9.02	9.35
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)		0.482 J	0.112 J	0.101 J	0.717 J	0.844 J	0.627 J	0.61 J
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)		5.03	4.48	4.68	18.8	10	14.2	15
Total Tetrachlorodibenzofuran (TCDF)		19.9	21.3 J	18.9	72	27.2 J	51.7	49.3 J
Total Pentachlorodibenzofuran (PeCDF)		8.55 J	7.78 J	7.26 J	33.2	13 J	23.5	25.5
Total Hexachlorodibenzofuran (HxCDF)		6.13 J	5.91 J	4.84 J	22.4 J	11.1 J	17.7 J	19.3 J
Total Heptachlorodibenzofuran (HpCDF)		7.5	6.57 J	6.94 J	30.2	14.8 J	22.9 J	22.8 J
Total Dioxin/Furan TEQ 2005 (Mammal) (U = 1/2)	5	2.507439 J	1.741234 J	1.669949 J	6.61181 J	3.79384 J	4.80483 J	5.483 J

Table F-1
Baseline Sediment Recovery Grab Sample Results

	Task	**2014RemedialDesign**	**2014RemedialDesign**	**2014RemedialDesign**	**2014RemedialDesign**	**2014RemedialDesign**	**2014RemedialDesign**
	Location ID	PGSS-29	PGSS-29	PGST-1	PGST-1	PGST-5	PGST-5
	Sample ID	PGSS-29-SG-0-2-140811	PGSS-29-SG-2-10-140811	PGST-1-SG-0-2-140811	PGST-1-SG-2-10-140811	PGST-5-SG-0-2-140811	PGST-5-SG-2-10-140811
	Sample Date	8/11/2014	8/11/2014	8/11/2014	8/11/2014	8/11/2014	8/11/2014
	Depth	0 to 2 cm	2 to 10 cm	0 to 2 cm	2 to 10 cm	0 to 2 cm	2 to 10 cm
	Sample Type	N	N	N	N	N	N
	Matrix	SE	SE	SE	SE	SE	SE
	Site-specific Criteria						
Conventional Parameters (mg/kg)							
Total organic carbon		0.798	1.46	3.59	2.03	2.5	3.65
Total solids		64.7	67.49	26.88	30.17	27.48	32.23
Grain Size (%)							
Gravel		0.2	0.5	0.1 U	0.1 U	0.2	0.9
Sand, very coarse		1.3	1.2	0.1 U	0.1	0.8	0.1 U
Sand, coarse		5	5.3	0.2	1.8	1.6	2.8
Sand, medium		19.7	19.3	1.8	1.3	2	2.3
Sand, fine		40.2	39.9	1.2	1	3.8	4.2
Sand, very fine		19.4	19.3	4.8	4.8	13.1	12.7
Silt, coarse		3.9	3.5	13.4	15.9	12.7	11
Silt, medium		2.8	3.1	24.5	16.4	17	16.8
Silt, fine		1.8	2.1	16.1	15.8	13.7	13.4
Silt, very fine		1.3	1.4	11.1	12.3	11.2	11.5
Total fines (Reported, not calculated)		--	--	--	--	--	--
Clay, coarse		0.9	0.9	7.3	9.5	5.4	6.3
Clay, medium		0.8	1	6	7.1	4.9	5.5
Clay, fine		2.7	2.5	13.6	14	13.7	12.6
Metals (mg/kg)							
Cadmium	3	0.8	0.8	2.5	2.5	2	2
Polycyclic Aromatic Hydrocarbons (µg/kg)							
2-Methylnaphthalene		8	9.2	10	12	16	26
Acenaphthene		8.2 J	8.4 J	10 J	11 J	21 J	35 J
Acenaphthylene		20	21	26	29	69	120
Anthracene		16 J	17 J	21 J	24 J	31 J	50 J
Benzo(a)anthracene		11 J	9.2 J	23 J	33 J	32 J	47 J
Benzo(a)pyrene		12	9.6	26	31	29	44
Benzo(b,j,k)fluoranthenes		22	18	57	68	61	88
Benzo(g,h,i)perylene		11	10	20	24	23	36
Chrysene		12	12	32	69	81	63
Dibenzo(a,h)anthracene		5 UJ	4.9 UJ	2.7 J	3.2 J	2.8 J	3.9 J
Fluoranthene		84 J	76 J	94 J	120 J	140 J	200 J
Fluorene		11 J	11 J	12 J	14 J	19 J	28 J
Indeno(1,2,3-c,d)pyrene		6.1	4.9 J	13	16	14	22
Naphthalene		130	120	89	100	190	370
Phenanthrene		69 J	71 J	67 J	80 J	120 J	180 J
Pyrene		87 J	77 J	85 J	110 J	130 J	190 J
cPAH TEQ (U=1/2)	16	16.28 J	13.175 J	35.89 J	43.71 J	40.79 J	60.72 J
Dioxin Furans (ng/kg)							
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)		0.304 J	1.14 J	0.648 J	0.691 J	0.76 J	0.826 J

Table F-1
Baseline Sediment Recovery Grab Sample Results

	Task	**2014RemedialDesign**	**2014RemedialDesign**	**2014RemedialDesign**	**2014RemedialDesign**	**2014RemedialDesign**	**2014RemedialDesign**
	Location ID	PGSS-29	PGSS-29	PGST-1	PGST-1	PGST-5	PGST-5
	Sample ID	PGSS-29-SG-0-2-140811	PGSS-29-SG-2-10-140811	PGST-1-SG-0-2-140811	PGST-1-SG-2-10-140811	PGST-5-SG-0-2-140811	PGST-5-SG-2-10-140811
	Sample Date	8/11/2014	8/11/2014	8/11/2014	8/11/2014	8/11/2014	8/11/2014
	Depth	0 to 2 cm	2 to 10 cm	0 to 2 cm	2 to 10 cm	0 to 2 cm	2 to 10 cm
	Sample Type	N	N	N	N	N	N
	Matrix	SE	SE	SE	SE	SE	SE
	Site-specific Criteria						
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)		0.536 J	1.97 J	1.58	1.94	2.03	2.12
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)		0.393 J	1.27 J	1.11 J	1.45	1.41	1.42
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)		1.09	2.26 J	4.38	5.41	4.45	4.96
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)		0.895 J	2.52 J	2.78	3.07	2.88	3.08
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)		16.7	16.1	75.1	99.8	79.4	74.6
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)		125	112	631	858	664	584
Total Tetrachlorodibenzo-p-dioxin (TCDD)		9.38 J	12.7 J	48.2 J	47.5	64.7	58 J
Total Pentachlorodibenzo-p-dioxin (PeCDD)		8.07	12.7 J	40	37	40.8	42.2
Total Hexachlorodibenzo-p-dioxin (HxCDD)		18.4 J	20.8 J	78.5 J	92.7	73.4	82.3
Total Heptachlorodibenzo-p-dioxin (HpCDD)		76.1	64.60	358	512	388	325
2,3,7,8-Tetrachlorodibenzofuran (TCDF)		0.846 J	2.17 J	2.78	2.91	3.73	4.31
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)		0.419 J	1.89 J	1.1 J	1.16 J	1.4	1.6
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)		0.383 J	1.72 J	1.22	1.29	1.4 J	1.76 J
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)		0.245 J	1.2 J	1.15 J	1.24	1.36 J	1.42 J
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)		0.261 J	1.14 J	0.776 J	0.932 J	0.945 J	1.19
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)		0.117 J	2.07 J	0.299 J	0.337 J	0.339 J	0.409 J
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)		0.259 J	0.956 J	1.06 J	1.17 J	1.29 J	1.41 J
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)		2.07	3.41 J	10.6	12.7	11	11.7 J
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)		0.148 J	1.83 J	0.516 J	0.649 J	0.684 J	0.691 J
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)		3.64	4.86 J	21.2	25	22.3	23
Total Tetrachlorodibenzofuran (TCDF)		14.3	19.7 J	42.9	49.9	59	76.6
Total Pentachlorodibenzofuran (PeCDF)		6.49 J	9.63 J	20.6 J	24.5 J	26.4 J	29.6 J
Total Hexachlorodibenzofuran (HxCDF)		4.19 J	10.7 J	18.8 J	21.7 J	20.5 J	22.3 J
Total Heptachlorodibenzofuran (HpCDF)		5.33 J	9.41 J	29.2 J	35.9 J	30.8	32.8 J
Total Dioxin/Furan TEQ 2005 (Mammal) (U = 1/2)	5	1.605842 J	5.289758 J	5.11832 J	6.10109 J	6.00913 J	6.39391 J

Notes:

µg/kg = micograms per kilogram
cm = centimeter
cPAH = carcinogenic polycyclic aromatic hydrocarbon
FD = field duplicate
J = estimated value
mg/kg = mliligrams per kilogram

N= normal
ng/kg = nanograms per kilogram
SE = sediment
TEQ = Toxic Equivalents Quotient
U = not detected above reporting limit

Table F-2
Natural Recovery Model Input Parameters

Model Parameter	**SMA-1**	**SMA-2**	**SMA-3**	**SMA-4**	**SMA-5**	**Comments**
Starting Surface Sediment cPAH (µg/kg)	525	162	39	32	35	SWAC based on 10-cm surface data (2008 – 2011)
Depositing Particle cPAH (µg/kg)	5 and 10					Estimated based on multiple lines of evidence, including 0 to 2 cm core data
Net sedimentation rate (cm/yr)	0.4					Dated lead-210 cores (range of 0.3 to 0.5 cm/yr)
Model domain and mixing depth						Model framework is based on a 2-cm completely mixed zone overlying an 8-cm-thick zone with no mixing (for total thickness of 10 cm for assessing compliance)
Area (acres)	6	19	61	19	609	
Post-Capping/Thin Layer Capping cPAH (µg/kg)	8			NA	NA	1/2 cleanup level
cPAH Dredge Residual (µg/kg)	430		NA	NA	NA	Average concentration in dredge areas (SMA-1 and SMA-2)

Notes:

Model framework is based on a 2-cm completely mixed zone overlying an 8-cm-thick zone with no mixing (for total thickness of 10 cm for assessing compliance).

NA - not applicable

µg/kg - microgram per kilogram

cm/yr - centimeters per year

FIGURES

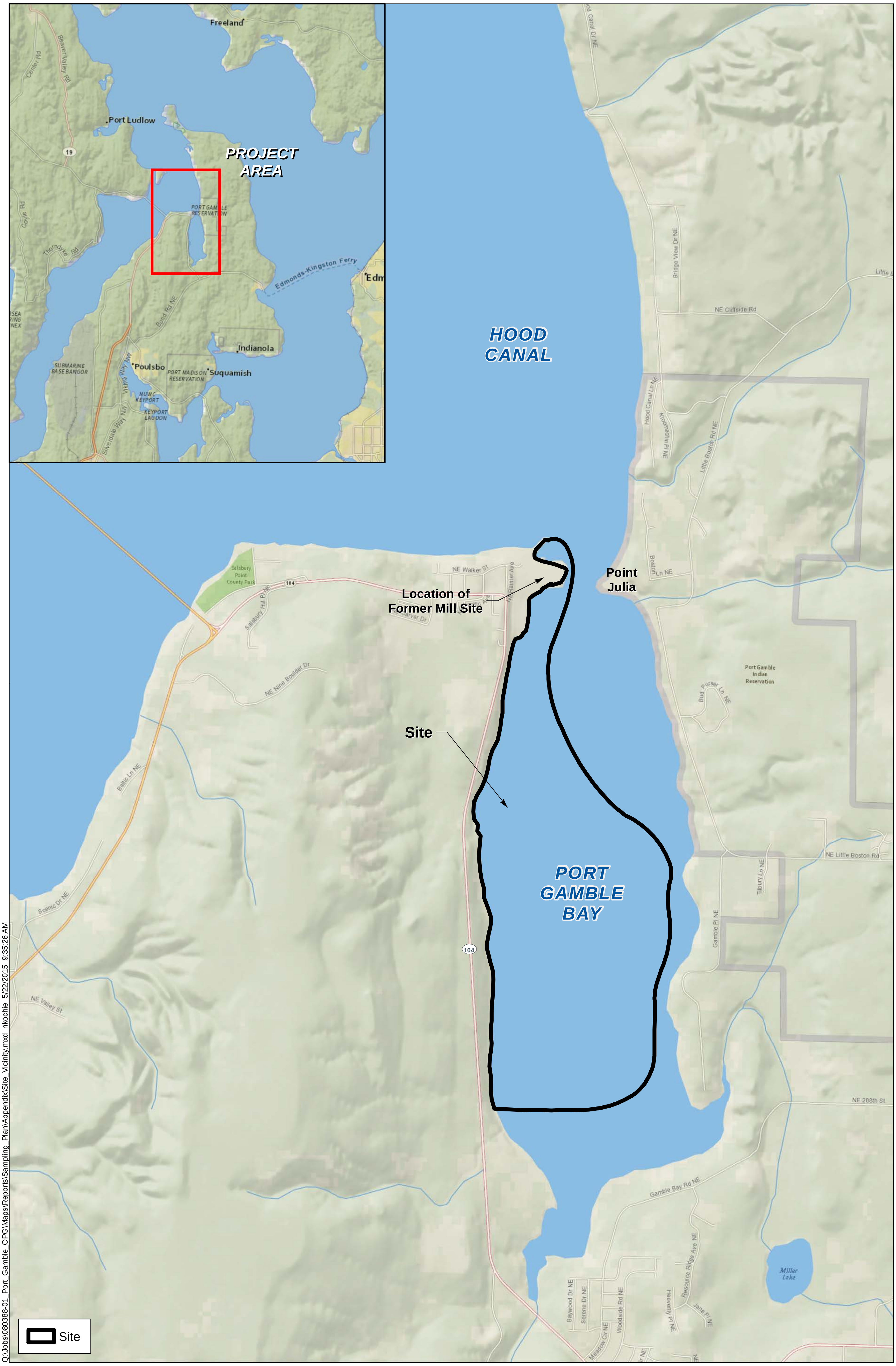

Figure F-1
Site Vicinity Map
Appendix F: Operations, Maintenance, and Monitoring Plan
Port Gamble Bay Cleanup

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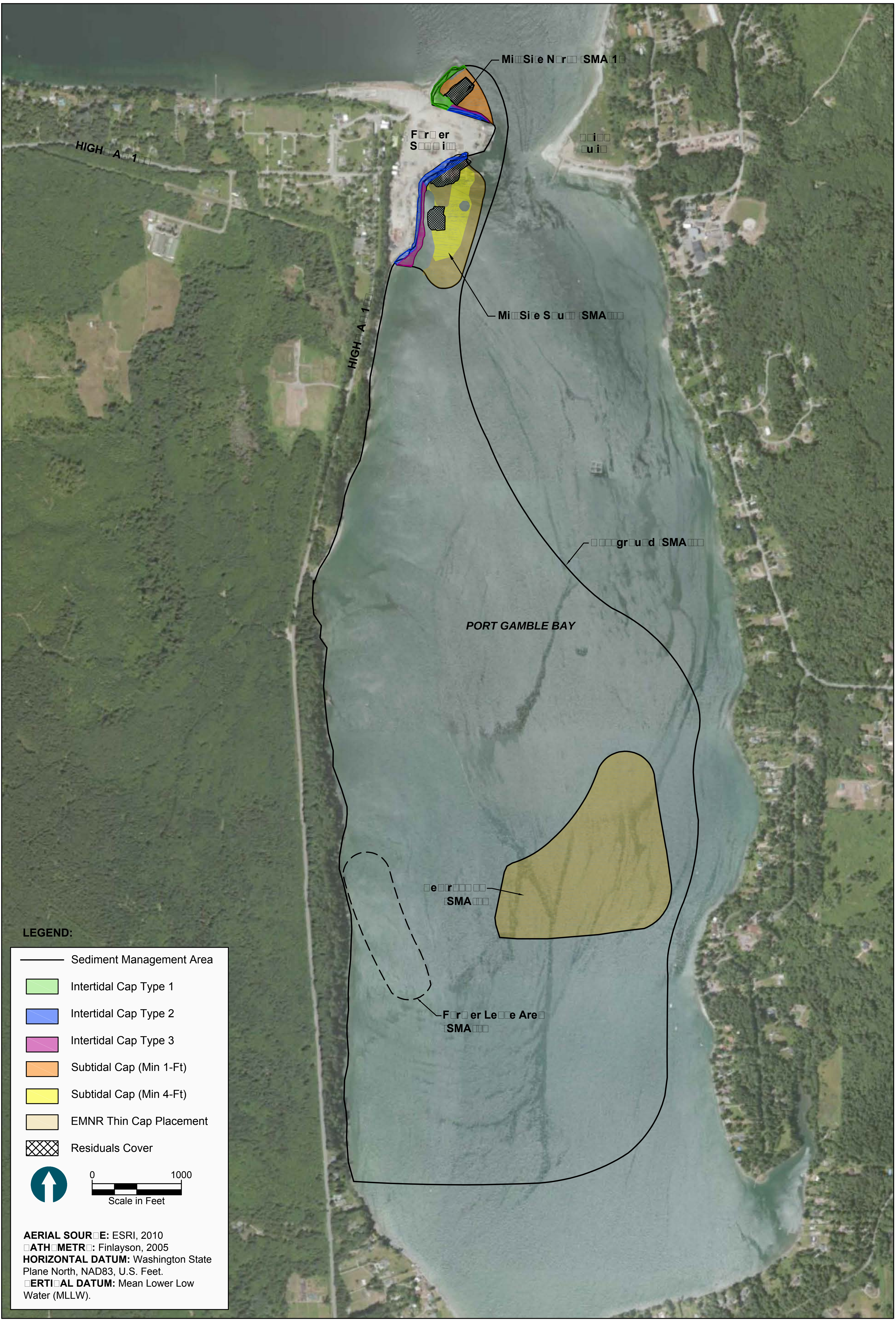

AERIAL SOUR□E: ESRI, 2010
□ATH□METR□: Finlayson, 2005
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
□ERTI□AL DATUM: Mean Lower Low Water (MLLW).

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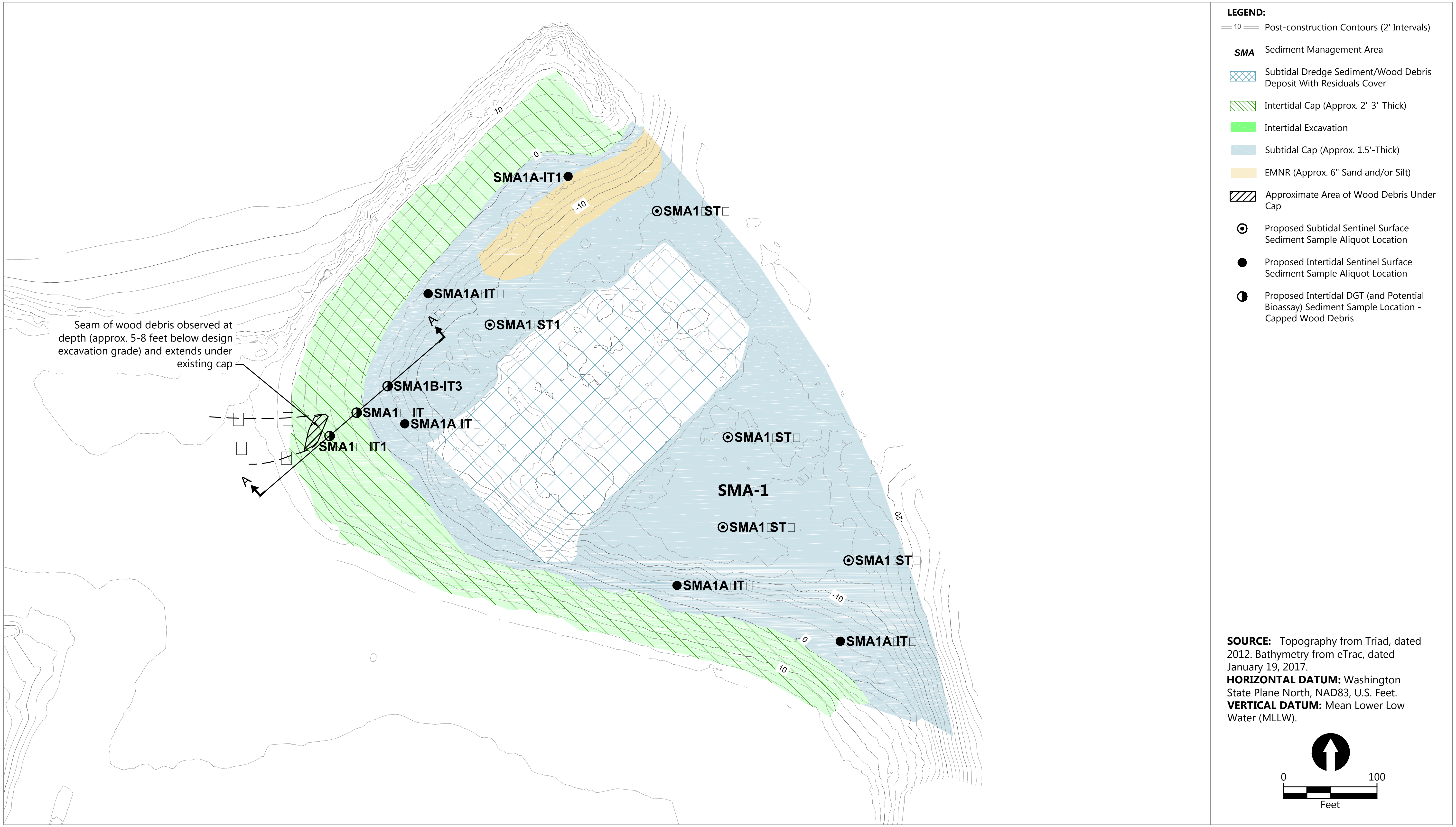
Figure F□□
Capping and EMNR Areas in SMA-1, SMA-2, and SMA-3
Appendix F: Operations, Maintenance, and Monitoring Plan
Port Gamble Bay Cleanup



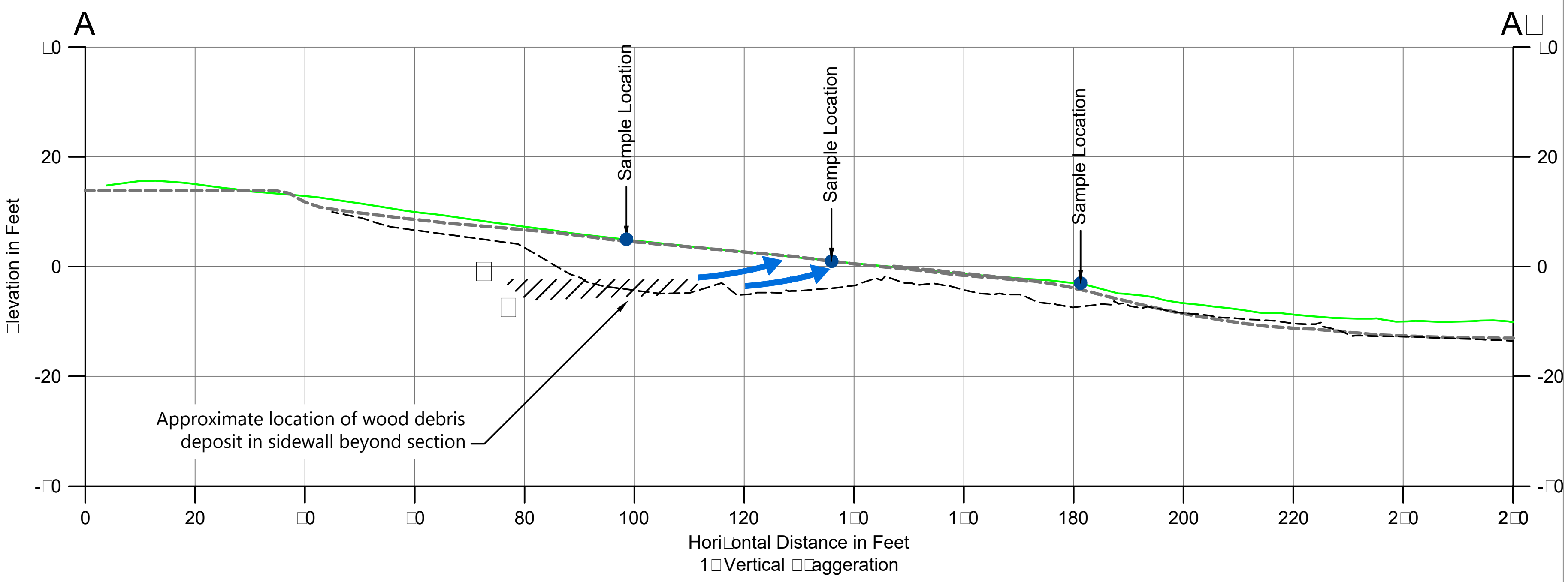
SOURCE: Topography from Triad, dated 2012. Bathymetry from eTrac, dated January 19, 2017.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

Publish Date: 2017/12/19 9:06 AM | User: chewett
Filepath: K:\Projects\0388-Pope Resources\Port Gamble Sediment Cleanup RI-FS\0388-WK-143 (MAF Porewater XS).dwg F3a

ANCHOR QEA

Figure F-3a
Sediment Sampling Stations (SMA-1)

Appendix F: Operations, Maintenance, and Monitoring Plan
Port Gamble Bay Cleanup



LEGEND:

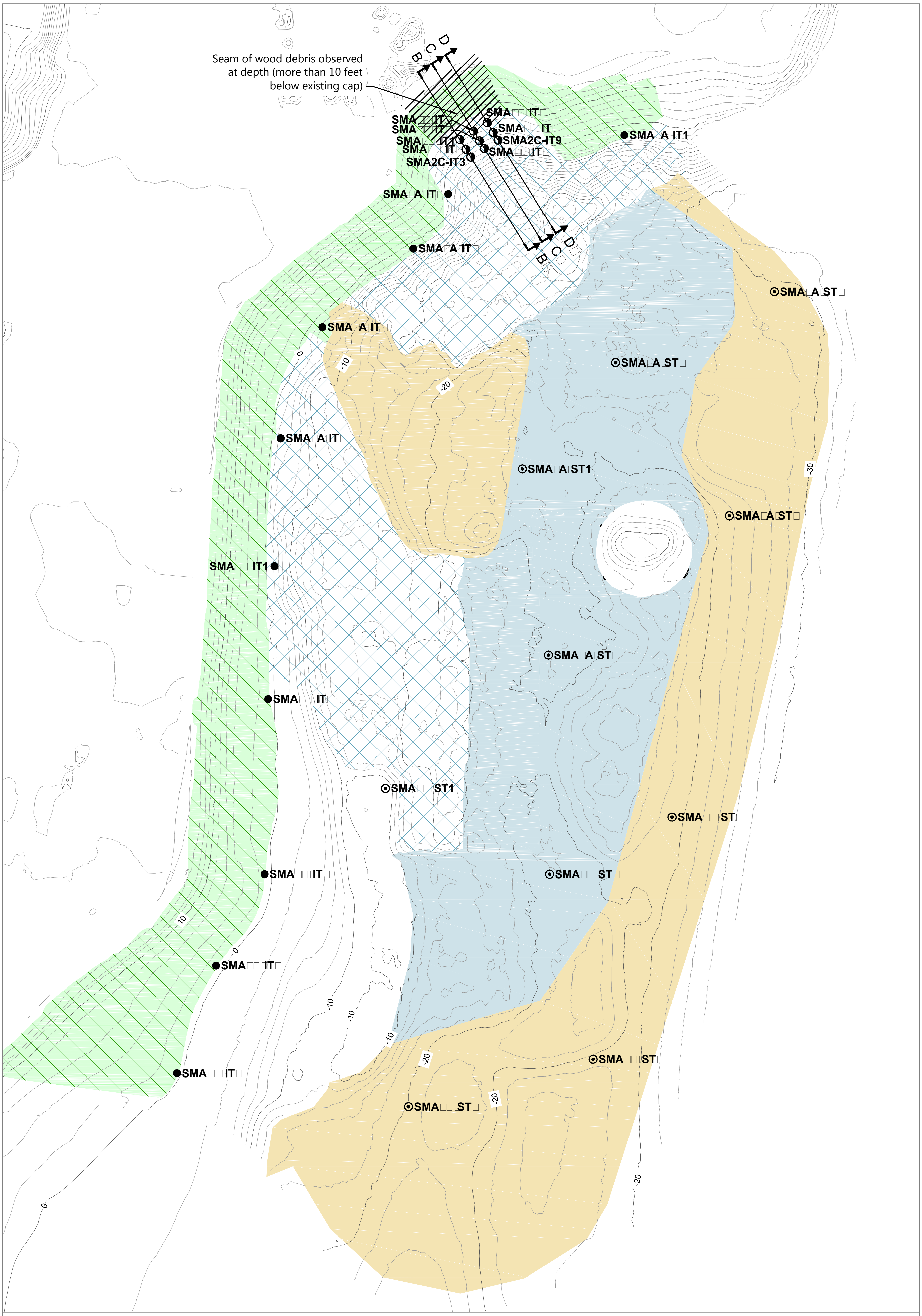
- - - - - (thick grey dashed)	Pre-construction Grade
- - - - - (thin black dashed)	Post-dredge Grade
───	Post-cap and -backfill Grade
▨	Approximate Wood Debris Seam Under Cap
↗	Approximate Groundwater Flow
●	Proposed Sample Location

SOURCE: Pre-construction bathymetry from eTrac, dated August 27, 2014. Post-dredge bathymetry from Orion. Post-cap and -backfill bathymetry from eTrac, dated January 19, 2017.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

Publish Date: 2017/12/19 9:06 AM | User: chewett
Filepath: K:\Projects\0388-Pope Resources\Port Gamble Sediment Cleanup RI-FS\0388-WK-143 (MAF Porewater XS).dwg F3b

Figure F-3b
Sediment Sampling Cross Section (SMA-1)

Appendix F: Operations, Maintenance, and Monitoring Plan
Port Gamble Bay Cleanup



SOURCE: Topography from Triad, dated 2012. Bathymetry from eTrac, dated January 19, 2017.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

LEGEND:

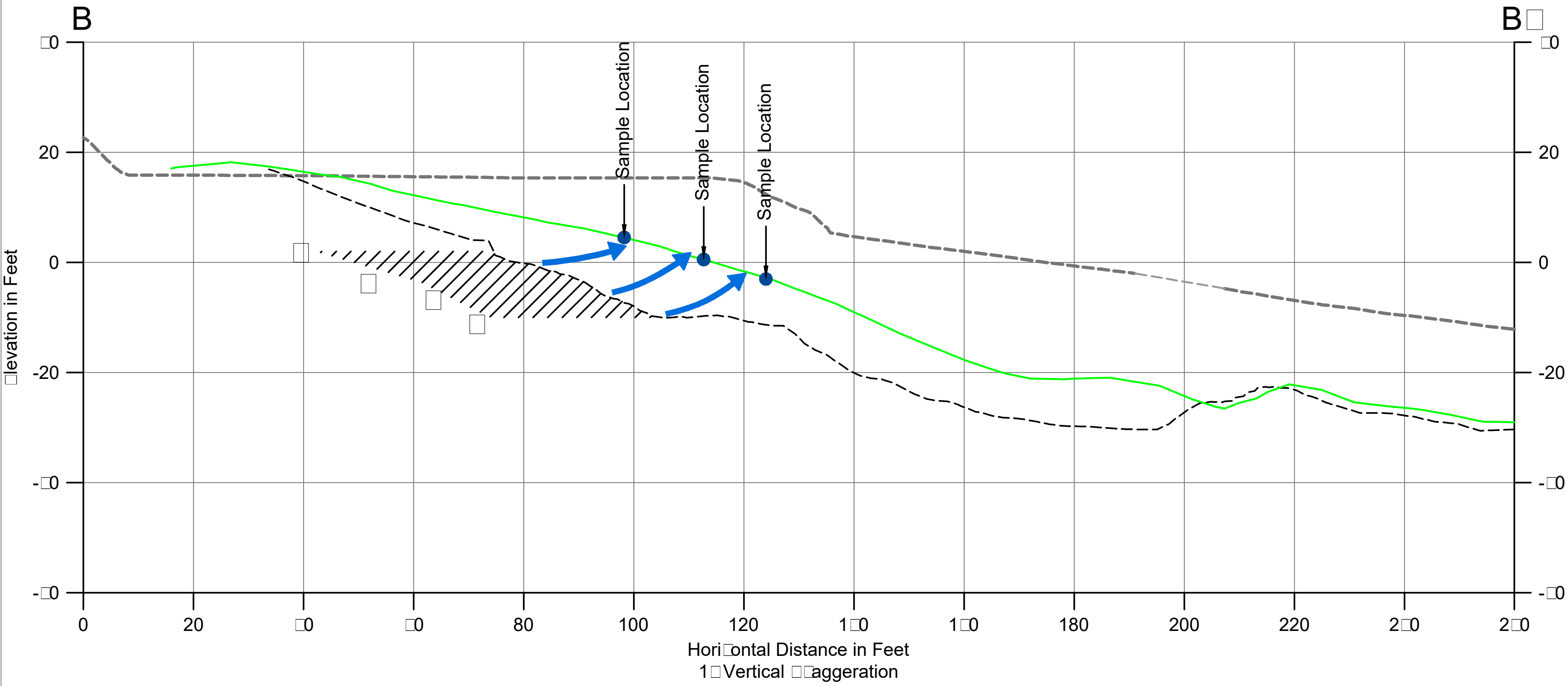
10	Post-construction Contours (2' Intervals)
SMA	Sediment Management Area
▨	Subtidal Dredge Sediment/ Wood Debris Deposit With Residuals Cover
▨	Intertidal Cap (Approx. 2'-3'-Thick)
🟩	Intertidal Excavation
🟦	Sand Cap (Approx. 4'-Thick)
🟨	EMNR (Approx. 6" Sand and/or Silt)
▨	Approximate Area of Wood Debris Under Cap
⊙	Proposed Subtidal Sentinel Surface Sediment Sample Aliquot Location
●	Proposed Intertidal Sentinel Surface Sediment Sample Aliquot Location
◐	Proposed Intertidal DGT (and Potential Bioassay) Sediment Sample Location - Capped Wood Debris

0 120
Feet

Publish Date: 2018/01/04 10:22 AM | User: chewett
Filepath: K:\Projects\0388-Pope Resources\Port Gamble Sediment Cleanup RI-FS\0388-WK-143 (MAF Porewater XS).dwg F4a

Figure 4a
Sediment Sampling Stations (SMA-2)

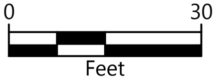
Appendix F: Operations, Maintenance, and Monitoring Plan
Port Gamble Bay Cleanup



SOURCE: Pre-construction bathymetry from eTrac, dated August 27, 2014. Post-dredge bathymetry from Orion. Post-cap and -backfill bathymetry from eTrac, dated January 19, 2017.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

LEGEND:

- Pre-construction Grade
- Post-dredge Grade
- Post-cap and -backfill Grade
- ▨ Approximate Wood Debris Seam Under Cap
- Approximate Groundwater Flow
- ● Proposed Sample Location



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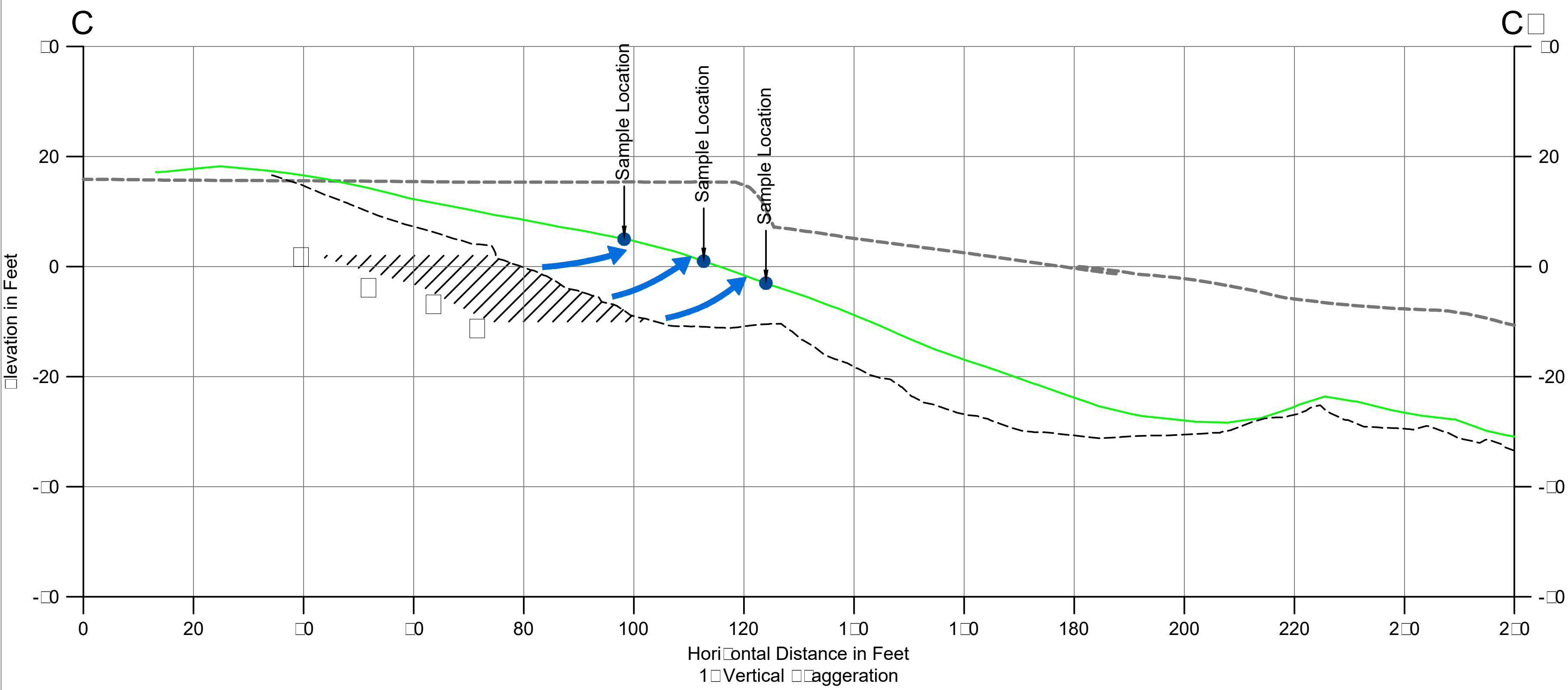
Filepath: K:\Projects\0388-Pope Resources\Port Gamble Sediment Cleanup RI-FS\0388-WK-143 (MAF Porewater XS).dwg F4b

ANCHOR QEA

Figure F-4b
Sediment Sampling Cross Section (SMA-2)

Appendix F: Operations, Maintenance, and Monitoring Plan
Port Gamble Bay Cleanup



SOURCE: Pre-construction bathymetry from eTrac, dated August 27, 2014. Post-dredge bathymetry from Orion. Post-cap and -backfill bathymetry from eTrac, dated January 19, 2017.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

LEGEND:

- Pre-construction Grade
- Post-dredge Grade
- Post-cap and -backfill Grade
- ▨ Approximate Wood Debris Seam Under Cap
- Approximate Groundwater Flow
- ● Proposed Sample Location

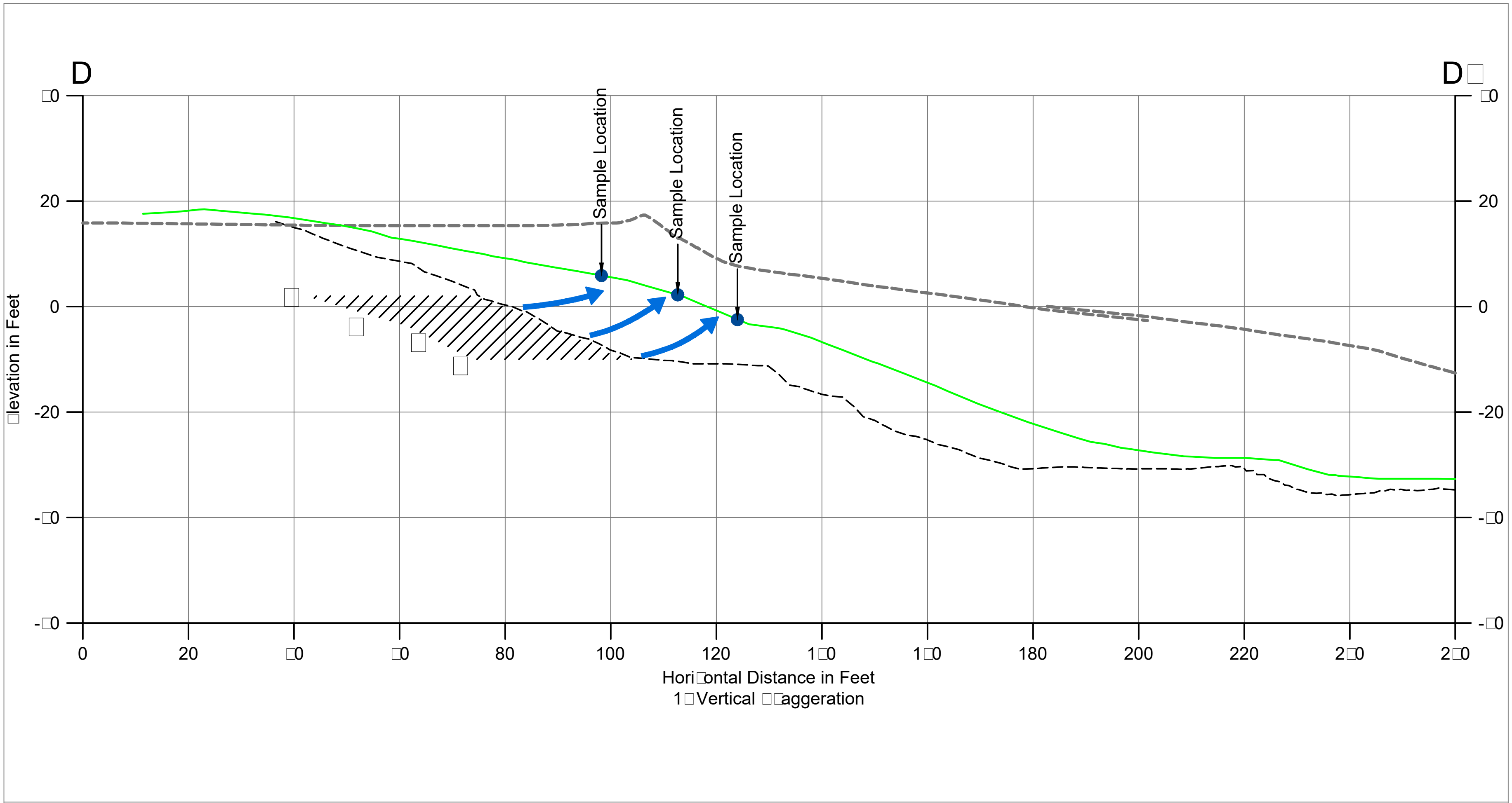
0 30
Feet

Publish Date: 2017/12/19 9:06 AM | User: chewett
Filepath: K:\Projects\0388-Pope Resources\Port Gamble Sediment Cleanup RI-FS\0388-WK-143 (MAF Porewater XS).dwg F4c

ANCHOR QEA

Figure F-4c
Sediment Sampling Cross Section (SMA-2)

Appendix F: Operations, Maintenance, and Monitoring Plan
Port Gamble Bay Cleanup



SOURCE: Pre-construction bathymetry from eTrac, dated August 27, 2014. Post-dredge bathymetry from Orion. Post-cap and -backfill bathymetry from eTrac, dated January 19, 2017.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

LEGEND:

- Pre-construction Grade
- Post-dredge Grade
- Post-cap and -backfill Grade
- ▨ Approximate Wood Debris Seam Under Cap
- Approximate Groundwater Flow
- ● Proposed Sample Location

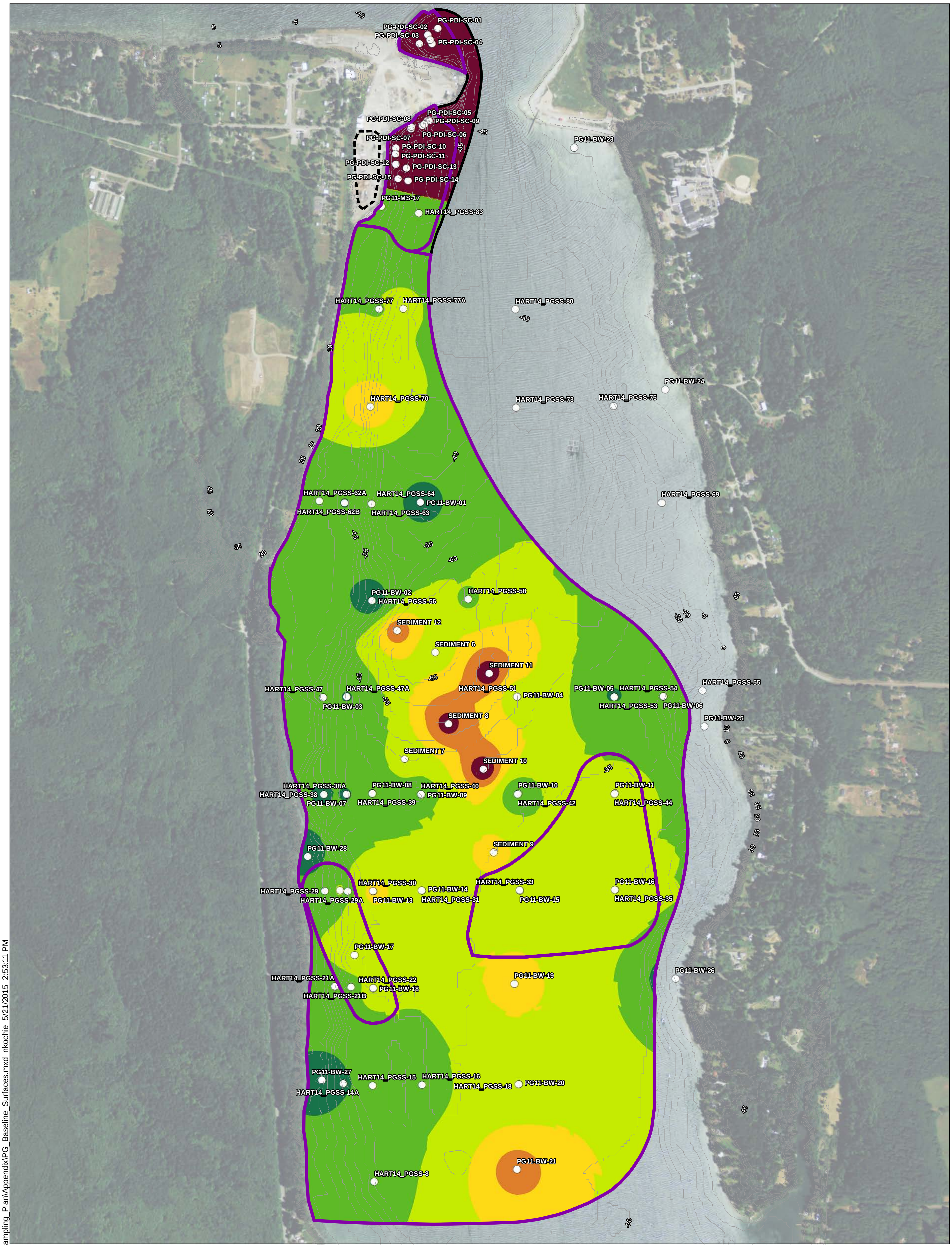
0 30
Feet

Publish Date: 2017/12/19 9:06 AM | User: chewett
Filepath: K:\Projects\0388-Pope Resources\Port Gamble Sediment Cleanup RI-FS\0388-WK-143 (MAF Porewater XS).dwg F4d

ANCHOR QEA

Figure F-4d
Sediment Sampling Cross Section (SMA-2)

Appendix F: Operations, Maintenance, and Monitoring Plan
Port Gamble Bay Cleanup



○ Sample Locations

Port Gamble SMA

▭ Sediment Management Area (SMA)

⬚ Proposed Upland Re-handling/Beneficial Reuse Area

▭ SWAC Area

cPAH TEQ (U=1/2 µg/kg)

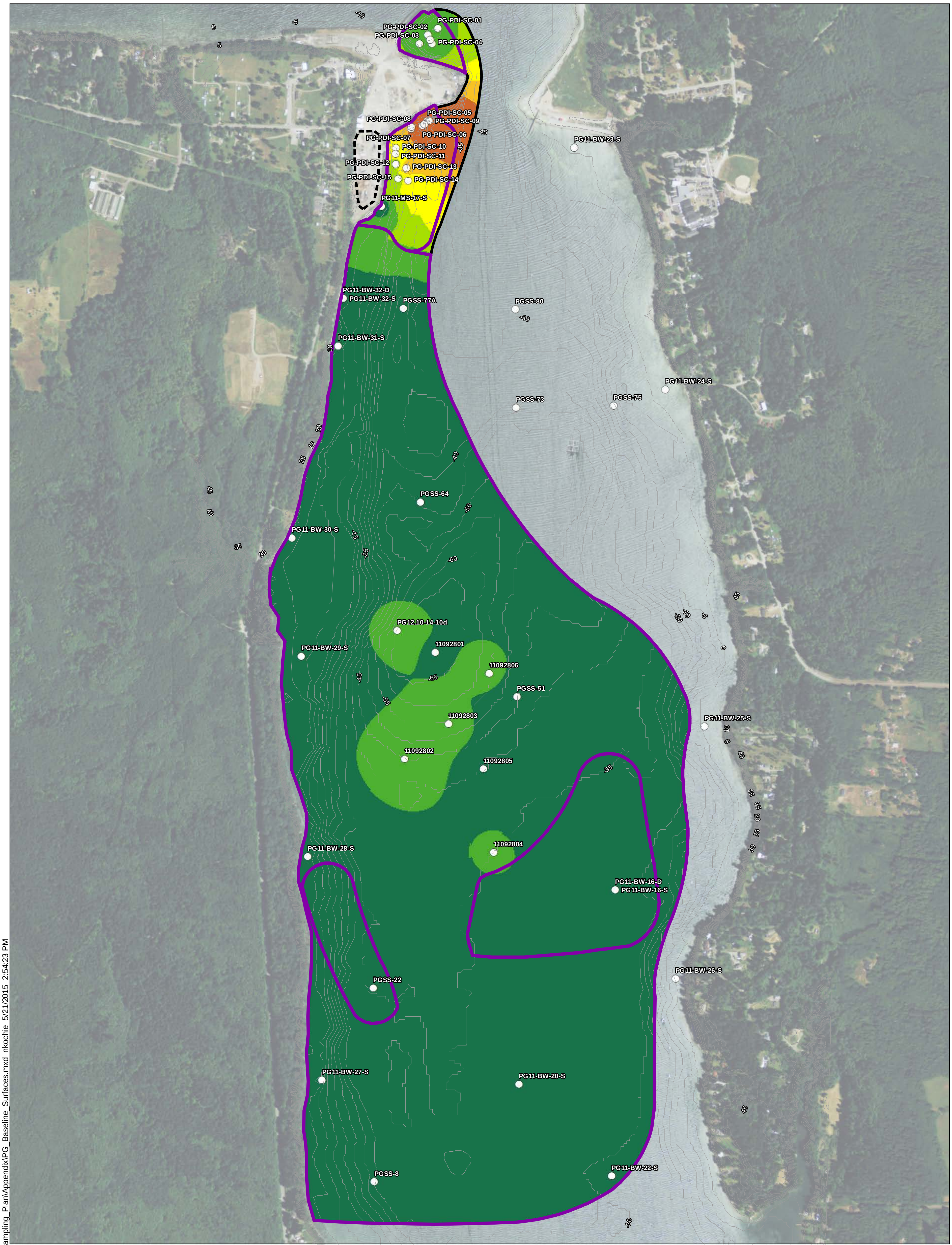
🟩	< 16
🟩	16 - 32
🟨	32 - 48
🟨	48 - 64
🟧	64 - 80
🟥	> 80

NOTE:
Site-wide area-weighted average
cPAH TEQ = 42.4 µg/kg

Feet
0 500 1,000

Q:\Jobs\080388-01_Port_Gamble_OPG\Maps\Reports\Sampling_Plan\Appendix\PG_Baseline_Surfaces.mxd nkochie 5/21/2015 2:53:11 PM

Figure F-5
Baseline (2010) Surface Sediment TEQ
Appendix F: Operations, Maintenance, and Monitoring Plan
Port Gamble Bay Cleanup



○ Sample Locations

Port Gamble SMA

▭ Sediment Management Area (SMA)

⬚ Proposed Upland Re-handling/Beneficial Reuse Area

▭ SWAC Area

DF TEQ (U=1/2 Mammal)

- 🟩 < 5
- 🟩 5 - 10
- 🟩 10 - 15
- 🟨 15 - 20
- 🟧 20 - 25
- 🟧 25 - 50
- 🟥 > 50

NOTE:
Site-wide area-weighted average dioxin/furan TEQ = 2.9 ng/kg

Feet
0 500 1,000

Q:\Jobs\080388-01_Port_Gamble_OPG\Maps\Reports\Sampling_Plan\Appendix\PG_Baseline_Surfaces.mxd nkochie 5/21/2015 2:54:23 PM

Figure F-6
Baseline (2010) Surface Sediment Dioxin/Furan TEQ
Appendix F: Operations, Maintenance, and Monitoring Plan
Port Gamble Bay Cleanup

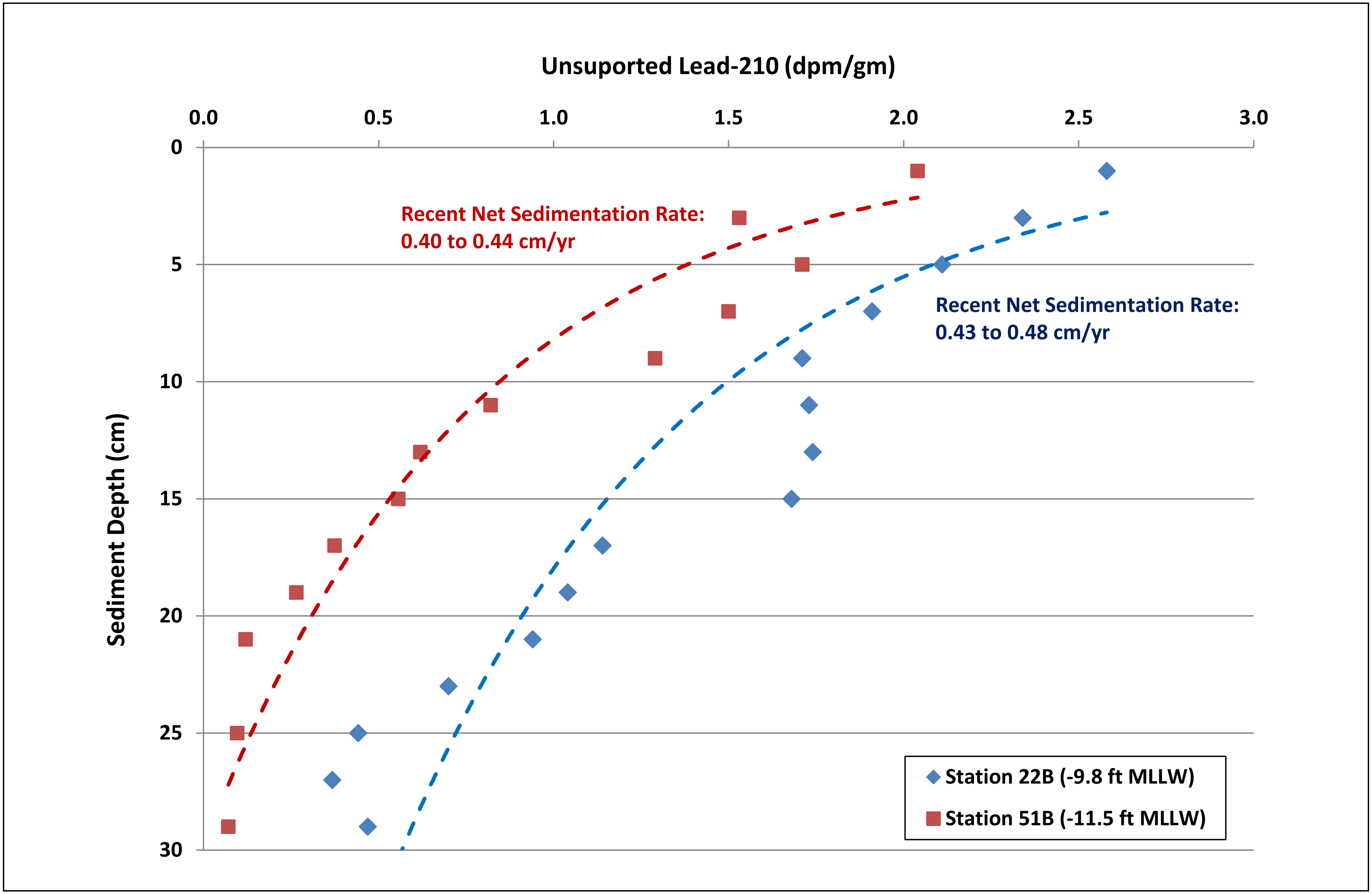


Figure F-7
Radioisotope Core Data: Central Port Gamble Bay
Appendix F: Operations, Maintenance, and Monitoring Plan
Port Gamble Bay Cleanup

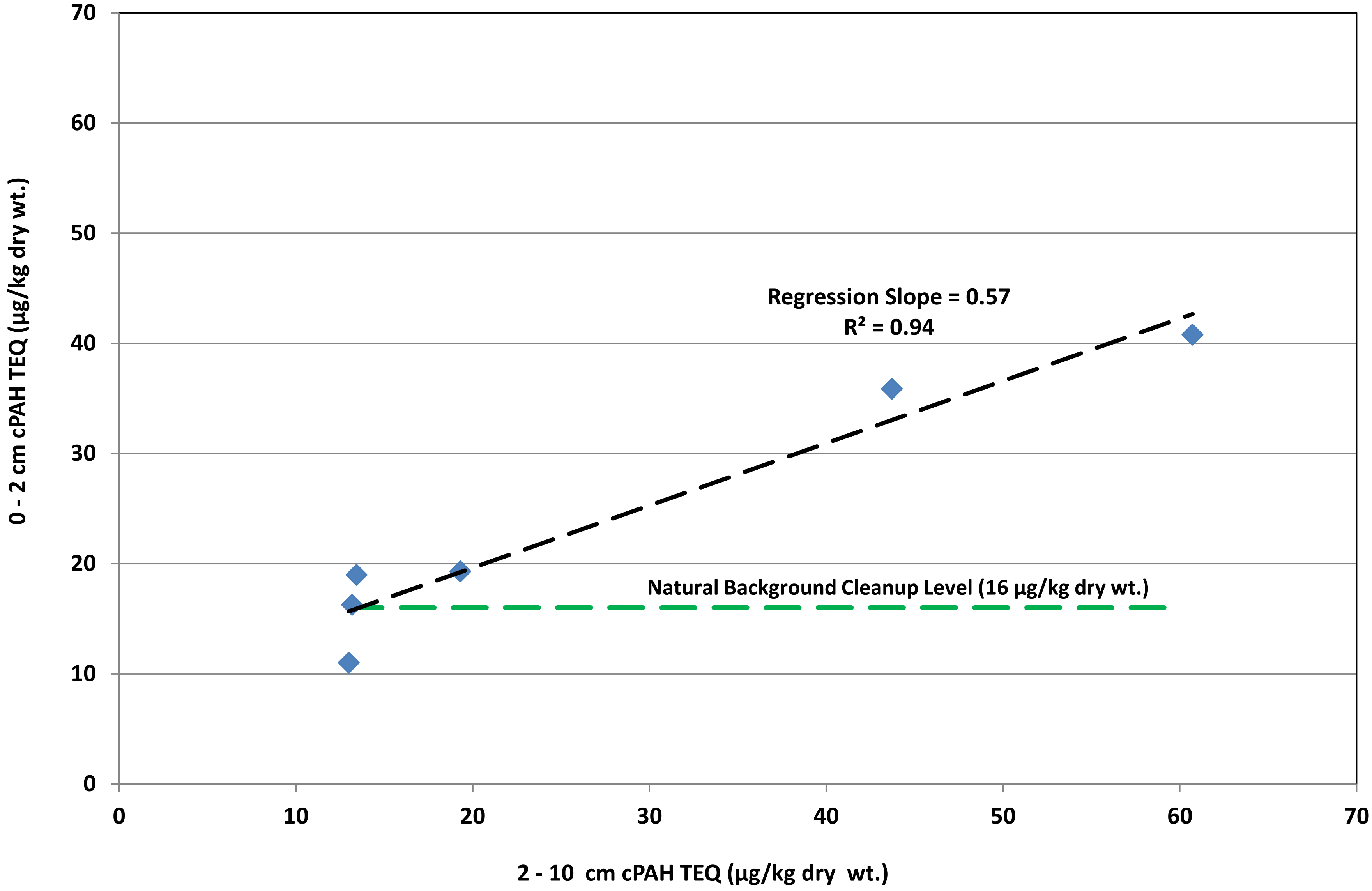


Figure F-8

Comparison of Near-Surface Sediment cPAH Concentrations in SMA-5
Appendix F: Operations, Maintenance, and Monitoring Plan
Port Gamble Bay Cleanup

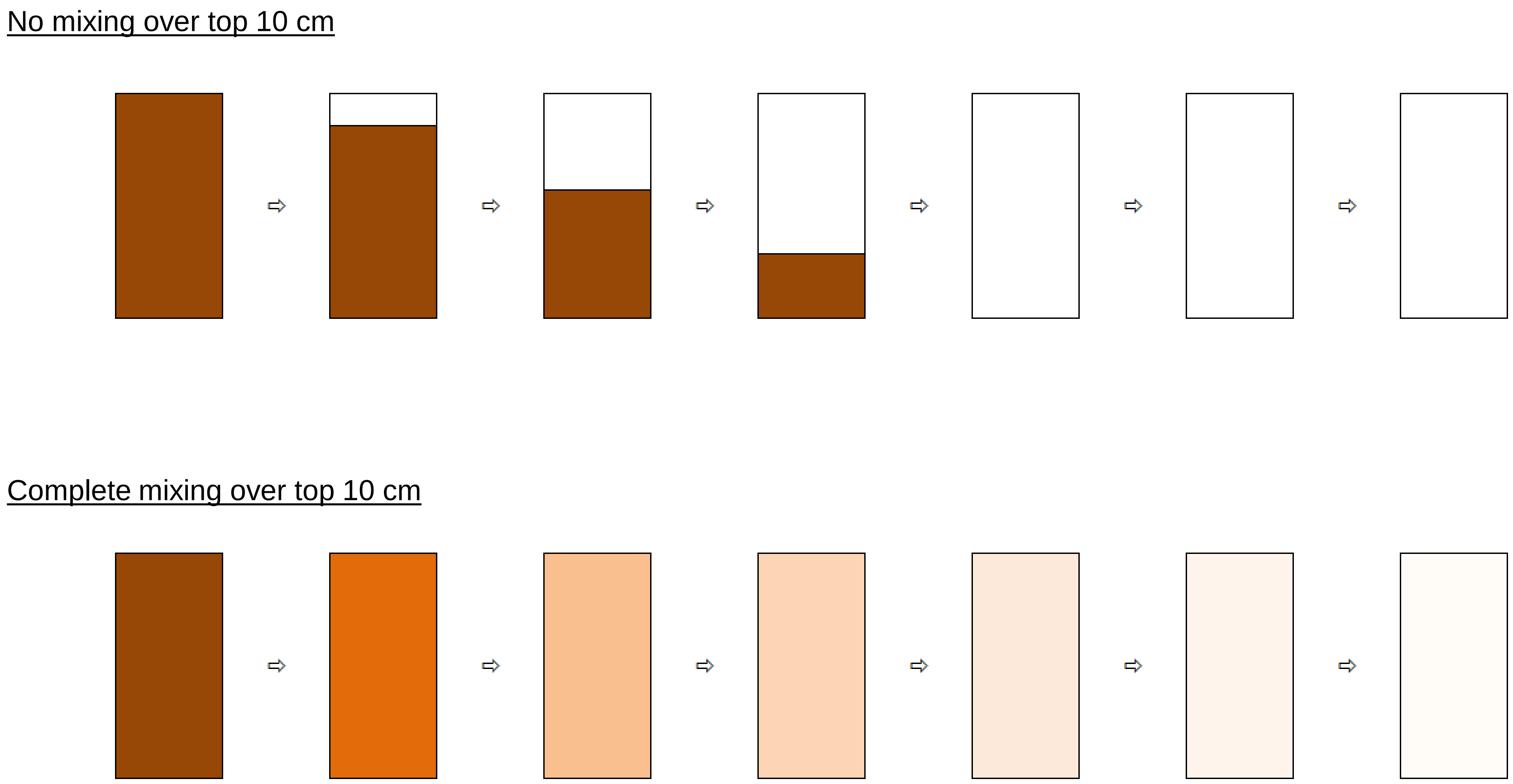


Figure F-9

Schematic Depicting Bounding Natural Recovery Calculations
Appendix F: Operations, Maintenance, and Monitoring Plan
Port Gamble Bay Cleanup

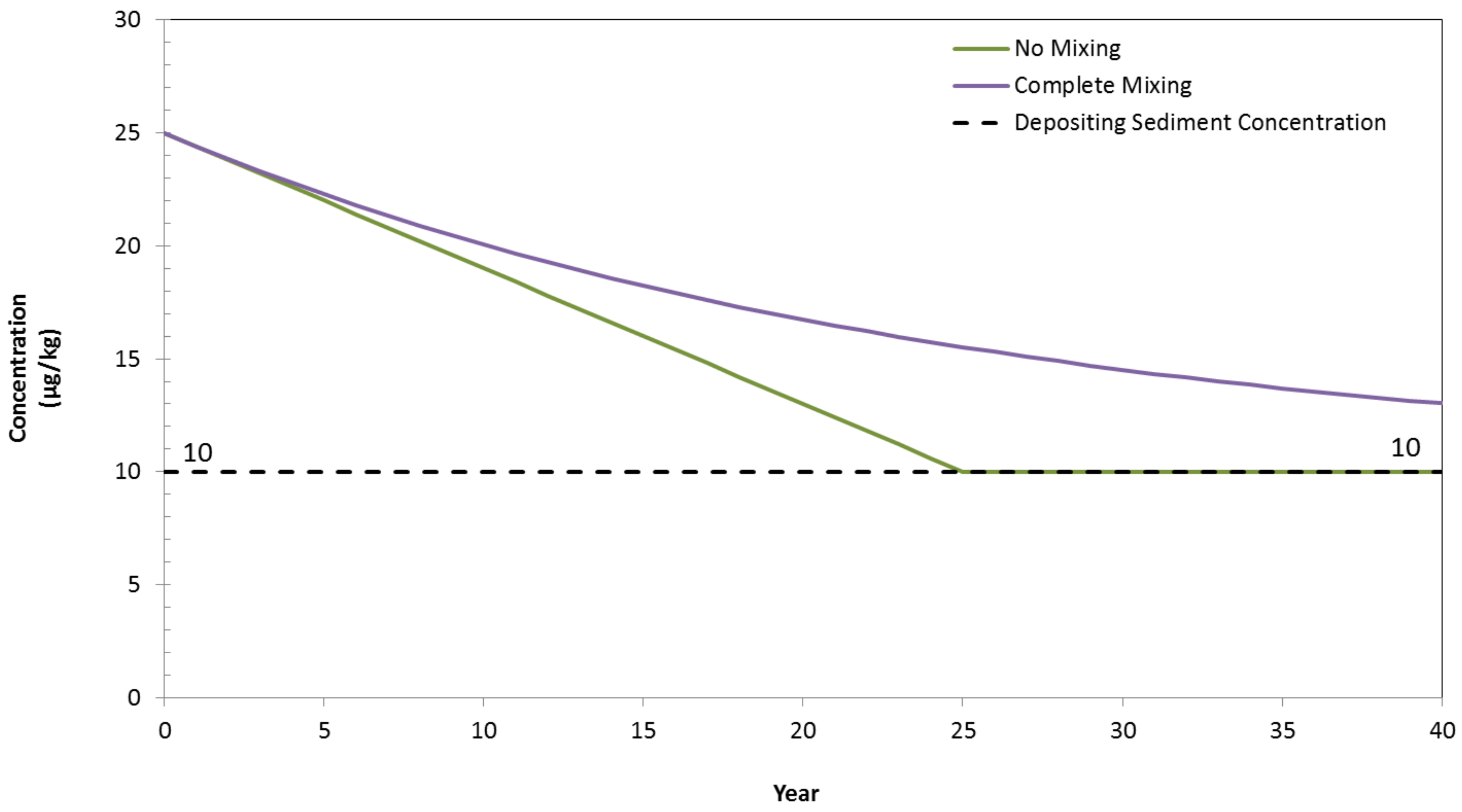


Figure F-10
Example Bounding Calculation Model Results
Appendix F: Operations, Maintenance, and Monitoring Plan
Port Gamble Bay Cleanup

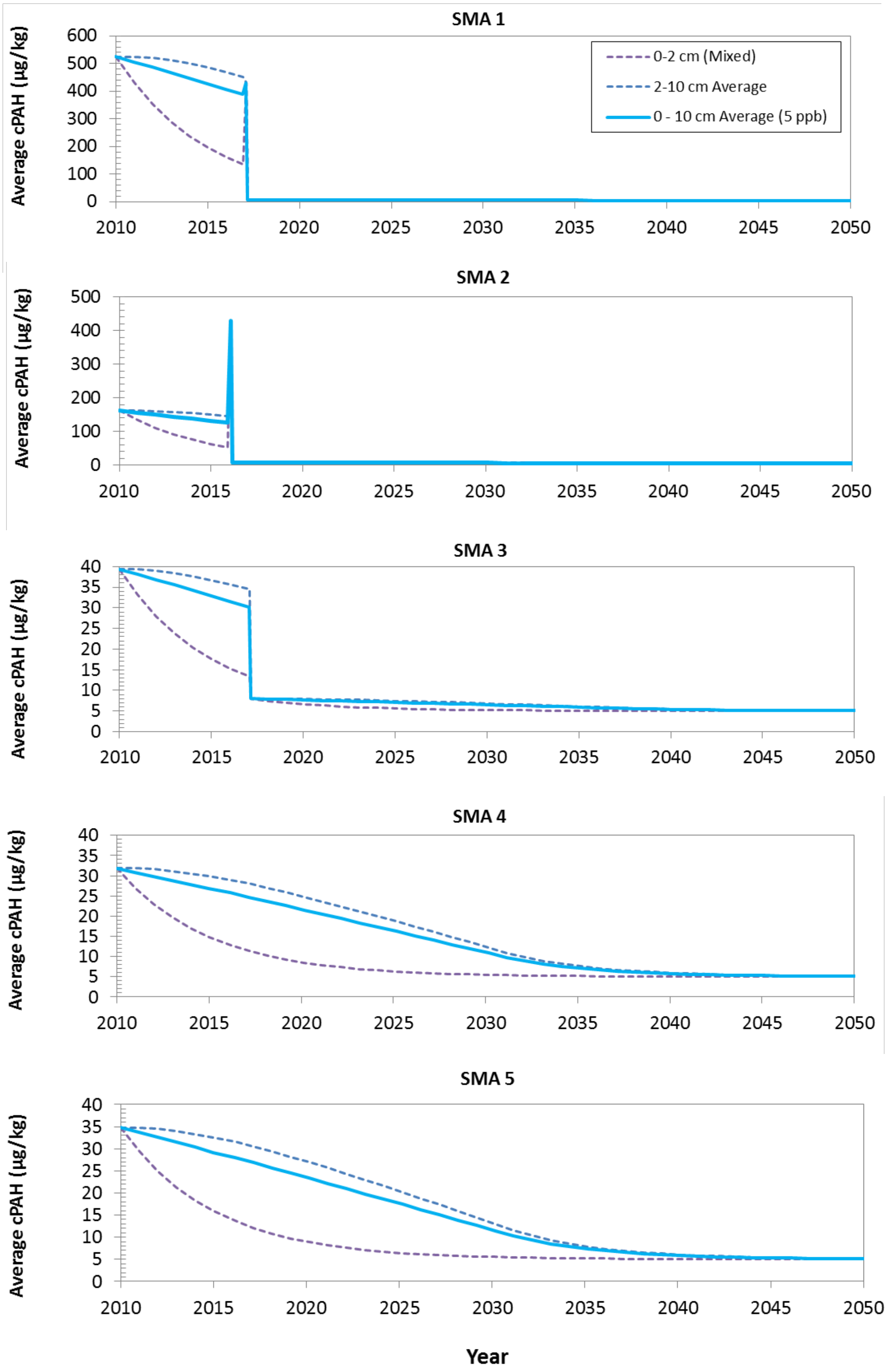


Figure F-11

SMA-specific Model Results Assuming 5 µg/kg on Depositing Sediment
Appendix F: Operations, Maintenance, and Monitoring Plan
Port Gamble Bay Cleanup

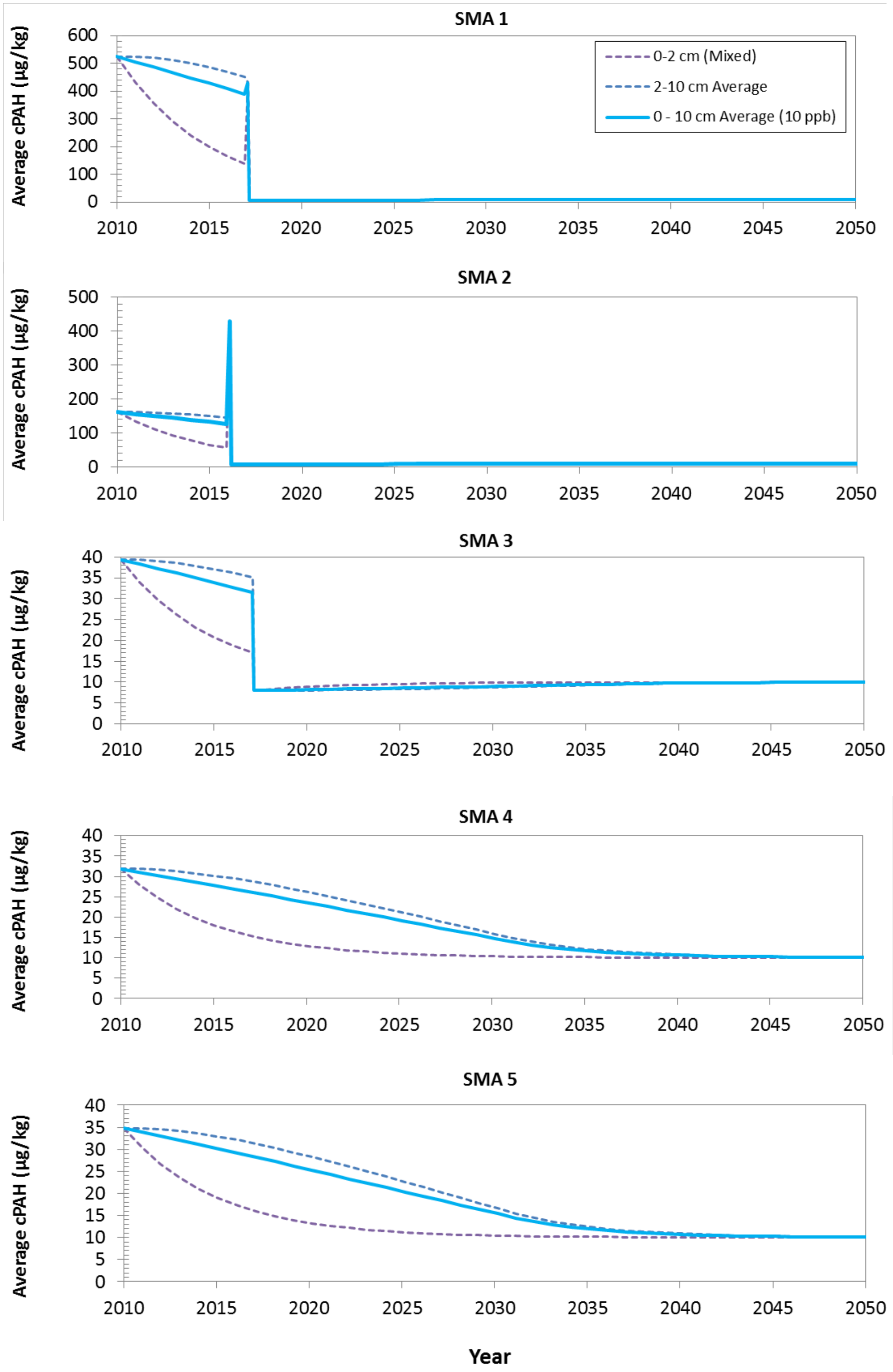


Figure F-12
SMA-specific Model Results Assuming 10 µg/kg on Depositing Sediment
Appendix F: Operations, Maintenance, and Monitoring Plan
Port Gamble Bay Cleanup

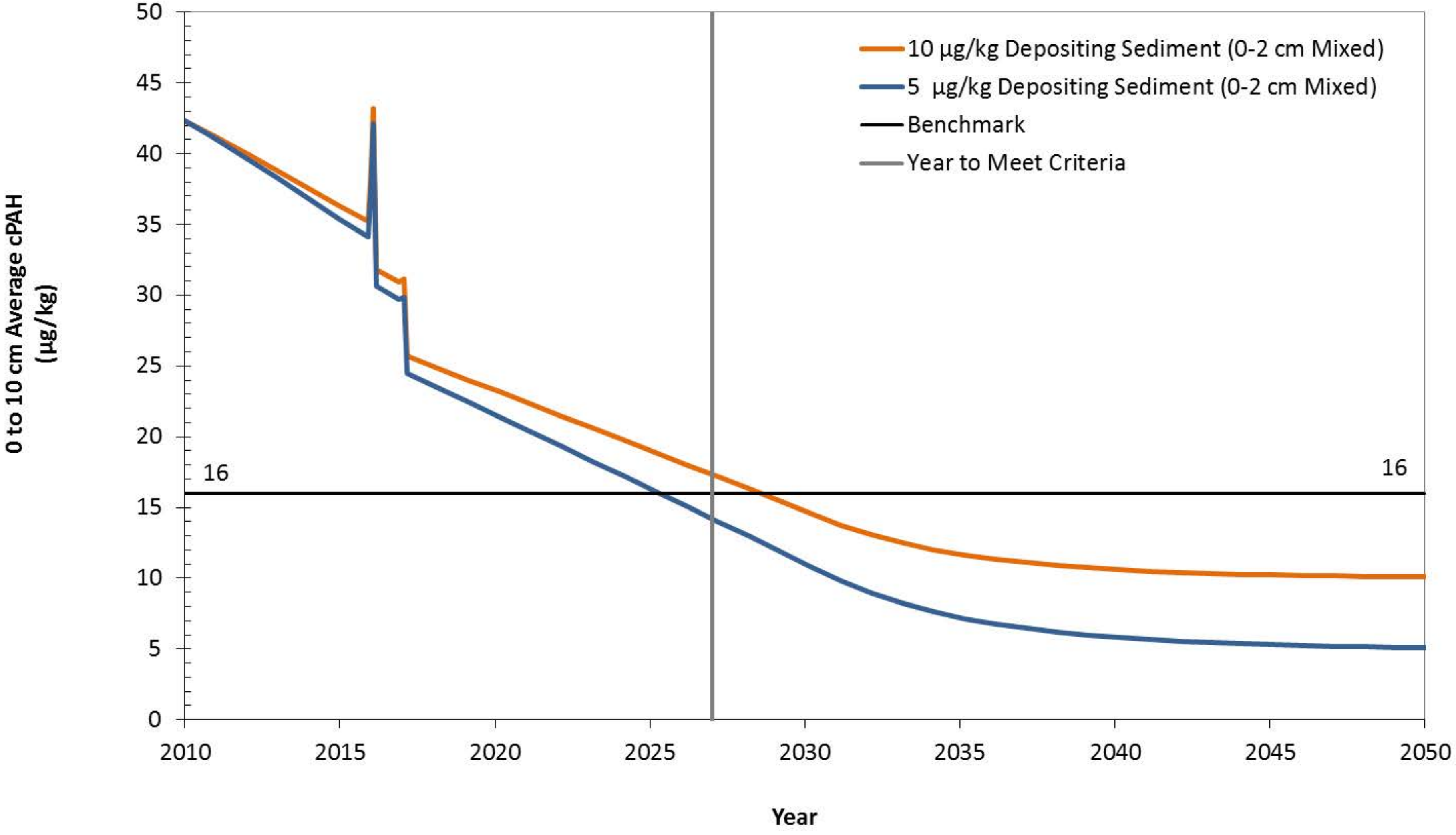
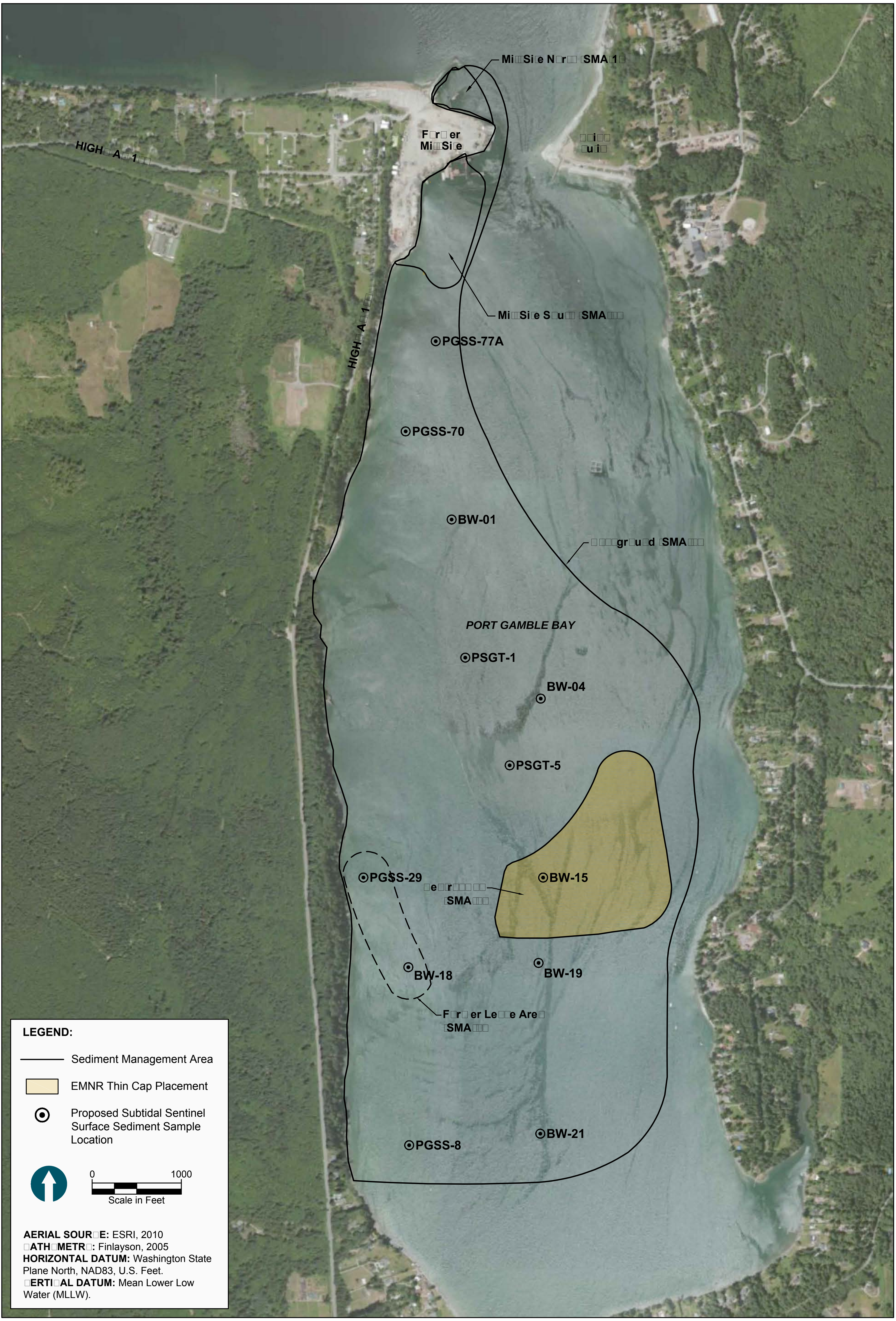


Figure F-13

Modeled Site-wide Surface Sediment cPAH Concentrations
Appendix F: Operations, Maintenance, and Monitoring Plan
Port Gamble Bay Cleanup



AERIAL SOURCE: ESRI, 2010
BATHYMETRY: Finlayson, 2005
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

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Figure F-1□
Surface Sediment Sampling Stations, Port Gamble Bay
Appendix F: Operations, Maintenance and Monitoring Plan
Port Gamble Bay Cleanup

ATTACHMENT F-1
SAMPLING AND ANALYSIS PLAN

TABLE OF CONTENTS

List of Tables

List of Attachments

LIST OF ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
AgI	silver iodide
Ag_2S	silver sulfide
ASTM	American Society for Testing and Materials
CCV	continuing calibration verifications
cm	centimeter
COC	chain-of-custody
cPAH	carcinogenic polycyclic aromatic hydrocarbon
DGPS	differential global positioning system
DGT	diffusive gradient thin sheet
DMMP	Dredge Material Management Program
Ecology	Washington State Department of Ecology
FC	Field Coordinator
GC/MS	gas chromatograph/mass spectrometer
H_2S	hydrogen sulfide
HDPE	high-density polyethylene
mL	milliliter
MLLW	mean lower low water
MSS	Marine Sampling Systems
NAD83	North American Datum 1983
OD	optical densitometer
OMMP	*Operations, Maintenance, and Monitoring Plan*
PSEP	Puget Sound Estuary Program
QA/QC	quality assurance/quality control
QAPP	*Quality Assurance Project Plan*
SAP	*Sampling and Analysis Plan*
Site	Port Gamble Bay Cleanup Project Site
SMA	Sediment Management Area
SMS	Sediment Management Standards
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency

1 INTRODUCTION

This *Sampling and Analysis Plan* (SAP) describes sampling and analysis activities for long-term monitoring in Port Gamble Bay, Washington (the "Site"). This SAP is appended to the *Operations, Maintenance, and Monitoring Plan* (OMMP). Attachment F-2 of the OMMP is the *Quality Assurance Project Plan* (QAPP). This SAP provides information specific to the collection and analysis of intertidal and subtidal sediment core samples, and collection of surface sediment grab samples for Site-specific chemicals of concern (carcinogenic polycyclic aromatic hydrocarbons [cPAHs], dioxins/furans, and cadmium) and bioassays.

This document summarizes the sampling plan, field sampling methods, and analytical and biological laboratory procedures. This SAP was prepared following the Washington State Department of Ecology (Ecology) *Sediment Sampling and Analysis Plan Appendix* guidance document (Ecology 2008). Analytical quality assurance/quality control (QA/QC) procedures were also developed based on the analytical protocols and QA guidance of the Puget Sound Estuary Program (PSEP) and U.S. Environmental Protection Agency's (USEPA's) *EPA Contract Laboratory Program National Functional Guidelines for Data Review* (USEPA 1999, 2004). All sample handling and biological analyses will follow the most recent PSEP protocols (PSEP 1986 as updated in 1989, 1991, 1995, and 1997). Biological analyses will follow Sediment Management Standards (SMS) Clarification Paper *Bioassay Endpoint Refinements: Bivalve Larval and Neanthes Growth Bioassays* (Kendall 2013).

2 SAMPLE PROCESS DESIGN

Long-term surveys and sampling and analysis plans for the Site are summarized in Sections 2.1 through 2.4.

2.1 Field Surveys

Field surveys will be conducted in the subtidal, intertidal, and upland areas to determine the stability of the Site following construction. Immediately following construction completion, a comprehensive survey was performed to document post-construction elevations. The post-construction survey will be subsequently compared to monitoring surveys. Bathymetric and topographic survey elements will be integrated into a single elevation contour surface to allow for comparison of the post-construction elevations. For consistency, the bathymetric and topographic surveys will be performed in accordance with applicable guidance.

Bathymetric survey will be performed using multi-beam survey equipment in subtidal and lower intertidal areas to determine mudline elevations. The multi-beam surveys will be conducted by a licensed surveyor and will meet or exceed the accuracy standards of +/- 0.2 feet as referenced in the U.S. Army Corp of Engineers (USACE) Hydrographic Survey Manual, April 2004 Revision (USACE 2004).

Topographic surveys will be conducted in the upper intertidal and upland Site areas to identify changes in elevations. For upper intertidal cap areas not included in the bathymetric survey, a topographic survey will be performed using established control points as part of long-term monitoring to identify changes in shoreline sloping cap elevations. The topographic surveys will be conducted by a licensed surveyor and will meet or exceed the accuracy standards of +/- 0.1 foot as referenced in the USACE Control and Topographic Surveying Manual, January 2007 (USACE 2007).

Following the completion of the bathymetric and topographic surveys, a licensed surveyor will integrate the bathymetric and topographic elevation contours into a single set of elevation contours. These contours will then be evaluated by Computer Aided Drafting isopach methodology. This comparison will be used to identify zones of accretion, settlement, or erosion.

2.2 Sediment Cap Physical Integrity Core Collection and Processing

As discussed in the OMMP, sediment core sampling may be performed in the intertidal and/or subtidal cap areas where topographic and/or bathymetric survey data suggest possible cap settlement and/or erosion of cap thicknesses. At these locations, cores would be advanced to a minimum depth of 1 foot below the cap thicknesses described in the Engineering Design Report.

2.3 Sediment Quality Confirmation Monitoring at Sentinel Cap Locations

Surface sediment quality monitoring will be conducted at six designated sentinel intertidal and subtidal sampling stations composed of 5-point aliquots representative of the sediment management area (SMA)-1 and SMA-2 cap areas (see Figures F-3a and F-4a of the accompanying OMMP). Samples will be collected using a van Veen grab sampler or equivalent deployed from a winch line on a sampling vessel. Sample aliquots in intertidal areas may be collected directly from the cap surface during low tide using hand tools (e.g., hand auger steel spoons or scoops). The sediment samples will be collected from the 0- to 10-centimeter (cm) biologically active zone, composited, and submitted for analysis of cPAHs, dioxin/furans, cadmium, and larval bioassays.

2.4 Confirmation Monitoring in Nearshore Wood Debris Cap Locations

Surface sediment quality monitoring will also be conducted within two areas where buried nearshore wood debris deposits that could not be practicably removed were capped along the shoreline (i.e., within the North Basin in SMA-1 and the Former Pier 4 Area in SMA-2). Sediment monitoring in nearshore wood debris cap locations will consist of initial passive in situ diffusive gradient thin sheet (DGT) monitoring of porewater total free sulfide. DGT probes will be advanced at three locations along a single transect in SMA-1 (total of three locations), and at three locations along three parallel transects in SMA-2 (total of nine locations). At each of these twelve DGT sampling locations, probes will be installed at two depth intervals, approximately 6 and 24 inches below the mudline, respectively, for a total of six sample points in SMA-1 and 18 sample points in SMA-2. If the probe encounters refusal above the 24-inch depth, two additional attempts will be conducted within approximately 3 feet of the original sample location; if all three attempts are unsuccessful, the attempts will be documented, and no deep DGT deployment will be conducted at that location.

Following an approximate 24-hour DGT deployment period, representative surface sediment (approximately 6 inches below mudline) porewater temperature, pH, and salinity measurements will be conducted at all twelve porewater sampling locations during low tide conditions (i.e., at the time the DGTs are retrieved). Surface sediment (6-inch depth) temperature, pH, and salinity will also be representative of the underlying shallow subsurface (24-inch depth) interval. Porewater H_2S concentrations will be calculated based on field optical densitometry of the DGT gels and concurrent temperature, pH, and salinity data.

Bioassay sampling at discrete surface sample locations will be conducted following DGT retrieval and calculation of porewater H_2S concentrations. Surface sediment samples for bioassay analyses will be collected at all sample locations with a surface (6-inch depth) or subsurface (24-inch depth) porewater H_2S concentration greater than 0.07 mg/L, the risk-based sediment porewater H_2S benchmark developed by Ecology for Port Gamble Bay. If all surface or shallow subsurface porewater H_2S concentrations along a transect are less than 0.07 mg/L, then a single bioassay sample will be collected from each transect (one in SMA-1 and three in SMA-2) at the transect location with the highest porewater H_2S concentration. If all porewater H_2S concentrations within a transect are below detection limits, the location along the transect with the lowest porewater salinity measurement will be selected for bioassay analysis. In any event, a minimum of one surface sediment bioassay sample will be collected from each of the four transects (one in SMA-1 and three in SMA-2).

The bioassay testing that will be performed on targeted surface sediment samples collected from within the targeted nearshore wood debris cap locations will include the following suite of SMS bioassays (two acute and one chronic test):

- Larval Development Acute Test (using the SMS resuspension method, either with bivalve or echinoderm organisms, depending on seasonal availability)
- 10-day Amphipod Survival Acute Test
- 20-day Juvenile Polychaete Growth Chronic Test

2.5 Natural Recovery Sediment Quality Monitoring

Surface sediment recovery sampling will be performed at a total of 12 sentinel monitoring locations in SMA-3, SMA-4, and SMA-5 (see Figure F-14 of the accompanying OMMP) to verify natural recovery at the Site. Samples will be collected using a van Veen grab sampler or equivalent deployed from a winch line on a sampling vessel. The sediment samples will be collected from the 0- to 2-cm and 2- to 10-cm intervals; homogenized; submitted for cPAH, dioxin/furan, and cadmium analysis; and compared to baseline (2014) concentrations to characterize surface sediment natural recovery trends. The frequency of the long-term natural recovery monitoring at the Site is defined in the OMMP.

3 SAMPLING METHOD REQUIREMENTS

This section addresses the sample collection and processing procedures that will be used to ensure data quality from sample collection to sample processing. Specifically, this section describes collection, subsampling, compositing, sample scheduling, positioning, identification, field QA, and waste management.

3.1 Sediment Cap Physical Integrity Core Collection and Processing

Sections 3.1.1 and 3.1.2 describe the collection, processing, and handling procedures for the collection of sediment core samples.

3.1.1 Sediment Cap Physical Integrity Core Collection Procedures

As discussed in the OMMP, sediment cores will be collected using vibracore or other similar methods at intertidal and/or subtidal locations as may be identified from the topographic/bathymetric surveys. The vibracore will use a rigid external tube approximately 4 inches in diameter and may use either polycarbonate liners or a dedicated aluminum tube. The vibracore will be lowered to the cap surface, where the unit will then be energized and allowed to penetrate. The cores will be advanced to a minimum depth of approximately 1 foot below the below the cap design thickness. Acceptance criteria for a sediment core sample are as follows:

- The core penetrated and retained sediment material underlying the cap. If core refusal occurs before the required depth, an additional core will be advanced within 6 inches of the original position. Relocations will be made along depth contours generally parallel to the shore.
- Recovery was at least 75% of the length of core penetration.
- Cored material did not extend out the top of the core tube or contact any part of the sampling apparatus at the top of the core tube.
- There were no obstructions in the cored material that might have blocked the subsequent entry of sediment into the core tube and resulted in incomplete core collection.

The following procedure will be used to decontaminate core sample tubes prior to use:

- Rinse and pre-clean with tap water
- Wash and scrub in a solution of laboratory grade, non-phosphate-based soap and tap water
- Rinse with tap water
- Rinse three times with distilled water
- Seal both ends of each core tube with aluminum foil

The core tube caps will be removed immediately prior to placement into the coring device. Care will be taken during sampling to avoid contact of the sample tube with potentially contaminated surfaces. Extra sample tubes will be available during sampling operations for uninterrupted sampling in the event of a potential core tube breakage or contamination. Core tubes suspected to have been accidentally contaminated will not be used. Logs and field notes of all core samples will be maintained as samples are collected and correlated to the sampling location map. The following information will be included in the logs:

- Elevation of each station sampled as measured from mean lower low water (MLLW)
- Location of each station as determined by differential global positioning system (DGPS)
- Date and time of collection of each sediment core sample
- Names of Field Coordinator (FC) and person(s) collecting and handling the sample
- Observations made during sample collection including complications and other details associated with the sampling effort
- The sample station identification
- Length and depth intervals of each core section and estimated recovery for each sediment sample as measured from MLLW
- Qualitative notation of apparent resistance of sediment column to coring
- Any deviation from the approved SAP

3.1.2 Sediment Cap Physical Integrity Core Processing Procedures

The core processing station will either be located at an upland location adjacent to the Site or at the analytical laboratory. Transported cores will be handled consistent with American Society for Testing and Materials (ASTM 2007) procedures (ASTM D 4220) and stored upright in the analytical laboratory refrigerators or on site until processed. Filled sample containers will be stored in coolers containing ice to maintain the samples at 4 degrees Celsius (°C) ±2°C until delivery or shipping to the analytical laboratory.

All working surfaces and instruments will be thoroughly cleaned, decontaminated, and covered with aluminum foil to minimize outside contamination between sampling events. Disposable gloves will be discarded after processing each station and replaced prior to handling decontaminated instruments or work surfaces.

The steps for processing the samples are as follows:

1. Cut core longitudinally using a circular saw or power shears, taking care not to penetrate the sediment while cutting.
2. Use decontaminated utensils to split the core to expose the center of the two halves for sampling.
3. Photograph the entire length of the core.
4. Record the description of the core sample on the core log form for the following parameters as appropriate and present:
    - Sample recovery (depth in feet of penetration and sample compaction)
    - Physical soil description in accordance with the Unified Soil Classification System (includes soil type, density/consistency of soil, and color)
    - Odor (e.g., hydrogen sulfide or petroleum)
    - Vegetation
    - Debris
    - Biological activity (e.g., detritus, shells, tubes, bioturbation, or live or dead organisms)
    - Visual stratification, structure, and texture
    - Presence of oil sheen
    - Any other distinguishing characteristics or features

3.2 Sediment Cap Quality Confirmation Monitoring Collection and Processing

Sections 3.2.1 and 3.2.2 describe the collection, processing, and handling procedures for the collection of surface sediment samples for bioassay recovery and chemicals of concern monitoring.

3.2.1 Sediment Cap Quality Confirmation Monitoring Sample Collection Procedures – Sentinel Locations

As discussed in the OMMP, surface sediment grab samples will be conducted at six designated sentinel intertidal and subtidal stations in SMA-1 and SMA-2, each composed of 5-point aliquots from the 0- to 10-cm interval. Samples from each location will be archived and also composited for each sentinel location and submitted for chemical (i.e., cPAHs, dioxins/furans, and cadmium) and larval bioassay analyses. In addition, location BW-15 within SMA-3 will be submitted for larval bioassay analyses, which will be collected from a single 0- to 10-cm grab sample (not a 5-point composite). Samples will be collected using a van Veen type hydraulic power grab sampler, in accordance with PSEP protocols (1997). Sample aliquots in intertidal areas may be collected directly from the cap surface, during low tide, using hand tools (e.g., hand auger steel spoons or scoops). The target locations and coordinates for each sentinel station are included in Table F-1-1. Samples will be collected in the following manner in accordance with the PSEP protocols:

- The vessel will be maneuvered to the proposed location.
- The sampler will be decontaminated.
- The sampler will be deployed to the bottom.
- The winch cable to the grab sampler will be drawn taut and vertical.
- Location coordinates of the cable hoist will be recorded by the location control person.
- The sediment sample will be retrieved aboard the vessel and evaluated against the following PSEP acceptability criteria:
  - Grab sampler is not overfilled (i.e., sediment surface is not against the top of the sampler).
  - Sediment surface is relatively flat, indicating minimal disturbance or winnowing.
  - Overlying water is present, indicating minimal leakage.
  - Overlying water has low turbidity, indicating minimal sample disturbance.

  - Desired penetration depth of at least 10 cm is achieved.

- Overlying water will be siphoned off.
- Observations (i.e., texture, odor, presence/absence of vegetation, debris, and any other distinguishing characteristics) will be recorded on the sample collection forms (Attachment F-1-1).
- A stainless steel trowel or similar device will be used to collect the top 10 cm of sediment, taking care not to collect sediment in contact with the sides of the sampling device, and placed in a stainless steel bowl.

Sediment samples that meet the above collection criteria will be processed as described below.

3.2.2 Sediment Cap Quality Confirmation Sample Processing Procedures – Sentinel Locations

Sediment grab processing will be conducted aboard the sampling vessel. All working surfaces and instruments will be thoroughly cleaned, decontaminated, and covered with aluminum foil to minimize outside contamination between sampling stations. Disposable gloves will be discarded after processing each station and replaced prior to handling decontaminated instruments or work surfaces. The steps for processing the samples are as follows:

- Place the grab on a stable surface. Remove any overlying water using a syphon hose or turkey baster. Following grab acceptance criteria listed in Section 3.2.1, determine whether the grab is acceptable.
- After noting their presence, remove any large objects or debris from the sediment surface.
- Prior to sampling, color photographs may be taken, and a sediment description of each grab will be recorded on a grab sampling log form (Attachment F-1-1). Record the description of the grab sample on the grab log form for the following parameters as appropriate and present:
  - Sample recovery (depth in inches or centimeters of recovery in the grab sampler.

  - Physical soil description of the grab in accordance with the Unified Soil Classification System (includes soil type, density/consistency of soil, moisture, and color)
  - Odor (e.g., hydrogen sulfide and petroleum)
  - Note any vegetation
  - Debris
  - Biological activity (e.g., detritus, shells, tubes, bioturbation, or live or dead organisms)
  - Presence of oil sheen
  - Any other distinguishing characteristics or features

- Using a clean spoon, place sample material from the top 10 cm for chemical and larval bioassay testing into a clean, stainless steel bowl or high-density polyethylene (HDPE) bucket. To avoid cross contamination, take care to remove only sediment that has not come into contact with the sides or bottom of the grab. Cover bowl with aluminum foil until each aliquot station has been collected.
- After material has been collected from each aliquot station, the material will combined and homogenized until a uniform color and consistency is achieved.
- Immediately after filling the sample container with sediment, place the screw cap on the sample container and tighten.
- Thoroughly check all sample containers for proper identification, analysis type, and lid tightness.
- Pack each container carefully to prevent breakage and place inside of a cooler with ice for storage at the proper temperature (4°C ±2°C for all samples).

Samples will be submitted for testing as presented in Table F-1-1. In addition, sample mass will be collected at location BW-15 from within SMA-3, and submitted for larval bioassay analysis. The BW-15 bioassay sample will be collected from a single 0- to 10-cm grab sample (not a 5-point composite).

3.2.3 Sediment Cap Quality Confirmation Monitoring Sample Collection Procedures – Nearshore Wood Debris Cap Locations

As discussed in the OMMP, DGT sampling probes will be advanced along four transects (A through D; Figures F3a and F4a), within SMA-1 and SMA-2, at mudline elevations ranging from approximately +5 feet MLLW to approximately -3 feet MLLW. The target coordinates for each station are included in Table F-1-1, but may be adjusted in the field based on accessibility.

Probes will be installed by hand during low tide conditions to confirm proper installation. After an approximate 24-hour equilibration period, visual confirmation will be made to verify the DGT has remained embedded in the sediments prior to retrieval. The extracted sampling assemblies will be flushed with deionized water and placed in a cool environment until analysis. Representative surficial porewater temperature, pH, and salinity will be measured using probes inserted along the each transect as the tide recedes prior to retrieval of the DGT sample probes.

Surface sediment bioassay sampling at discrete sample locations will be conducted following the DGT sampling, as discussed in Section 2.4. Bioassay sample collection will follow the same collection procedures as described in Section 3.2.1 for collection of surface sediment grab samples at sentinel cap locations.

3.2.4 Sediment Cap Quality Confirmation Sample Processing Procedures – Nearshore Wood Debris Cap Locations

The DGT sampling method uses silver iodide (AgI), a white powder, impregnated in a gel. The AgI reacts with dissolved total free sulfide (sulfide; including hydrogen sulfide [H_2S], hydrosulfide, and disulfide) in porewater to form silver sulfide (Ag_2S), which is a black solid. The intensity of the resulting gray-scale color change, from white to black, is proportional to the amount of sulfide in the gel. The amount of total free sulfide in the gel can be quantified using an optical densitometer (OD). The details of this method and a laboratory verification study demonstrating that quantification of sulfide accumulated in DGT gel using OD provides accurate and reproducible results are provided in *Method Development and*

Verification Study for Sulfide Measurement in Porewater Using Diffusive-Gradients-in-Thin-Films (DGT) (Attachment F-1-2).

The DGT sample assemblies will be analyzed using the OD method described above to measure the accumulated total free sulfide in each DGT. Using location-specific surficial porewater measurements of temperature, pH and salinity the H_2S fraction of the total free sulfide result will be calculated following Millero (1998). As discussed in Section 2.4, H_2S concentrations greater than 0.07 mg/L will be targeted for bioassay sample collection.

Bioassay samples from areas of capped wood debris will be processed following the same procedures described in Section 3.2.2 for processing surface sediment grab samples at sentinel cap locations.

3.3 Natural Recovery Sediment Quality Monitoring Collection and Processing

Sections 3.3.1 and 3.3.2 describe the collection, processing, and handling procedures for the collection of surface sediment samples to evaluate natural recovery.

3.3.1 Natural Recovery Surface Sediment Sample Collection Procedures

The target locations and coordinates for each sentinel station are included in Table F-1-1. Samples will be collected in the following manner in accordance with the PSEP protocols:

- The vessel will be maneuvered to the proposed location.
- The sampler will be decontaminated.
- The sampler will be deployed to the bottom.
- The winch cable to the grab sampler will be drawn taut and vertical.
- Location coordinates of the cable hoist will be recorded by the location control person.
- The sediment sample will be retrieved aboard the vessel and evaluated against the following PSEP acceptability criteria:
  - Grab sampler is not overfilled (i.e., sediment surface is not against the top of the sampler).
  - Sediment surface is relatively flat, indicating minimal disturbance or winnowing.

  - Overlying water is present, indicating minimal leakage.
  - Overlying water has low turbidity, indicating minimal sample disturbance.
  - Desired penetration depth of at least 10 cm is achieved.
- Overlying water will be siphoned off.
- Observations (i.e., texture, odor, presence/absence of vegetation, debris, and any other distinguishing characteristics) will be recorded on the sample collection forms (Attachment F-1-1).
- A stainless steel trowel or similar device will be used to collect the top 0- to 2-cm and 5-to 10-cm of sediment, taking care not to collect sediment in contact with the sides of the sampling device, and placed in a stainless steel bowl.

Sediment samples that meet the above collection criteria will be processed as described below.

3.3.2 Natural Recovery Surface Sediment Sample Processing Procedures

Sediment grab processing will be conducted aboard the sampling vessel. All working surfaces and instruments will be thoroughly cleaned, decontaminated, and covered with aluminum foil to minimize outside contamination between sampling stations. Disposable gloves will be discarded after processing each station and replaced prior to handling decontaminated instruments or work surfaces. The steps for processing the samples are as follows:

- Place the grab on a stable surface. Remove any overlying water using a syphon hose or turkey baster. Following grab acceptance criteria listed in Section 3.3.1, determine whether the grab is acceptable.
- After noting their presence, remove any large objects or debris from the sediment surface.
- Prior to sampling, color photographs may be taken, and a sediment description of each grab will be recorded on a grab sampling log form (Attachment F-1-1). Record the description of the grab sample on the grab log form for the following parameters as appropriate and present:
  - Sample recovery (depth in inches or centimeters of recovery in the grab sampler.

  - Physical soil description of the grab in accordance with the Unified Soil Classification System (includes soil type, density/consistency of soil, moisture, and color)
  - Odor (e.g., hydrogen sulfide and petroleum)
  - Note any vegetation
  - Debris
  - Biological activity (e.g., detritus, shells, tubes, bioturbation, or live or dead organisms)
  - Presence of oil sheen
  - Any other distinguishing characteristics or features

- Using a clean spoon, place sample material from the 0- to 2-cm and 2- to 10-cm depths for chemical analyses in both intervals into separate clean, stainless steel bowls or HDPE buckets. To avoid cross contamination, take care to remove only sediment that has not come into contact with the sides or bottom of the grab. Cover bowl with aluminum foil until each aliquot station has been collected.
- After material has been collected from each aliquot station, the material will combined and homogenized until a uniform color and consistency is achieved.
- Immediately after filling the sample container with sediment, place the screw cap on the sample container and tighten.
- Thoroughly check all sample containers for proper identification, analysis type, and lid tightness.
- Pack each container carefully to prevent breakage and place inside of a cooler with ice for storage at the proper temperature (4°C ±2°C for all samples).

Samples will be submitted for testing as presented in Table F-1-1.

3.4 Sampling Schedule and Platform

Sampling will occur after approval of this SAP by Ecology as described in the OMMP. The preferred timeframe for sampling is September through October. It is anticipated that mobilization, field sampling, sample processing, and demobilization will require approximately 3 to 5 days.

Collection of subsurface sediment cores and surface sediment grab samples will be conducted by Marine Sampling Systems (MSS) and overseen by Anchor QEA from a vessel properly equipped to deploy and recover a vibracorer and power grab and to provide the required navigation. The vibracore equipment is hydraulically driven, low-frequency, spring-loaded, and mounted on a sampling platform to ensure a vertical drive into the sediment. The vibracore is equipped with a piston device fitted into the upper portion of the core barrel to assist in recovery of soft surface material. The vibracore is also equipped with an inverse fathometer that displays real-time penetration within the wheelhouse to monitor penetration progress and determine refusal depth. The vessel will be operated by a licensed captain and will conform to U.S. Coast Guard regulations. The vessel captain and crew have extensive experience in subsurface core and surface grab collection in Puget Sound.

3.5 Horizontal Positioning and Vertical Control

Horizontal positioning will be determined using DGPS based on target coordinates shown in Table F-1-1. The horizontal datum will be North American Datum 1983 (NAD83), Washington State Plane, North Zone. Measured station positions will be converted to latitudinal and longitudinal NAD83 coordinates to the nearest 0.01 second. The accuracy of measured and recorded horizontal coordinates is typically less than 1 meter and will be within ±3 meters following Ecology guidance.

The vertical elevation of each sediment sample or probe location will be measured using a fathometer or lead line and converted to MLLW correcting for the tidal elevation. Tidal elevations will be determined after sample collection using National Oceanic and Atmospheric Administration’s Bangor tide station.

3.6 Field Documentation

Field documentation will consist of a daily field log and sample collection forms (Attachment F-1-1). The daily field log is intended to provide sufficient data and observations to enable readers to reconstruct events that occurred during the sampling period. All data entries will be made using indelible ink pen. Corrections will be made by drawing a single line through the error, writing in the correct information, then dating and initialing the change. Examples of information to be recorded are field personnel, weather conditions, complications encountered, field communications, and other general details associated with the sampling effort. At a minimum, the following information will be included in this log:

- Names of the FC and person(s) collecting and logging the sample
- The sample station number
- Date and collection time of each sediment sample
- Observations made during sample collection including weather conditions, complications, communications, and other details associated with the sampling effort
- Qualitative notation of apparent resistance of sediment column to sampling, including notes on debris
- Any deviations from the approved SAP

In addition to maintaining a daily field log, sample collection forms will be completed for each sample. The sample collection forms will include standard entries for station identifiers, station coordinates, date and time of sample location, type of samples collected, type of analyses for each sample, and specific information pertaining to the matrix being collected. For sediment core samples, the collection form will include information regarding penetration of the sampler and physical characteristics of the sediment such as texture, color, odor, stratification, and sheens.

3.7 Sample Station Locations and Sample Identification

Figures F-3a, F-4a, and F-5 of the accompanying OMMP show the locations of the proposed surface sediment sampling locations. Table F-1-1 includes a list of all station locations, sample identifiers, and analysis and/or testing required for each location. The sample identification schemes are described below:

- Individual core samples are identified by alphanumeric ID used to identify the core location SMA, ITC to depict intertidal core location or STC to depict subtidal core location, followed by the number of feet below mudline (0-5) and appended with the date collected in the format YYMMDD (e.g., SMA1-ITC1-0-5-190901 for a core collected from SMA-1 on September 1, 2019 in the intertidal area from the 0- to 5-foot increment).

- Surface sediment grabs will be identified by alphanumeric ID used to identify the core location SMA; IT to depict intertidal, ST to depict subtidal, or NR to depict natural recovery location; followed by the depth below mudline (0-10); followed by Comp for composite; and appended with the date collected in the format YYMMDD (e.g., SMA1-IT-0-10-Comp-190901 or SMA5-NR-2-10-Comp).

3.8 Equipment Decontamination Procedures

Sample containers, instruments, working surfaces, technician protective gear, and other items that may come into contact with sediment sample material must meet high standards of cleanliness. All equipment and instruments used that are in direct contact with the sediment collected for analysis must be made of glass, stainless steel, or HDPE and will be cleaned prior to each day's use and between sampling or compositing events. Decontamination of all items will follow PSEP protocols. The decontamination procedure is:

- Scrub until free of visible sediment and rinse with site water
- Pre-wash rinse with tap water
- Wash with solution of tap water and Alconox soap (brush)
- Rinse with tap water
- Rinse three times with distilled water
- Cover (no contact) all decontaminated items with aluminum foil
- Store in clean, closed container for next use if not used immediately

3.9 Sample Containers for Analysis

The contract laboratory will provide certified, pre-cleaned, USEPA-approved containers for all chemistry samples. Sediment for bioassay testing will be placed in commercially available HDPE buckets that have been decontaminated as described in Section 3.8. Table F-1-2 lists container size, holding times, and preservation for the categories of analytes. At a minimum, each sample container will be labelled with the following information:

- Project name and number
- Sample identifier
- Date of collection
- Initials of field personnel responsible for sample collection

- Analyses required
- Preservative (if applicable)

3.10 Sample Transport and Chain-of-Custody Procedures

This section addresses the sampling program requirements for maintaining custody of the samples throughout the sample collection and shipping process and provides specific procedures for sample shipping.

3.10.1 Sample Custody Procedures

Samples are considered to be in one's custody if they are: 1) in the custodian's possession or view; 2) in a secured location (under lock) with restricted access; or 3) in a container that is secured with an official seal(s) such that the sample cannot be reached without breaking the seal(s).

Chain-of-custody (COC) procedures will be followed for all samples throughout the collection, handling, and analysis process. The principal document used to track possession and transfer of samples is the laboratory-provided COC form. Each sample will be represented on a COC form the day it is collected. All data entries will be made using indelible ink pen. Corrections will be made by drawing a single line through the error, writing in the correct information, then dating and initialing the change. Blank lines/spaces on the COC form will be lined-out and dated and initialed by the individual maintaining custody.

A COC form will accompany each cooler of samples to the analytical laboratories. Each person who has custody of the samples will sign the COC form and ensure that the samples are not left unattended unless properly secured. Copies of all COC forms will be retained in the project files.

3.10.2 Sample Shipping and Receipt Requirements

All samples will be shipped or hand delivered to the analytical laboratory no later than the day after collection. If samples are collected on Friday, they may be held until the following

Monday for shipment, provided that this does not adversely impact holding time requirements. Specific sample shipping procedures are as follows:

- Each cooler or container containing the samples for analysis will be shipped via overnight delivery to the appropriate analytical laboratory. In the event that Saturday delivery is required, the FC will contact the analytical laboratory before 3 p.m. on Friday to ensure that the laboratory is aware of the number of coolers shipped and the airbill tracking numbers for those coolers. Following each shipment, the FC will call the laboratory and verify the shipment from the day before has been received and is in good condition.
- Coolant ice will be sealed in separate double plastic bags and placed in the shipping containers.
- Individual sample containers will be placed in a sealable plastic bag, packed to prevent breakage, and transported in a sealed ice chest or other suitable container.
- Glass jars will be separated in the shipping container by shock-absorbent material (e.g., bubble wrap) to prevent breakage.
- The shipping containers will be clearly labeled with sufficient information (name of project, time and date container was sealed, person sealing the container and consultant's office name and address) to enable positive identification.
- The shipping waybill number will be documented on all COC forms accompanying the samples.
- A sealed envelope containing COC forms will be enclosed in a plastic bag and taped to the inside lid of the cooler.
- A minimum of two signed and dated COC seals will be placed on adjacent sides of each cooler prior to shipping.
- Each cooler will be wrapped securely with strapping tape, labeled "Glass – Fragile" and "This End Up," and will be clearly labeled with the laboratory's shipping address and the consultant's return address.

Upon transfer of sample possession to the analytical laboratory, the persons transferring custody of the sample container will sign the COC form. Upon receipt of samples at the laboratory, the shipping container seal will be broken and the receiver will record the condition of the samples on a sample receipt form. COC forms will be used internally in the laboratory to track sample handling and final disposition.

3.11 Waste Management

All sediment remaining after sampling will be washed overboard at the collection site prior to moving to the next sampling station. Any sediment spilled on the deck of the sampling vessel will be washed into the surface waters at the collection site.

All disposable sampling materials and personnel protective equipment used in sample processing, such as disposable coveralls, gloves, and paper towels, will be placed in heavy-duty garbage bags or other appropriate containers.

Sediment remaining after core processing and sampling will be collected in 55-gallon drums and consolidated. The 55-gallon drum area will be located in a secure area and labeled appropriately. After core processing is completed, a composite sample will be collected and analyzed to obtain representative data for sediment disposal profiling.

4 PHYSICAL AND CHEMICAL ANALYTICAL METHODS

This section summarizes the target physical and chemical analyses for the various media sampled. All sample analyses will be conducted in accordance with Ecology-approved methods. Prior to analysis, all samples will be maintained according to the appropriate holding times and temperatures for each analysis (Table F-1-2). Table F-2-1 of the accompanying QAPP (Attachment F-2) presents the proposed analytes, screening criteria, the analytical methods to be used, and the targeted detection limits for the evaluation of sediment.

Prior to the analysis of the samples, the laboratory will calculate method detection limits for each analyte of interest, where applicable. Method detection limits will be below the sediment criteria specified in Table F-2-1 of the accompanying QAPP (Attachment F-2), if technically feasible. To achieve the required detection limits, some modifications to the methods may be necessary. These modifications from the specified analytical methods will be provided by the laboratory at the time of establishing the laboratory contract and must be approved by Ecology prior to implementation.

4.1 Quality Assurance/Quality Control

Laboratory QC procedures, where applicable, include initial and continuing instrument calibrations, standard reference materials, laboratory control samples, matrix replicates, matrix spikes, surrogate spikes (for organic analyses), and method blanks. Table F-2-2 of the accompanying QAPP (Attachment F-2) summarizes the data quality objectives for precision, accuracy, and completeness. Table F-2-3 of the accompanying QAPP lists the frequency of analysis for laboratory QA/QC samples.

Results of the QC samples from each sample group will be reviewed by the analyst immediately after a sample group has been analyzed. All samples will be diluted and reanalyzed if target compounds are detected at levels that exceed their respective established calibration ranges. Any cleanups will be conducted prior to the dilutions. The QC sample results will be evaluated to determine if control limits have been exceeded. If control limits are exceeded in the sample group, the QA/QC Manager will be contacted immediately, and corrective action (e.g., method modifications followed by reprocessing the affected samples) will be initiated prior to processing a subsequent group of samples.

4.1.1 Laboratory Instrument Calibration and Frequency

An initial calibration will be performed on each laboratory instrument to be used at the start of the project, after each major interruption to the analytical instrument, and when any ongoing calibration does not meet method control criteria. Calibration verification will be analyzed following each initial calibration and will meet method criteria prior to analysis of samples. Continuing calibration verifications (CCV) will be performed daily prior to any sample analysis to track instrument performance. The frequency of CCVs varies with method. For gas chromatograph/mass spectrometer (GC/MS) methods, one will be analyzed every 12 hours. For GC, metals, and inorganic methods, one will be analyzed for every ten field samples, or daily, whichever is more frequent. If the ongoing continuing calibration is out of control, the analysis must come to a halt until the source of the control failure is eliminated or reduced to meet control specifications. All project samples analyzed while instrument calibration was out of control will be reanalyzed.

Instrument blanks or continuing calibration blanks provide information on the stability of the baseline established. Continuing calibration blanks will be analyzed immediately prior to or immediately following continuing calibration verification at the instrument for each type of applicable analysis.

4.1.2 Laboratory Duplicates/Replicates

Analytical duplicates provide information on the precision of the analysis and are useful in assessing potential sample heterogeneity and matrix effects. Analytical duplicates and replicates are subsamples of the original sample that are prepared and analyzed as a separate sample.

4.1.3 Matrix Spikes/Matrix Spike Duplicates

Analysis of matrix spike samples provides information on the extraction efficiency of the method on the sample matrix. By performing duplicate matrix spike analyses, information on the precision of the method is also provided for organic analyses.

4.1.4 Method Blanks

Method blanks are analyzed to assess possible laboratory contamination at all stages of sample preparation and analysis. The method blank for all analyses must be less than the method reporting limit of any single target analyte/compound. If a laboratory method blank exceeds this criterion for any analyte/compound, and the concentration of the analyte/compound in any of the samples is less than five times the concentration found in the blank (10 times for common contaminants), analyses must stop and the source of contamination must be eliminated or reduced.

4.1.5 Laboratory Control Samples

Laboratory control samples are analyzed to assess possible laboratory bias at all stages of sample preparation and analysis. The laboratory control sample is a matrix-dependent spiked sample prepared at the time of sample extraction along with the preparation of sample and matrix spikes. The laboratory control sample will provide information on the precision of the analytical process and, when analyzed in duplicate, will provide accuracy information as well.

4.2 Laboratory Report

The analytical laboratory will prepare detailed laboratory reports documenting all activities associated with the sample analyses. Included in this report will be:

- **Project Narrative:** A detailed report that describes the samples received, analyses performed, and corrective actions undertaken.
- **COC Documentation:** Laboratory policy requires that COC documentation be available for all samples received. The COC form will document basic sample demographics such as client and project names, sample identification, analyses requested, and special instructions.
- **Data Summary Form:** A tabular listing of concentrations and/or detection limits for all target analytes. The data report will also list other pertinent information such as amount of sample analyzed, dilution factors, sample processing dates, extract cleanups, and surrogate recoveries.

- **QA Summary:** Includes results of all QC analyses, specifically recovery information. Laboratory control samples are reported with each batch. Additional QC analyses may include laboratory replicates, matrix spikes, and standard reference materials.
- **Instrument Calibration Forms and Raw Data:** Includes initial and continuing calibration summaries and instrument tuning data, laboratory bench sheets, and logbook pages.

In completing chemical analyses for this project, the contract laboratory is expected to meet the following minimum requirements:

- Adhere to the methods outlined in this SAP, including methods referenced for each analytical procedure (Table F-2-1 of the accompanying QAPP [Attachment F-2])
- Deliver facsimile, hard copy, and electronic data as specified
- Meet reporting requirements for deliverables
- Meet turnaround times for deliverables
- Implement QA/QC procedures, including laboratory QC requirements (Table F-2-3 of the accompanying QAPP) and data quality objectives (Table F-2-2 of the accompanying QAPP), and performance evaluation testing requirements
- Notify the project QA/QC Manager of any QAPP QA/QC problems when they are identified to allow for quick resolution
- Allow laboratory and data audits to be performed, if deemed necessary

Laboratory data will be provided in the EQuIS electronic format. Laboratory data, which will be electronically provided and loaded into the database, will undergo a 10% check against the laboratory hard copy data. Data will be validated or reviewed manually, and qualifiers, if assigned, will be entered manually. The accuracy of all manually entered data will be verified by a second party. Data tables and reports will be exported from EQuIS to Microsoft Excel tables.

5 BIOLOGICAL TESTING

Bioassay testing will be performed by NewFields. Biological testing will be performed in accordance with *Recommended Protocols for Conducting Laboratory Bioassays on Puget Sound Sediments* (PSEP 1995) for the larval abnormality/mortality test using the resuspension modifications described in 2013 Dredge Material Management Program (DMMP)/SMS clarification paper (Kendall 2013). All bioassay analyses, including retests, are required to commence within 56 days after collection to meet holding times.

Bioassay testing requires that test sediments be matched and conducted simultaneously with appropriate reference sediment in order to factor out sediment grain size effects on bioassay organisms. The selection of the reference sediment will be based on the percent fines determined from the analytical laboratory's grain-size analysis of the test sediments. The laboratory determination of grain size will be performed on an expedited schedule in order to select the appropriate reference sediment prior to bioassay initiation.

The samples for bioassay testing will be placed into lidded HDPE buckets with no head space and stored in coolers at approximately 4°C ± 2°C until transported to the laboratory. Temperature within the coolers will be monitored, and COC procedures will be followed throughout sample handling by the laboratory.

5.1 Biological Testing Procedures

Sediment bioassay testing will be conducted in accordance with PSEP (2015), except where applicable SMS clarification papers (e.g., Bioassay Endpoint Refinements: Larval and Neanthes Growth Bioassays) are applicable. Sediment bioassay testing at sentinel locations in SMA-1 and SMA-2 will be for larval bioassays only. Sediment bioassay testing in nearshore wood debris cap locations within SMA-1 and SMA-2 will include three standard SMS tests (two acute and one chronic), as summarized in Section 2.4. Testing methodologies and results will be summarized in a data report (Section 6).

5.2 Test Quality Assurance/Quality Control

Sediment toxicity tests will incorporate standard QA/QC procedures to ensure that the test results are valid. Standard QA/QC procedures include the use of negative controls, positive controls, reference sediment samples, replicates, and measurements of water quality during testing.

5.2.1 Negative Controls

The negative control to be used for the sediment toxicity tests will be a clean control, which consists of using the same seawater used in testing sediment toxicity. For the tests to be used in this study, the negative control will be a seawater control. For the sediment test results to be valid, the seawater control shall have a 70% normal survivorship at time-final.

5.2.2 Positive Controls

A positive control will be run for each bioassay using the same batch of organisms used in the test. The positive control to be used for the sediment toxicity test will be a toxic control in which a reference toxicant is used to establish the relative sensitivity of the test organism. The positive control for sediment tests is typically conducted with diluent seawater and without sediment. Copper sulfate will be used as the reference toxicant for the bivalve larval test.

5.2.3 Reference Sediment

Reference sediment will also be included with each bioassay, tested concurrently with test sediments to provide data that can be used to separate toxicant effects from unrelated effects, such as those of sediment grain size. Reference sediment samples should be collected from an area documented to be free from chemical contamination and should represent the range of important characteristics of the test sediments (e.g., sediment grain size). For this study, reference sediment samples will be collected from Carr Inlet in Puget Sound, Washington (PSEP 1995). All bioassays have performance standards for reference sediments as mentioned above. Failure to meet these standards may result in the requirement to retest.

5.2.4 *Replicates*

Five replicate chambers for each test sediment, reference sediment, and negative controls treatment will be run for each bioassay. A water quality replicate will also be run for each treatment.

5.2.5 *Water Quality Monitoring*

Water quality monitoring will be conducted for the amphipod, larval, and juvenile polychaete bioassay and reference toxicant tests. This monitoring consists of daily measurements in the water quality replicate of salinity, temperature, pH, and dissolved oxygen for the larval tests. Ammonia and sulfides in the overlying water will be determined at test initiation and termination for all three tests. Monitoring will be conducted for all test and reference sediments and negative controls (including seawater controls). Measurements for each treatment will be made on a separate test chamber that is set up identically to the other replicates within the treatment group, including the addition of test organisms.

5.3 Interpretation

Test interpretation consists of endpoint comparisons of test sediments to the measurements observed in the controls and in reference sediments on an absolute percentage basis, as well as statistical comparison between the test and reference endpoints, where appropriate. The SMS criteria for the larval test are exceeded if the larval test sediment has a mean survivorship of normal larvae that is significantly less (t-test, P=0.1) than the mean normal survivorship in the reference sediment, and the mean normal survivorship in the test sediment is less than 85% of the mean normal survivorship in the reference sediment.

5.4 Bioassay Retest

Any bioassay retests must be fully coordinated with and approved by Ecology.

5.5 Data Deliverables

The laboratory conducting the bioassay tests will be responsible for internal checks on data reporting and will correct errors identified during the QA review. The bioassay laboratory for this study will be required to report results that include all information recommended by PSEP protocols for QA review, as follows:

- A description of any deviations from the methodology or problems with the process and procedures of analyses
- Test methods used for bioassay testing and statistical analyses
- Results for mortality and abnormalities, water quality parameters, reference toxicant, and statistical analyses
- Original data sheets for water quality, mortality and abnormalities, reference toxicant, and statistical analyses
- COC records

Close contact with the laboratory will be maintained to resolve any QA/QC problems in a timely manner.

6 SAMPLING AND ANALYSIS RESULTS REPORT

A final sampling and analysis results report will be prepared by Anchor QEA documenting all activities associated with collecting, compositing, transporting, and chemically and biologically analyzing sediment samples. The laboratory reports will be included as appendices and the chemistry report will be submitted in both hard copy and electronic formats. At a minimum, the following will be included in the final report:

- Summary of all field activities including a description of any deviations from the approved SAP
- Locations of sediment sampling stations in state plane coordinates to the nearest foot (Washington North Zone), and in latitude and longitude in degrees and minutes to four decimal places NAD83; all vertical elevations of mudline and water surface will be reported to the nearest 0.1-foot relative to MLLW
- A project map with actual sampling locations
- A QA/QC narrative for chemical, and if appropriate, biological testing
- Summary data results tables
- Summary of comparison of chemical and toxicity test results with DMMP interpretive criteria
- Print copies of field data will be provided with the data report; laboratory analysis results and associated QA/QC data will be available
- Results will be submitted to the Ecology in EIM format
- Source sampling and/or supplier locations for all bioassay testing species utilized for testing

7 REFERENCES

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TABLES

Table F-1-1
Station Locations and Sample Matrix Summary for Samples

	Archive	(Washington SP NAD 83 North Zone)		Parameter	Dissolved Sulfides	Cadmium	PAHs	Dioxin/Furan	Larval Bioassay	Full Suite Bioassay*
	8-oz glass			Container	DGT	4-oz glass	16-oz glass	8-oz glass	1-Gallon	1-Gallon
	4° C			Preservative	4° C	4° C	4° C	4° C	4° C	4° C
Location ID		Easting	Northing	Sample ID						
Capping Areas										
SMA1A-IT1	X	1211536.9	317657.5	SMA1A-IT-0-10-Comp	--	X	X	X	X	--
SMA1A-IT2	X	1211387.1	317532.1							
SMA1A-IT3	X	1211362.1	317392.9							
SMA1A-IT4	X	1211653.4	317220.0							
SMA1A-IT5	X	1211828.0	317160.3							
SMA1B-IT1	X	1211281.7	317379.8	SMA1B-IT1-0-6	X	--	--	--	--	TBD
	X			SMA1B-IT1-24	X					--
SMA1B-IT2	X	1211310.7	317404.8	SMA1B-IT2-0-6	X					TBD
	X			SMA1B-IT2-24	X					--
SMA1B-IT3	X	1211343.9	317433.2	SMA1B-IT3-0-6	X					TBD
	X			SMA1B-IT3-24	X					--
SMA1-ST1	X	1211453.2	317498.9	SMA1-ST-0-10-Comp	--	X	X	X	X	--
SMA1-ST2	X	1211632.0	317620.4							
SMA1-ST3	X	1211707.7	317378.5							
SMA1-ST4	X	1211702.4	317282.3							
SMA1-ST5	X	1211836.8	317246.7							
SMA2A-IT1	X	1211603.1	316658.1	SMA2A-IT-0-10-Comp	--	X	X	X	X	--
SMA2A-IT2	X	1211497.5	316592.4							
SMA2A-IT3	X	1211352.5	316505.4							
SMA2A-IT4	X	1211227.8	316419.7							
SMA2A-IT5	X	1211176.0	316281.5							
SMA2A-ST1	X	1211476.2	316243.4	SMA2A-ST-0-10-Comp	--	X	X	X	X	--
SMA2A-ST2	X	1211592.1	316375.6							
SMA2A-ST3	X	1211789.4	316463.6							
SMA2A-ST4	X	1211508.5	316012.2							
SMA2A-ST5	X	1211733.4	316185.2							
SMA2B-IT1	X	1211168.2	316122.8	SMA2B-IT-0-10-Comp	--	X	X	X	X	--
SMA2B-IT2	X	1211160.4	315957.5							
SMA2B-IT3	X	1211155.9	315740.1							
SMA2B-IT4	X	1211095.5	315626.6							
SMA2B-IT5	X	1211047.0	315492.7							
SMA2B-ST1	X	1211306.1	315846.5	SMA2B-ST-0-10-Comp	--	X	X	X	X	--
SMA2B-ST2	X	1211662.2	315810.9							
SMA2B-ST3	X	1211509.9	315740.0							
SMA2B-ST4	X	1211334.8	315451.2							
SMA2B-ST5	X	1211564.0	315510.2							

Table F-1-1
Station Locations and Sample Matrix Summary for Samples

	Archive	(Washington SP NAD 83 North Zone)		Parameter	Dissolved Sulfides	Cadmium	PAHs	Dioxin/Furan	Larval Bioassay	Full Suite Bioassay*
	8-oz glass			Container	DGT	4-oz glass	16-oz glass	8-oz glass	1-Gallon	1-Gallon
	4° C			Preservative	4° C	4° C	4° C	4° C	4° C	4° C
Location ID		Easting	Northing	Sample ID						
SMA2C-IT1	X	1211398.5	316652.6	SMA2C-IT1-0-6	X	--	--	--	--	TBD
	X			SMA2C-IT1-24	X					--
SMA2C-IT2	X	1211406.1	316640.4	SMA2C-IT2-0-6	X					TBD
	X			SMA2C-IT2-24	X					--
SMA2C-IT3	X	1211412.0	316630.8	SMA2C-IT3-0-6	X					TBD
	X			SMA2C-IT3-24	X					--
SMA2C-IT4	X	1211415.6	316663.1	SMA2C-IT4-0-6	X					TBD
	X			SMA2C-IT4-24	X					--
SMA2C-IT5	X	1211423.1	316651.0	SMA2C-IT5-0-6	X					TBD
	X			SMA2C-IT5-24	X					--
SMA2C-IT6	X	1211429.0	316641.3	SMA2C-IT6-0-6	X					TBD
	X			SMA2C-IT6-24	X					--
SMA2C-IT7	X	1211432.6	316673.6	SMA2C-IT7-0-6	X					TBD
	X			SMA2C-IT7-24	X					--
SMA2C-IT8	X	1211440.1	316661.5	SMA2C-IT8-0-6	X					TBD
	X			SMA2C-IT8-24	X					--
SMA2C-IT9	X	1211446.0	316651.9	SMA2C-IT9-0-6	X					TBD
	X			SMA2C-IT9-24	X					--
Natural Recovery										
BW-01	--	1211482.1	312628.3	BW-01-0-2	--	X	X	X	--	--
				BW-01-2-10	--	X	X	X	--	--
BW-04	--	1212480.62	310620.97	BW-01-0-2	--	X	X	X	--	--
				BW-01-2-10	--	X	X	X	--	--
BW-15	--	1212507.8	308614.9	BW-15-0-2	--	X	X	X	X (Sample ID: BW-15-0-10)	--
				BW-15-2-10	--	X	X	X		--
BW-18	--	1210996.74	307610.05	BW-01-0-2	--	X	X	X	--	--
				BW-01-2-10	--	X	X	X	--	--
BW-19	--	1212456.51	307658.08	BW-01-0-2	--	X	X	X	--	--
				BW-01-2-10	--	X	X	X	--	--
BW-21	--	1212475.8	305744.0	BW-21-0-2	--	X	X	X	--	--
				BW-21-2-10	--	X	X	X	--	--
PGSS-29	--	1210493.1	309872.8	PGSS-29-0-2	--	X	X	X	--	--
				PGSS-29-2-10	--	X	X	X	--	--
PGSS-70	--	1210966.3	313616.1	BW-01-0-2	--	X	X	X	--	--
				BW-01-2-10	--	X	X	X	--	--
PGSS-77A	--	1211303.7	314627	BW-01-0-2	--	X	X	X	--	--
				BW-01-2-10	--	X	X	X	--	--
PGSS-8	--	1211006	305614.9	BW-01-0-2	--	X	X	X	--	--
				BW-01-2-10	--	X	X	X	--	--

Table F-1-1
Station Locations and Sample Matrix Summary for Samples

	Archive	(Washington SP NAD 83 North Zone)		Parameter	Dissolved Sulfides	Cadmium	PAHs	Dioxin/Furan	Larval Bioassay	Full Suite Bioassay*
	8-oz glass			Container	DGT	4-oz glass	16-oz glass	8-oz glass	1-Gallon	1-Gallon
	4° C			Preservative	4° C	4° C	4° C	4° C	4° C	4° C
Location ID		**Easting**	**Northing**	**Sample ID**						
PGST-1	--	1211635.1	312628.3	PGST-1-0-2	--	X	X	X	--	--
				PGST-1-2-10	--	X	X	X	--	--
PGST-5	--	1212132.5	308615.3	PGST-2-0-2	--	X	X	X	--	--
				PGST-2-2-10	--	X	X	X	--	--

Notes:
IT = Intertidal
PAHs = polycyclic aromatic hydrocarbons
ST = Subtidal
* Full suite bioassay sampling will be performed at sample locations where DGT porewater sulfide results are greater than 0.07 milligrams per liter (mg/L). Bioassay samples will only be collected from surface sediment.
TBD = To be determined.

Table F-1-2
Guidelines for Sample Handling and Storage

Parameter	Sample Size	Container Size and Type[a]	Holding Time	Preservative
Total metals	50 g	4-oz Glass	6 months; 28 days for Hg	Cool/4° C
			3 years; 28 days for Hg	Freeze[a]/-18° C
Polycyclic aromatic hydrocarbons	150 g	16-oz glass	14 days until extraction	Cool/4° C
			1 year until extraction	Freeze/-18° C
			40 days after extraction	Cool/4° C
Dioxins/Furans	150 g	8-oz Glass	1 year to extraction	Freeze -18° C
			1 year after extraction	Freeze -18° C
Bivalve larvae bioassay	1,000 g	1-gallon HDPE	56 days	Cool/4° C/Dark
Full suite bioassay	1,000 g	1-gallon HDPE	56 days	Cool/4° C/Dark

Note:

a. All sample containers will have lids with Teflon inserts.

ATTACHMENT F-1-1
SAMPLE COLLECTION FORMS

ANCHOR QEA

Sediment Core Collection Log

Page __ of __

Job:	**Station ID:**
Job No:	**Attempt No.**
Field Staff:	**Date:**
Contractor:	**Logged By:**
Vertical Datum:	**Horizontal Datum:**

Field Collection Coordinates:

Lat/Northing: Long/Easting:

A. Water Depth	**B. Water Level Measurements**	**C. Mudline Elevation**
DTM Depth Sounder:	Time:	
DTM Lead Line:	Height:	
	Source:	

Recovery Measurements (prior to cuts)

Core Collection Recovery Details:

Core Accepted: Yes / No

Core Tube Length:

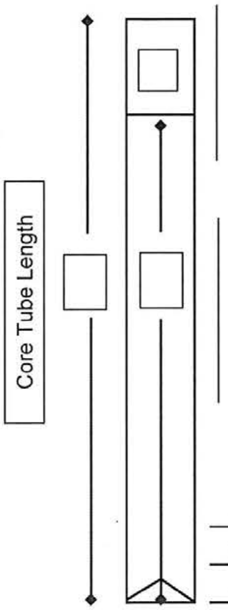
Drive Penetration:

Headspace Measurement:

Recovery Measurement:

Recovery Percentage:

Total Length of Core To Process:



Drive Notes:

Sections To Process:

A:

B:

C:

D:

Core Field Observations and Description:

Sediment type, moisture, color, minor modifier, MAJOR modifier, other constituents, odor, sheen, layering, anoxic layer, debris, plant matter, shells, biota

Notes:

Sediment Core Processing Log

ANCHOR QEA

Job:	Station ID:
Job No.	Date/Time:
No. of Sections:	Core Logged By:
Drive Length:	Attempt #:
Recovery:	Type of Core ☐ Mudmole ☐ Vibracore ☐ Other
% Recovery:	Diameter of Core (inches)
Notes:	Core Quality ☐ Good ☐ Fair ☐ Poor ☐ Disturbed

Recovered Length (ft)	Size % G	Size % S	Size % F	PID	**Classification and Remarks** (Density, Moisture, Color, Minor Constituent, MAJOR Constituent, with Additional Constituents, Sheen, Odor)	Sample	Subsample	Summary Sketch

Page _____ of _____

ANCHOR QEA

Surface Sediment Field Log

Job:
Station:
Job No:
Date:
Field Staff:
Sample Method:
Contractor:
Target Coordinates: Lat.
Horizontal Datum:
Long.

Water Height
DTM Depth Sounder:
DTM Lead Line:

Tide Measurements
Time:
Height:

Sample Acceptability Criteria:
1) Overlying water is present
2) Water has low turbidity
3) Sampler is not overfilled
4) Surface is flat
5) Desired penetration depth

Mudline Elevation (lower low water-large tides): calculated after sampling

Notes:

Grab #	Time	Actual Coordinates		Sample Accept (Y/N)	Recovery Depth (cm)	Comments: jaws close, good seal, winnowing, overlying water, surface intact, etc
		Longitude/Easting	Latitdue/ Northing			

Sample Description: surface cover, (density), moisture, color, minor modifier, MAJOR modifier, other constituents, odor, sheen, layering, anoxic layer, debris, plant matter, shells, biota

Sample Containers:

Analyses:

ATTACHMENT F-1-2 METHOD DEVELOPMENT AND VERIFICATION STUDY FOR SULFIDE MEASUREMENT IN POREWATER USING DIFFUSIVE-GRADIENTS-IN-THIN-FILMS (DGT)

DRAFT

421 SW 6th Avenue, Suite 750
Portland, Oregon 97204
503.688.5057

ANCHOR QEA

Memorandum

November 10, 2017

To: Clay Patmont

From: Masa Kanematsu, PhD; Dimitri Vlassopoulos, PhD

Re: Method Development and Verification Study for Sulfide Measurement in Porewater Using Diffusive-Gradients-in-Thin-Films (DGT)

This document presents the results of a laboratory verification study of a passive porewater sampling technique for dissolved sulfide using Diffusive Gradients in Thin-films (DGT). The method, developed over the last two decades (Teasdale et al. 1999; Rearick et al. 2005), is finding increasing use as a reliable in situ technique for quantifying sulfide levels in sediment porewater. The method is based on the reaction of sulfide with silver iodide (AgI), a white powder impregnated in a gel to produce silver sulfide (Ag_2S), a black solid. The intensity of the color developed is proportional to the amount of sulfide accumulated in the gel.

For this study, we developed a calibration curve using optical densitometry (OD) to quantify the amount of sulfide accumulated in the DGT device over a dissolved sulfide concentration range of 0 to 6 mg/L sulfide. To verify the DGT technique, sulfide was extracted from exposed DGTs and quantified using two different extraction and analysis methods:

- Extraction of chromium reducible sulfur (CRS) from the DGT gel and analysis by sulfide ion-specific electrode
- Extraction of the DGT gel by nitric acid/hydrogen peroxide (commonly used in selective sequential extraction schemes to quantify metals associated with sulfides) and analysis of total sulfur released by ICP-MS

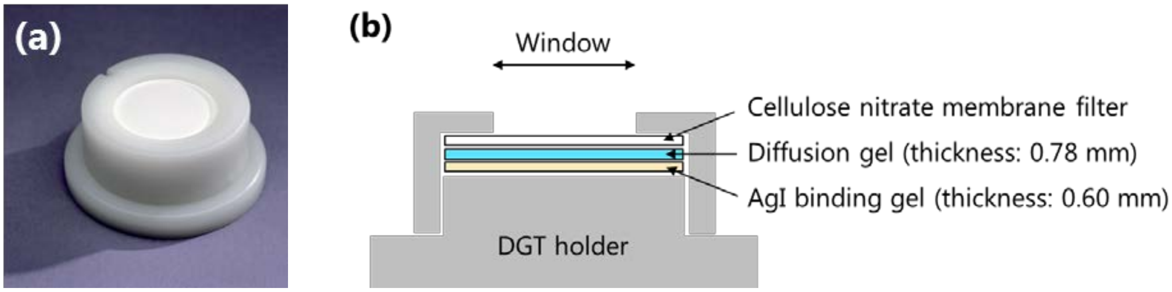
Results from both methods were in excellent agreement and quantitative recovery of sulfide from the DGT gels was confirmed by comparison with the theoretical mass of accumulated sulfide calculated using a mass-transfer model. Sulfide recoveries from the DGT gels averaged 101.0% and 96.9% for the CRS and nitric acid/peroxide extraction methods, respectively.

Materials and Methods

DGT Samplers

DGT piston devices for deployment in soil were obtained from DGT® Research (http://www.dgtresearch.com). The DGT samplers were preloaded for sulfide measurement and consist of a standard DGT holder containing a 0.6 mm thick silver iodide (AgI) impregnated binding gel layer, overlain by a 0.78 mm thick polyacrylamide diffusive gel, and held in place by a 0.45 µm cellulose nitrate membrane filter (Figure 1). The window size of the DGT sampler is 2.54 cm^2. Prior to use, the DGT assemblies were deoxygenated by immersion in 0.01 M sodium nitrate purged with high-purity nitrogen gas for at least 2 days to remove any residual oxygen.

Figure 1
DGT piston assembly (a) and cross-section view (b)



* DGT® Research: http://www.dgtresearch.com/

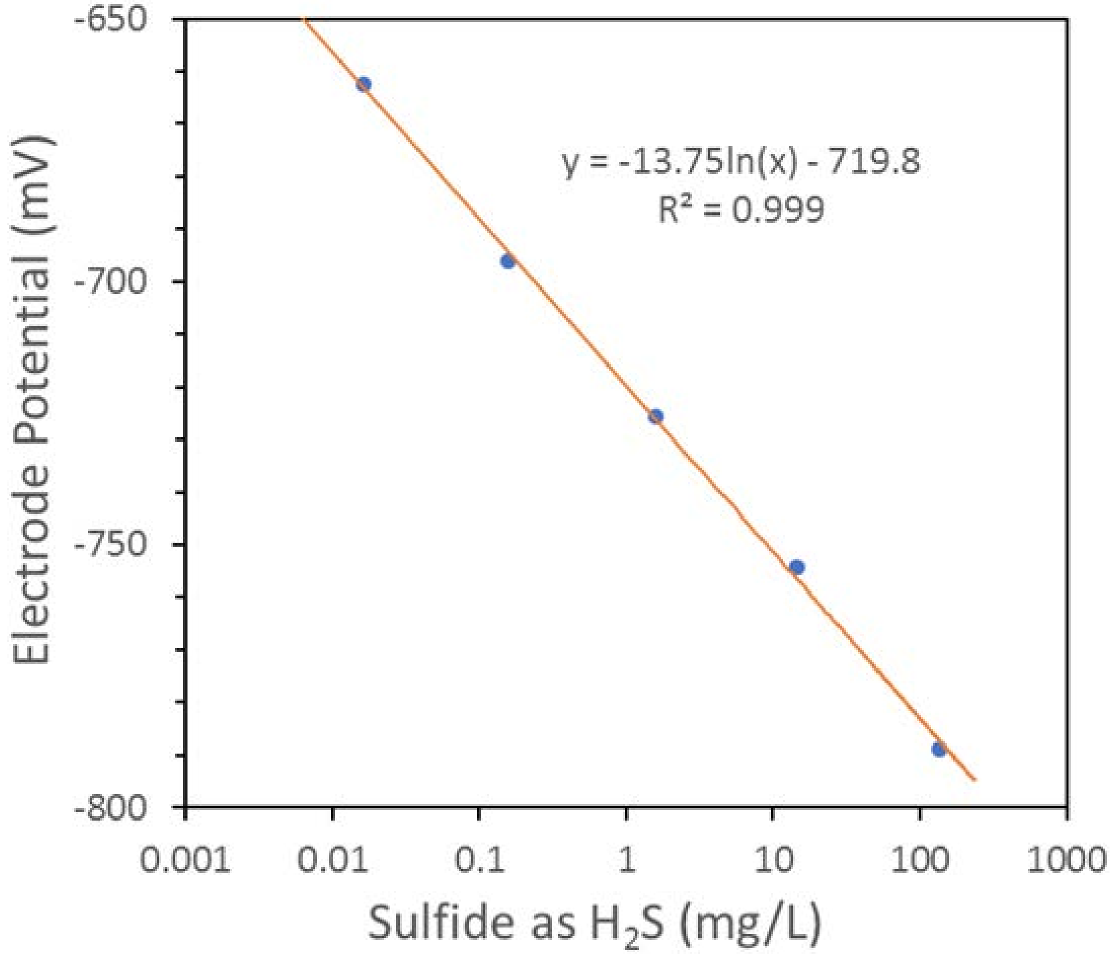
Preparation of Stock Sulfide Solutions

All sulfide solutions were prepared from a stock solution of approximately 1,000 mg/L as S (1,063 mg/L as H_2S). The stock solution was prepared by first washing a crystal of sodium sulfide nonahydrate ($Na_2S \cdot 9H_2O$) with deionized (DI) water to remove oxidation products, blotting it dry on tissue paper, accurately weighing it, and dissolving it in deoxygenated DI water. Between uses, the stock solution was stored under nitrogen sealed in a Mylar bag with oxygen absorber packets to minimize exposure to oxygen. The sulfide stock solution was standardized daily by iodometric titration (Standard Method 4500-S2-F; APHA 2005).

Sulfide Measurement by Ion Selective Electrode

Dissolved sulfide concentrations were measured by Standard Method 4500-S2-G (APHA 2005) using a Thermo Scientific silver sulfide solid-state ion selective electrode (ISE) connected to a Thermo Scientific Orion Star A211 potentiometer. Alkaline anti-oxidant buffer (Thermo Scientific Orion 941609) was added to samples and standards to inhibit oxidation of sulfide by oxygen and to provide a constant ionic strength and pH during analysis. A five-point calibration curve was developed daily (Figure 2).

Figure 2
Example calibration curve for sulfide ISE



Calibration Curve for the Densitometric Determination of Sulfide

DGT sampler assemblies were exposed in duplicate to test solutions prepared at 8 different sulfide concentrations (0 to 6 mg/L as H_2S) for 24 hours. The solutions were prepared in 0.7 M sodium chloride to simulate seawater ionic strength. To minimize sulfide loss, tests were prepared in glass jars with cone seal caps, all solutions were purged with N_2 gas before addition of the sulfide stock solution, and headspace in the glass containers was minimized. Sulfide concentrations in the standard solutions were monitored by ISE before and after deploying the DGT assemblies.

Following the 24-hour exposure period, the DGT assemblies were retrieved and rinsed with DI water. The binding gel layers were removed and placed on blotting paper. The binding gels were then laid on a thin cellophane sheet (Bio-Rad), and covered with a second cellophane sheet. The sheet assembly was then placed in a vacuum gel dryer (Bio-Rad, Model 583) and dried for 2 hours at 60°C. The dried sheet was digitally scanned (Konica Minolta BizHub-C364) and saved as a gray-scale image. Gel analysis software (UN-SCAN-IT Gel Version 7.1) was used to measure and record the gray-scale intensity of each binding gel on the scanned image.

Extraction and Quantification of Sulfide in DGT Binding Gels

Sulfide was extracted from the exposed DGT binding gels by a modified CRS method (Burton et al., 2008) as well as a nitric acid/peroxide extraction method. Six replicate sulfide-exposed DGT samplers were prepared by exposing the devices to a 3.00 mg/L H_2S solution for 24 hours. Three DGTs were extracted by each method to quantitatively assess sulfide recovery and method reproducibility.

The modified CRS method developed by Burton et al. (2008) was adopted to this study. Briefly, an acidic chromium(II) solution was added to a gas-tight reaction vessel containing the sulfide-reacted binding gel to convert sulfide to hydrogen sulfide gas, which was trapped in an alkaline zinc acetate solution contained in a small centrifuge tube placed inside the reaction vessel. On completion of the extraction, dissolved sulfide concentrations in the trapping solutions were immediately measured by ISE.

A nitric acid/peroxide extraction is one of the steps employed in some selective sequential extraction procedures to quantify metals associated with organic matter and/or sulfides in soil and sediment (Tessier et al. 1979, Zimmerman and Weindorf 2010) and was used to extract sulfur from the DGT. In brief, the sulfide-reacted binding gel is extracted in acidic hydrogen peroxide followed by nitric acid. A detailed description of the procedure is provided in Appendix A. Sulfide released form the gel to the extraction fluid is oxidized to sulfate which is analyzed as total sulfur by Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES). ICP-OES analysis of the extracts was performed in the analytical geochemistry laboratory of the Geology Department at Portland State University. A procedural blank was also prepared and analyzed and sample results were blank corrected.

Results

Determination of Sulfide in DGT Samplers by Optical Densitometry

Dissolved sulfide concentrations in test solutions were measured before and after deployment of the DGT assemblies (Table 1). Sulfide losses from the solutions over the 24-hour exposure period ranged from 13 to 26 % and averaged 20 %. This is comparable to losses reported by Rearick et al. (2005)

due to oxidation, volatilization, or adsorption. The digital images of the sulfide-accumulated binding gels are shown in Figure 3 and the measured gray-scale intensities of the gels are given in Table 1.

Figure 3
Gray-scale images of DGT binding gels exposed to sulfide standard solutions for 24 hours

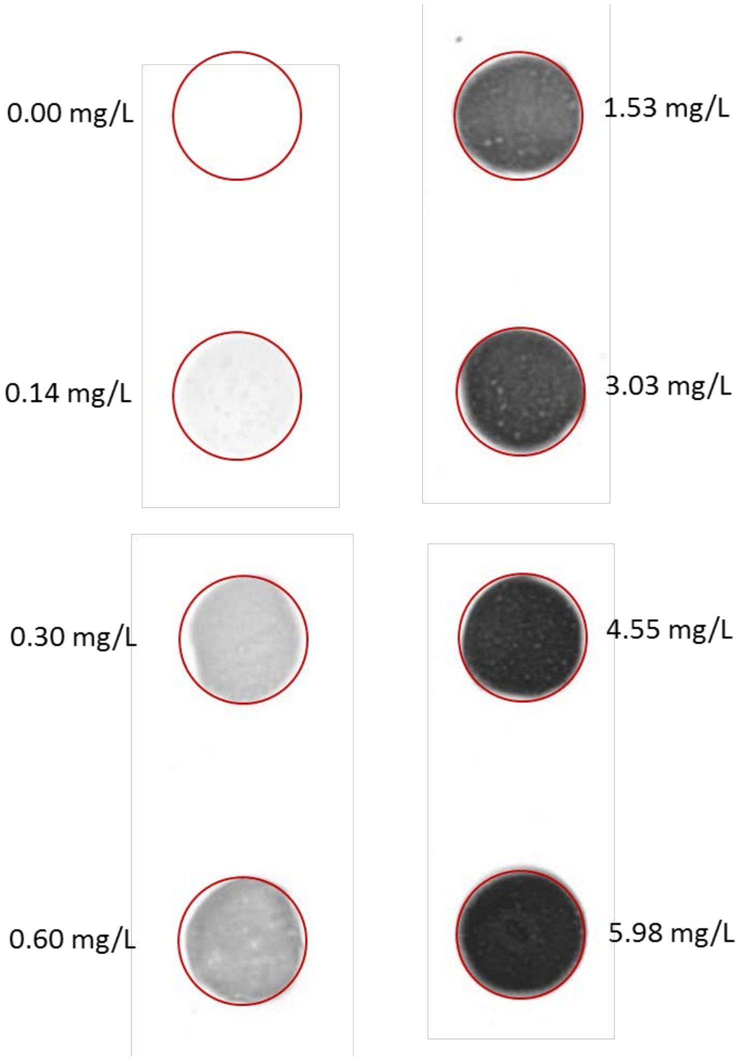


Table 1
Sulfide Mass Balance and Optical Densitometry Results

Solution	Target Concentration (mg/L as H_2S)	Measured Sulfide Concentration (mg/L as H_2S)[1]			Sulfide Loss[2] (%)	Gray-Scale Intensity[3]		
		Initial	Final	Average		1	2	Average
1	0.00	0.00	0.00	0.00	-	0	0	0 (0)
2	0.17	0.16	0.12	0.14	26%	6	14	10 (4)
3	0.34	0.33	0.26	0.30	23%	33	52	43 (10)
4	0.68	0.67	0.52	0.60	23%	100	77	89 (12)
5	1.70	1.70	1.35	1.53	21%	147	138	142 (5)
6	3.40	3.28	2.77	3.03	15%	171	155	163 (8)
7	5.10	4.86	4.24	4.55	13%	183	195	189 (6)
8	6.80	6.64	5.31	5.98	20%	194	193	194 (1)

Notes:

1. Measured by ISE.
2. Sulfide loss (%) during the experiments may be attributed to oxidation, volatilization, or adsorption.
3. Two DGTs were exposed at each sulfide concentration.

A calibration curve was developed by plotting the gray-scale intensity dissolved sulfide exposure concentrations and fitting the data to a function relating intensity to exposure sulfide concentration. As shown in Figure 4, the data were well fit by an exponential function (Equation 1) over the entire range of sulfide concentrations tested (0 – 6 mg/L as H_2S).

Equation 1 is useful for gray-scale intensities greater than about 10 (corresponding to sulfide concentrations greater than 0.15 mg/L). For lower concentrations, a three-point calibration curve was developed using the lowest concentration gel data. For the low range calibration, a power function was found to fit the data best (Equation 2).

Equation 1 is recommended for estimating porewater sulfide concentrations from DGT gels for gray-scale intensity greater than 10 and Equation 2 is appropriate for gray-scale intensity less than or equal to 10.

Equation 1. DGT calibration curve for sulfide concentration using optical densitometry (24-hour exposure)

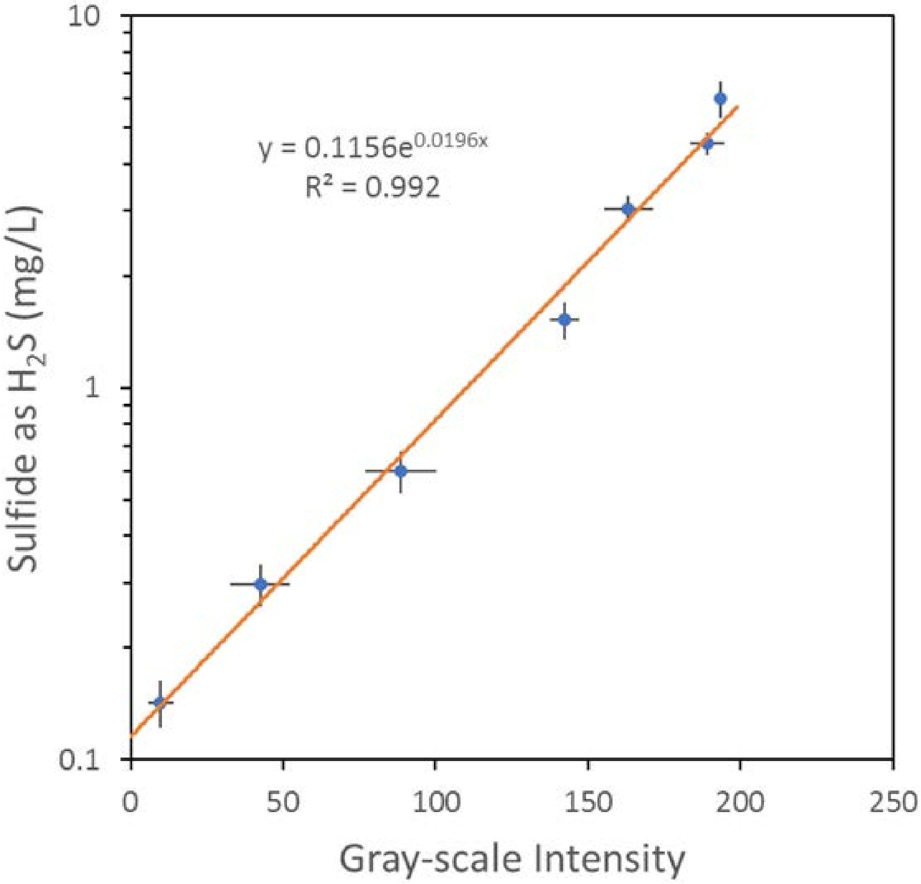
$$S = 0.1156 \times \exp\{0.0196 \times I\}$$

$$R^2 = 0.992$$

where:

S = sulfide concentration (mg/L as H_2S)
I = gray-scale intensity of binding gel image (10-256)

Figure 4
DGT calibration curve for a 24-hour exposure period



Equation 2. Low-range DGT calibration curve for sulfide concentration using optical densitometry (24-hour exposure)

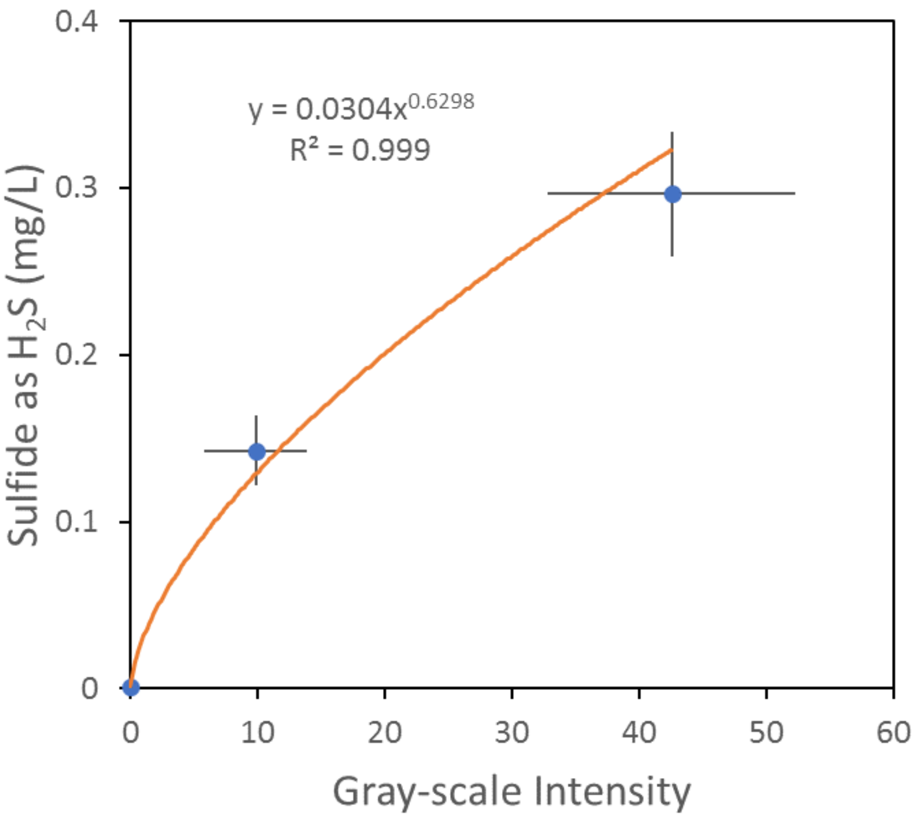
$$S = 0.0304 \times I^{0.6298}$$

$$R^2 = 0.999$$

where:

S = sulfide concentration (mg/L as H_2S)
I = gray-scale intensity of binding gel image (0-10)

Figure 5
Low-range DGT calibration curve for a 24-hour exposure period



Verification of Sulfide Accumulation in DGT Samplers

Sulfide recovered from DGT binding gels after exposure to 3.00 mg/L H_2S solution for 24 hours by the CRS and nitric acid/peroxide extraction methods are summarized in Table 2. The sulfide mass extracted by the two methods is in very good agreement and excellent sulfide mass recoveries were obtained.

Table 2
Verification of Sulfide Accumulation in DGT

Extraction Method	Measured Sulfide Concentration (mg/L as H_2S)[1]			Mass of Sulfide Extracted from DGT (µg as H_2S)		Theoretical Mass of Sulfide Accumulated in DGT (µg as H_2S)[2]	Recovery (%)[3]
	Initial	Final	Average				
Chromium Reducible Sulfur	3.65 ±0.11	2.34 ±0.04	2.99	1	13.5	13.9	97
				2	13.6		98
				3	15.2		109
				Average	14.1		101
Nitric acid /Peroxide	3.65 ±0.11	2.36 ±0.01	3.00	1	12.9	13.9	92
				2	14.5		104
				3	13.4		96
				Average	13.6		98

Notes:

1. Measured by iodometric titration.
2. Calculated with Equation 2 using the average sulfide concentration, $D=1.65\times10^{-6}$ cm^2/s (derived from data in Teasdale et al. 1999), t=86,400 s, A=2.54 cm^2, and $\Delta g=0.078$ cm.
3. Recovery=100×(mass of sulfide extracted)/(theoretical mass of sulfide accumulated)

The extracted sulfide masses were compared to the theoretical amount accumulated calculated using the mass-transfer equation for sulfide accumulation in the DGT assembly (Equation 3) and used to calculate percent recoveries (Table 2).

Equation 3. Model equation for calculating sulfide mass accumulation in DGT binding gel (Teasdale et al. 1999)

$$\mathrm{M} = \frac{CDtA}{\Delta g}$$

where:

M = mass of sulfide accumulated in binding gel (mg as H_2S)
C = sulfide concentration in solution (mg/cm^3 as H_2S)
D = effective diffusion coefficient of sulfide in DGT (cm^2/s)
t = exposure time (s)
A = cross-sectional area of DGT window (cm^2)
Δg = thickness of diffusion layer (cm)

The sulfide mass recoveries were in excellent agreement with the theoretical sulfide mass accumulated calculated by equation 3 and averaged 101 % of theoretical for the CRS method and 98 % for the nitric acid/peroxide extraction (Table 2).

Summary

The present study verified the DGT method for passive sampling of dissolved sulfide by establishing a quantitative relationship between dissolved sulfide concentrations in the range of 0 to 6 mg/L and the gray-scale intensity developed by the DGT binding gel after a 24-hour exposure period, and confirmed that the sulfide accumulated in the DGT gel agreed with the amount expected from theory. The results of this study show that the DGT method with quantification by optical densitometry gives accurate and reproducible results for dissolved sulfide concentrations and calibration curves were developed for field application of the DGT devices.

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Appendix A

Nitric acid/peroxide extraction procedure

Fluid 1: 0.02 M nitric acid
Fluid 2: 30% hydrogen peroxide adjusted to pH 2 with nitric acid
Fluid 3: 3.2 M ammonium acetate in 20% v/v nitric acid

1. Place a sulfide exposed DGT binding gel in a 50 mL centrifuge tube
2. Add 3 mL of fluid 1 and 5 mL of fluid 2 and heat in shaker-water bath at 85 ± 2 °C for 2 hours
3. 3. Add 3 mL of fluid 2 and heat for an additional 3 hours
4. After cooling, add 5 mL of fluid 3, dilute to 20 mL and agitate for 30 minutes at room temperature
5. Centrifuge at 10,000 rpm for 25 minutes (if solid is present)
6. Decant fluid
7. Repeat steps 3-6 with DI water (if solid is present)
8. Combine all decanted fluid, acidify with nitric acid to pH <2
9. Dilute with DI water to a final volume of 50 mL and submit for analysis

ATTACHMENT F-2
QUALITY ASSURANCE PROJECT PLAN

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LIST OF ACRONYMS AND ABBREVIATIONS

ARI	Analytical Resources, Inc.
ASTM	American Society of Testing and Materials
COC	chain-of-custody
DQO	data quality objective
EC_{50}	concentration of test substance in dilution water calculated to affect 50% of a test population during continuous exposure over a specified period of time
Ecology	Washington State Department of Ecology
FC	Field Coordinator
GC	gas chromatograph
HDPE	high-density polyethylene
LC_{50}	lethal concentration of toxicant killing 50% of exposed organisms
MDL	method detection limit
MS	mass spectrometer
OMMP	*Operations, Maintenance, and Monitoring Plan*
PCB	polychlorinated biphenyl
PSEP	Puget Sound Estuary Program
QA	quality assurance
QAPP	*Quality Assurance Project Plan*
QC	quality control
RL	reporting limit
RPD	relative percent difference
SAP	*Sampling and Analysis Plan*
SDG	sample delivery group
SRM	standard reference material
USEPA	U.S. Environmental Protection Agency

1 INTRODUCTION

This *Quality Assurance Project Plan* (QAPP) establishes quality assurance (QA) objectives for sampling and analysis activities in Port Gamble Bay, as described in the accompanying *Sampling and Analysis Plan* (SAP; Attachment F-1 to the *Operations, Maintenance, and Monitoring Plan* [OMMP]). The methods and QA procedures described here will be followed by Anchor QEA and its contractors during long-term monitoring data collection activities beginning in 2019.

The goal of the QAPP is to ensure that data of sufficiently high quality are generated to support the project data quality objectives (DQOs). The QAPP will address project management responsibilities, sampling and analytical procedures, assessment and oversight, and data reduction, validation, and reporting.

Analytical QA/quality control (QC) procedures were developed based on the analytical protocols and quality assurance guidance of the Puget Sound Estuary Program (PSEP; 1986, 1995, 1997a, 1997b), the *Dredged Material Evaluation and Disposal Procedures* (DMMO 2013) and the *EPA Contract Laboratory Program National Functional Guidelines for Data Review* (USEPA 1999, 2004, 2005, 2008).

2 SAMPLE CUSTODY AND SHIPPING REQUIREMENTS

Samples are considered to be in one's custody if they are: 1) in the custodian's possession or view; 2) in a secured location (under lock) with restricted access; or 3) in a container that is secured with an official seal(s) such that the sample cannot be reached without breaking the seal(s).

Chain-of-custody (COC) procedures will be followed for all samples throughout the collection, handling, and analysis process. The principal document used to track possession and transfer of samples is the COC form. Each sample will be represented on a COC form the day it is collected. All data entries will be made using indelible ink pen. Corrections will be made by drawing a single line through the error, writing in the correct information, then dating and initialing the change. Blank lines and spaces on the COC form will be lined-out, dated, and initialed by the individual maintaining custody.

A COC form will accompany each shipment of samples to the analytical laboratory. Each person who has custody of the samples will sign the COC form and ensure that the samples are not left unattended unless properly secured. Copies of all COC forms will be retained in the project files.

All samples will be shipped, couriered, or hand-delivered to the analytical laboratory as soon as possible. Samples collected on Friday may be held until the following Monday for shipment provided that this delay does not jeopardize any hold time requirements. Specific sample shipping procedures are as follows:

- Each sample cooler or container will be shipped via overnight delivery to the appropriate analytical laboratory or picked up by the laboratory courier. In the event that Saturday delivery is required, the Field Coordinator (FC) will contact the analytical laboratory before 3 p.m. on Friday to ensure that the laboratory is aware of the number of containers shipped and the airbill tracking numbers for those containers. Following each shipment, the FC or QA/QC Manager will verify the shipment from the day before has been received and is in good condition.
- The samples for bioassay testing will be placed into lidded high-density polyethylene (HDPE) buckets with no head space and stored in coolers at approximately 4° ± 2°C

until transported to the laboratory. Temperature within the coolers will be monitored, and COC procedures will be followed throughout sample handling by the laboratory.

- Ice will be sealed in separate plastic bags and placed in the shipping containers.
- Individual sample containers or groups of containers will be placed in sealable plastic bags, packed to prevent breakage, and transported in a sealed ice chest or other suitable container.
- Glass jars will be separated in the shipping container by shock-absorbent material (e.g., bubble wrap) to prevent breakage.
- Shipping containers will be clearly labeled with sufficient information (name of project, time and date container was sealed, person sealing the container, and consultant's office name and address) to enable positive identification.
- COC forms will be enclosed in a plastic bag and taped to the inside lid of the cooler.
- Each cooler will be wrapped securely with strapping tape, labeled "Glass – Fragile" and "This End Up," and will be clearly labeled with the laboratory's shipping address and the consultant's return address.

Upon transfer of sample possession to the analytical laboratory, the persons transferring custody of the sample container will sign the COC form. Upon receipt of samples at the laboratory, the receiver will record the condition of the samples on a sample receipt form. COC forms will be used internally in the laboratory to track sample handling and final disposition.

3 OVERVIEW OF DATA GENERATION AND ACQUISITION

The rationale for the sampling design and design assumptions for locating and selecting environmental samples is detailed in the accompanying SAP (Attachment F-1). The methods and procedures for collection of field samples are also provided in the accompanying SAP.

3.1 Chemical Analytical Methods

This section summarizes the target chemical analyses for the sediment samples. All sample analyses will be conducted in accordance with U.S. Environmental Protection Agency (USEPA)-approved methods. Prior to analysis, all samples will be maintained according to the appropriate holding times and temperatures for each analysis as defined in Table F-1-2 of the accompanying SAP (Attachment F-1). Table F-2-1 of this QAPP presents the proposed analytes, the analytical methods to be used, and the targeted reporting limits for the sediment chemical testing. The analytical laboratory will prepare detailed reports in accordance with this QAPP.

Prior to the analysis of the samples, the laboratory will calculate method detection limits for each analyte of interest, where applicable. Method detection limits will be below the values specified in Table F-2-1.

Chemical testing will be conducted at Analytical Resources, Inc. (ARI). ARI is accredited under the Washington State Department of Ecology (Ecology) and the National Environmental Laboratories Accreditation Program. In completing chemical analyses for this project, the contract laboratory is expected to meet the following minimum requirements:

- Adhere to the methods outlined in this QAPP, including methods referenced for each analytical procedure (Table F-2-1)
- Deliver PDF and electronic data as specified
- Meet reporting requirements for deliverables
- Meet turnaround times for deliverables
- Implement QA/QC procedures including DQOs, laboratory QC requirements, and performance evaluation testing requirements

- Notify the project QA/QC Manager of any QA/QC problems when they are identified to allow for quick resolution
- Allow laboratory and data audits to be performed, if deemed necessary

4 QUALITY ASSURANCE/QUALITY CONTROL

This section describes DQOs and field and laboratory QA/QC requirements. The equipment calibration and maintenance requirements and the assessment of compliance and response actions are also discussed.

4.1 Data Quality Objectives and Criteria

The DQO for this project is to ensure that the data collected are of known and acceptable quality for project objectives described in the accompanying SAP (Attachment F-1) to be achieved. The quality of laboratory data is assessed by precision, accuracy, representativeness, comparability, and completeness (the "PARCC" parameters). Definitions of these parameters and the applicable QC procedures are presented below. Applicable quantitative goals for these data quality parameters are listed in Table F-2-2.

4.1.1 Precision

Precision is the ability of an analytical method or instrument to reproduce its own measurement. It is a measure of the variability, or random error, in sampling, sample handling, and laboratory analysis. The American Society of Testing and Materials (ASTM) recognizes two levels of precision: repeatability—the random error associated with measurements made by a single test operator on identical aliquots of test material in a given laboratory, with the same apparatus, under constant operating conditions—and reproducibility—the random error associated with measurements made by different test operators, in different laboratories, using the same method but different equipment to analyze identical samples of test material (ASTM 2002).

In the laboratory, "within-batch" precision is measured using replicate sample or QC analyses and is expressed as the relative percent difference (RPD) between the measurements. The "batch-to-batch" precision is determined from the variance observed in the analysis of standard solutions or laboratory control samples from multiple analytical batches.

Field precision will be evaluated by the collection of blind field duplicates for chemistry samples at a frequency of one in 20 samples. Field chemistry duplicate precision will be screened against a RPD of 50% for sediment samples; however, no data will be qualified based solely on field homogenization duplicate precision.

Precision measurements can be affected by the nearness of a chemical concentration to the method detection limit (MDL), where the percent error (expressed as RPD) increases. The equation used to express precision is as follows:

$$\mathrm{RPD} = \frac{(\mathrm{C}_1 - \mathrm{C}_2) \times 100\%}{(\mathrm{C}_1 + \mathrm{C}_2)/2} \qquad \text{(Equation 4-1)}$$

where:

RPD = relative percent difference

C_1 = larger of the two observed values

C_2 = smaller of the two observed values

4.1.2 Accuracy

Accuracy is a measure of the closeness of an individual measurement (or an average of multiple measurements) to the true or expected value. Accuracy is determined by calculating the mean value of results from ongoing analyses of laboratory-fortified blanks, standard reference materials, and standard solutions. In addition, laboratory-fortified (i.e., matrix-spiked) samples are also measured, which indicates the accuracy or bias in the actual sample matrix. Accuracy is expressed as percent recovery of the measured value, relative to the true or expected value. If a measurement process produces results for which the mean is not the true or expected value, the process is said to be biased. Bias is the systematic error either inherent in a method of analysis (e.g., extraction efficiencies) or caused by an artifact of the measurement system (e.g., contamination). Analytical laboratories use several QC measures to eliminate analytical bias, including systematic analysis of method blanks, laboratory control samples, and independent calibration verification standards. Because bias can be positive or negative, and because several types of bias can occur simultaneously, only the net, or total, bias can be evaluated in a measurement.

Laboratory accuracy will be evaluated against quantitative matrix spike and surrogate spike recovery performance criteria provided by the laboratory. Accuracy can be expressed as a percentage of the true or reference value, or as a percent recovery in those analyses where reference materials are not available and spiked samples are analyzed. The equation used to express accuracy is as follows:

$$\%R = 100\% \times (S-U)/C_{sa} \qquad \text{(Equation 4-2)}$$

where:

$\%R$ = percent recovery

S = measured concentration in the spiked aliquot

U = measured concentration in the unspiked aliquot

C_{sa} = actual concentration of spike added

Field accuracy will be controlled by adherence to sample collection procedures outlined in the SAP.

4.1.3 Representativeness

Representativeness expresses the degree to which data accurately and precisely represent an environmental condition. For the Site, the list of analytes is inclusive of those that may be identified as contaminants of concern.

4.1.4 Comparability

Comparability expresses the confidence with which one dataset can be evaluated in relation to another dataset. For this program, comparability of data will be established through the use of standard analytical methodologies, reporting formats, and common traceable calibration and reference materials.

4.1.5 Completeness

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

$$C = \frac{(\text{Number of acceptable data points}) \times 100}{(\text{Total number of data points})} \qquad \text{(Equation 4-3)}$$

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

4.1.6 Sensitivity

Analytical sensitivities must be consistent with or lower than reporting limits listed in Table F-2-1 in order to demonstrate compliance with this QAPP.

The MDL is defined as the minimum concentration at which a given target analyte can be measured and reported with 99% confidence that the analyte concentration is greater than zero. Laboratory reporting limits (RLs) are defined as the lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. Laboratory RLs will be used to evaluate the method sensitivity or applicability prior to the acceptance of a method for this program.

The sample-specific RLs will be reported by the laboratory and will take into account any factors relating to the sample analysis that might decrease or increase the RL (e.g., dilution factor, percent moisture, sample volume, sparge volume). In the event that the RLs are elevated for a sample due to matrix interferences and subsequent dilution or reduction in the sample aliquot, the data will be evaluated by QA/QC Manager and the laboratory to determine if an alternative course of action is required or possible.

4.2 Field and Laboratory Quality Assurance and Quality Control

Field and laboratory activities must be conducted in such a manner that results meet specified quality objectives and are fully defensible. Guidance for QA/QC is derived from the protocols developed for Sediment Management Standards (Ecology 2013) and the Model Toxics Control Act (Ecology 2007), the USEPA Test Methods (1986), National Functional Guidelines (USEPA 1999, 2004, 2005, 2008), and the cited methods.

4.2.1 Field Quality Control

Anchor QEA personnel will identify and label samples in a consistent manner to ensure that field samples are traceable and that labels provide all information necessary for the laboratory to conduct required analyses properly. Samples will be placed in appropriate containers and preserved for shipment to the laboratory.

4.2.1.1 Sample Containers

Sample containers and preservatives will be provided by the laboratory. The laboratory will maintain documentation certifying the cleanliness of bottles and the purity of preservatives provided. Specific container requirements are included in the accompanying SAP (Attachment F-1).

4.2.1.2 Sample Identification and Labels

Each sample will have an adhesive plastic or waterproof paper label affixed to the container and will be labeled at the time of collection. The following information will be recorded on the container label at the time of collection:

- Project name
- Sample identification
- Date and time of sample collection
- Preservative type (if applicable)
- Analysis to be performed

Samples will be uniquely identified with a sample identification number. Specific sample identification schemes are provided in the accompanying SAP (Attachment F-1).

4.2.1.3 Field Quality Assurance Sampling

Field QA procedures will consist of following acceptable practices for collecting and handling samples. Adherence to these procedures will be complemented by periodic and routine equipment inspection.

Field QA samples will be collected along with environmental samples. Field QA samples are useful in identifying possible problems resulting from sample collection or sample processing in the field. Field QA samples will be homogenization duplicates collected at a frequency of one in 20 samples processed.

Field QA samples will also include the collection of additional sample volume to ensure that the laboratory has sufficient sample volume to run the program-required analytical QA/QC samples for analysis, as specified in Table F-2-3. Additional sample volume to meet this requirement will be collected at a frequency of one in 20 samples processed.

Equipment rinsate blanks will be collected at a frequency of one per sample collection equipment type per event as a part of these collection events.

All field QA samples will be documented in the field logbook and verified by the QA/QC Manager or a designee.

4.2.2 Laboratory Quality Control

Laboratory QC procedures, where applicable, include initial and continuing instrument calibrations, standard reference materials, laboratory control samples, matrix replicates, matrix spikes, method blanks, internal standards, and surrogate spikes. Table F-2-3 lists the frequency of analysis for laboratory QA/QC samples, and Table F-2-2 summarizes the DQOs for precision, accuracy, and completeness.

Results of the QC samples from each sample group will be reviewed by the analyst immediately after a sample group has been analyzed. The QC sample results will then be evaluated to determine if control limits have been exceeded. If control limits are exceeded in the sample group, the QA/QC Manager will be contacted immediately, and corrective action (e.g., method modifications followed by reprocessing the affected samples) will be initiated prior to processing a subsequent group of samples.

4.2.2.1 Laboratory Instrument Calibration and Frequency

An initial calibration will be performed at the frequencies outlined in Table F-2-3 for each analysis and laboratory instrument to be used and when any ongoing calibration does not meet method control criteria. A calibration verification will be analyzed following each initial calibration and will meet method criteria prior to analysis of samples. Continuing calibrations will be performed as required by the analytical method and as outlined in Table F-2-3. If the ongoing continuing calibration is out of control, the analysis must come to a halt until the source of the control failure is eliminated or reduced to meet control specifications. All project samples analyzed while the instrument calibration was out of control will be reanalyzed.

Instrument blanks or continuing calibration blanks provide information on the stability of the baseline established. Continuing calibration blanks will be analyzed immediately prior to or following continuing calibration verification at the instrument for each type of applicable analysis.

4.2.2.2 Standard Reference Materials

Standard reference materials (SRMs) are substances of the same or similar matrix to the project samples and contain a known concentration of target analyte(s). These materials are prepared and analyzed in the same manner as routine samples and in the same preparation and analytical batch. The recovery of the target analyte(s) provide information on interferences caused by the sample matrix. The Puget Sound SRM will be analyzed for carcinogenic polycyclic aromatic hydrocarbons, dioxin/furans, and cadmium for this project. SRM results will be evaluated using the DQOs outlined in Table F-2-2.

4.2.2.3 Laboratory Duplicates/Replicates

Analytical duplicates provide information on the precision of the analysis and are useful in assessing potential sample heterogeneity and matrix effects. Analytical duplicates and replicates are aliquots of the original samples that are prepared and analyzed as separate samples.

4.2.2.4 Matrix Spikes and Matrix Spike Duplicates

Analyses of matrix spike samples provide information on the preparation efficiency of the method on the sample matrix. By performing duplicate matrix spike analyses, information on the precision of the method is also provided.

4.2.2.5 Method Blanks

Method blanks are analyzed to assess possible laboratory contamination at all stages of sample preparation and analysis. The method blank for all analyses must contain less than the quantitation limit of any single target analyte/compound. Sample results may be reported if they are below detection or greater than five times the concentration detected in the method blank. If a laboratory method blank exceeds these criteria for any analyte/compound, analyses must stop, the source of contamination must be eliminated or reduced, and the affected samples must be reanalyzed.

4.2.2.6 Laboratory Control Samples

Laboratory control samples are analyzed to assess possible laboratory bias at all stages of sample preparation and analysis. The laboratory control sample is a matrix-dependent spiked sample prepared at the time of sample extraction along with the preparation of sample and matrix spikes and/or duplicates. The laboratory control sample will provide information on the accuracy of the analytical process and, when analyzed in duplicate, will provide precision information as well.

4.2.2.7 Laboratory Deliverables

Data packages will be checked for completeness immediately upon receipt from the laboratory to ensure that data and QA/QC information requested are present. Data quality will be assessed on the following based on this QAPP and National Functional Guidelines (USEPA 1999, 2004, 2005, 2008):

- Holding times and sample receipt conditions
- All compounds of interest reported
- RLs
- Matrix spike/matrix spike duplicate results

- Laboratory control samples/laboratory control sample duplicates
- SRM results
- Method blanks
- Internal standard recoveries
- Surrogate standard recoveries
- Initial calibrations
- Calibration verifications
- Instrument performance checks
- Dual-column confirmation results

4.3 Bioassay Test Quality Assurance/Quality Control

Sediment toxicity tests will incorporate standard QA/QC procedures to ensure that the test results are valid. Standard QA/QC procedures include the use of negative controls, positive controls, reference sediment samples, replicates, and measurements of water quality during testing.

4.3.1 Negative Controls

The negative control to be used for both sediment toxicity tests will be a clean control, which consists of clean, inert material and the same seawater used in testing sediment toxicity. For the tests to be used in this study, the negative control will be the amphipod collection site sediment, which will most likely be clean sand. The negative control for the bivalve larval test will be a seawater control.

4.3.2 Positive Controls

An appropriate reference toxicant will be run with each batch of test sediments as a positive control to establish the relative sensitivity of the test organisms. The positive control for sediment tests is typically conducted with diluent seawater and without sediment. The LC_{50}

or the EC_{50} must be within the 95% confidence interval of responses expected for the toxicant used[1].

4.3.3 Reference Sediment

Reference sediment will also be included with each bioassay, tested concurrently with test sediments to provide data that can be used to separate toxicant effects from unrelated effects, such as those of sediment grain size. Reference sediment samples should be collected from an area documented to be free from chemical contamination and should represent the range of important natural, physical, and chemical characteristics of the test sediments (e.g., sediment grain size and total organic carbon). For this study, reference sediment samples will be collected from Carr Inlet in Puget Sound, Washington (PSEP 1995). All bioassays have performance standards for reference sediments as mentioned above. Failure to meet these standards may result in the requirement to retest.

4.3.4 Replicates

Five replicate chambers for each test sediment, reference sediment, and negative control treatments will be run for each bioassay. A water quality replicate will also be run for each treatment.

4.3.5 Water Quality Monitoring

Water quality monitoring will be conducted for the amphipod, larval, and juvenile polychaete bioassays and reference toxicant tests. This monitoring consists of daily measurements in the water quality replicate of salinity, temperature, pH, and dissolved oxygen for the amphipod and larval tests. These measurements will be made every three days for the juvenile polychaete bioassay, with the exception of dissolved oxygen, which will be measured daily. Ammonia and sulfides in the overlying water will be determined at test initiation and termination for all three tests. Monitoring will be conducted for all test and reference sediments and negative controls (including seawater controls). Measurements for

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[1] LC_{50} is the lethal concentration of toxicant killing 50% of exposed organisms. EC_{50} is the concentration of test substance in dilution water that is calculated to affect 50% of a test population during continuous exposure over a specified period of time.

each treatment will be made on a separate test chamber that is set up identically to the other replicates within the treatment group, including the addition of test organisms.

5 DOCUMENTATION, RECORD KEEPING, AND REPORTING REQUIREMENTS

This section describes field and laboratory documentation and record keeping, data validation, and data report requirements.

5.1 Documentation and Records

This project will require central project files to be maintained at Anchor QEA. Project records will be stored and maintained in a secure manner. Each project team member is responsible for filing all necessary project information or providing it to the person responsible for the filing system. Individual team members may maintain files for individual tasks, but must provide such files to the central project files upon completion of each task. A project-specific index of file contents is to be kept with the project files. Hard copy documents, when necessary, will be kept on file at Anchor QEA throughout the duration of the project, and all electronic data will be maintained in the database at Anchor QEA.

5.1.1 Field Records

All documents generated during the field effort are controlled documents that become part of the project file.

5.1.1.1 Field Logs

Field team members will keep a daily record of significant events, observations, and measurements in a field log. All field activities will be recorded in a bound, paginated field logbook maintained by the FC or a designee for each activity. Field logbooks will be the main source of field documentation for all field activities. The on-site field representative will record information pertinent to the investigation program in the field logbook. The sampling documentation may be recorded manually or electronically and will contain information on each sample collected including, at a minimum, the following information:

- Project name
- Field personnel on site
- Site visitors
- Weather conditions
- Field observations

- Maps and/or drawings
- Date and time sample collected
- Sampling method and description of activities
- Identification or serial numbers of instruments or equipment used
- Deviations from the QAPP and SAP
- Conferences associated with field sampling activities

The person recording information must enter the date and time and initial each entry. Additional specific field reporting requirements are defined in the SAP. In general, sufficient information will be recorded during sample collection so that reconstruction of the event can occur without relying on the memory of the field personnel.

The field logbooks will be permanently bound and durable for adverse field conditions. All pages will be numbered consecutively. Notes will be taken in indelible, waterproof blue or black ink. Errors will be corrected by crossing out with a single line, dating, and initialing.

5.1.2 Analytical and Chemistry Records

Analytical data records will be retained by the laboratory and in the Anchor QEA central project files. For all analyses, the data reporting requirements will include those items necessary to complete data validation, including electronic copies of all raw data. The analytical laboratory will be required, where applicable, to report the following:

- **Project Narrative.** This summary, in the form of a cover letter, will discuss problems, if any, encountered during any aspect of analysis. This summary should discuss, but is not limited to, QC, sample shipment, sample storage, and analytical difficulties. Any problems encountered, actual or perceived, and their resolutions will be documented in as much detail as appropriate.
- **COC Records.** Legible copies of the COC forms will be provided as part of the data package. This documentation will include the time of receipt and condition of each sample received by the laboratory. Additional internal tracking of sample custody by the laboratory will also be documented on a sample receipt form. The form must include all sample shipping container temperatures measured at the time of sample receipt.

- **Sample Results.** The data package will summarize the results for each sample analyzed. The summary will include the following information when applicable:
  - Field sample identification code and the corresponding laboratory identification code
  - Sample matrix
  - Date of sample extraction/preparation
  - Date and time of analysis
  - Weight and/or volume used for extraction/preparation/analysis
  - Final dilution volumes or concentration factor for the sample
  - Identification of the instrument used for analysis
  - MDLs and quantitation limits accounting for sample-specific factors (e.g., dilution, total solids)
  - Analytical results with reporting units identified
  - Data qualifiers and their definitions
- **QA/QC Summaries.** This will contain the results of the laboratory QA/QC procedures. Each QA/QC sample analysis will be documented with the same information required for the sample results (see above). No recovery or blank corrections will be made by the laboratory. The required summaries are listed below; additional information may be requested.
  - **Method Blank Results.** The method blank results associated with each sample and the concentration of all compounds of interest identified in these blanks will be reported.
  - **Matrix Spike Recovery.** All matrix spike recovery data will be included. The name and concentration of all compounds added, percent recoveries, and range of recoveries will be listed. The RPD for all matrix spike duplicate analyses will be reported.
  - **Matrix Duplicate.** The RPD for all matrix duplicate analyses will be reported.
  - **Laboratory Control Sample.** All laboratory control sample recovery data will be included. The names and concentrations of all compounds added, percent recoveries will be reported. The RPDs for all duplicate analyses will be included.

- **Internal Standard Area Summary.** The area counts of internal standard areas or their concentrations will be reported for all analyses that require internal standards.
- **Surrogate Spike Recovery.** The names and concentrations of all surrogate spike compounds added, the spiked concentrations, the percent recoveries, and the range of acceptable recoveries will be reported for organic analyses.
- **Calibration Data Summary.** This summary will report the concentrations of the initial calibration and calibration verification standards, and the date and time of analyses. The response factor, percent relative standard deviation, percent difference, and retention time for each analyte will be reported, as applicable.
- **Relative Retention Time.** The relative retention times for each analyte detected in the samples for both primary and confirmation analyses for applicable methods will be reported along with the acceptable retention time ranges.
- **Original Data.** Legible copies of the original data generated by the laboratory will include the following:
  - Sample preparation, identification of preparation method used, and cleanup logs
  - Instrument specifications and analysis logs for all instruments used on days of calibration and analysis
  - Calculation worksheets for inorganic analyses
  - Printouts of full scan chromatograms and quantitation reports for all gas chromatograph (GC) and GC/mass spectrometer (MS) sample, standard, blank, calibration, spike, replicate, and reference material results
  - Enhanced spectra of detected compounds with associated best-match spectra for each sample for GC/MS analyses

All instrument data shall be fully restorable at the laboratory from electronic backup. Data validation reports will be maintained in the central project files with the analytical data reports.

5.1.3 *Data Reduction*

Data reduction is the process by which original data (analytical measurements) are converted or reduced to a specified format or unit to facilitate analysis of the data. Data reduction requires that all aspects of sample preparation that could affect the test result, such as sample volume analyzed or dilutions required, be taken into account in the final result. It is the laboratory analyst's responsibility to reduce the data, which are subjected to further review by the Laboratory Manager, the project manager, the QA/QC Manager, and independent reviewers. Data reduction may be performed manually or electronically. If performed electronically, all software used must be demonstrated to be true and free from unacceptable error.

5.2 Bioassay Data Deliverables

The laboratory conducting the bioassay tests will be responsible for internal checks on data reporting and will correct errors identified during the QA review. The bioassay laboratory for this study will be required to report results that include all information recommended by PSEP protocols for QA review, as follows:

- A description of any deviations from the methodology or problems with the process and procedures of analyses
- Test methods used for bioassay testing and statistical analyses
- Results for survival, growth, reburial, abnormalities, water quality parameters, reference toxicant, and statistical analyses
- Original data sheets for water quality, survival, growth, reburial, abnormalities, reference toxicant, and statistical analyses
- COC records

Close contact with the laboratory will be maintained to resolve any QA/QC problems in a timely manner.

5.3 Data Management

Field data sheets will be checked for completeness and accuracy by the FC prior to delivery to the data manager. All data generated in the field will be documented and provided to the office data manager, who is responsible for the data's entry into the database. All manually entered data will be checked by a second party. Field documentation will be filed in the main project file after data entry and checking are complete.

Laboratory data will be provided to the data manager in the EQuIS electronic format. The laboratory data that are provided electronically and loaded into the database will undergo a 10% check against the laboratory hard copy data. Data will be validated or reviewed manually and qualifiers, if assigned, will be entered manually. The accuracy of all manually entered data will be verified by a second party.

6 DATA VALIDATION AND USABILITY

This section describes the processes that will be used to review project data quality.

6.1 Data Review, Validation, and Verification

Stage 2B data validations (USEPA 2009) will be performed on most data and Stage 4 data validations will be performed on the dioxin/furan data. During the validation process, analytical data will be evaluated for method QC and laboratory QC compliance, and their validity and applicability for program purposes will be determined. Based on the findings of the validation process, data validation qualifiers may be assigned. The validated project data, including qualifiers, will be entered into the project database, thus enabling this information to be retained or retrieved, as needed.

6.2 Validation and Verification Methods

Data validation includes signed entries by the field and laboratory technicians on field data forms and laboratory datasheets, respectively, review for completeness and accuracy by the FC and Laboratory Manager, review by the QA/QC Manager (or designee) for outliers and omissions, and the use of QC criteria to accept or reject specific data. All data will be entered into the project database.

All laboratory data will be reviewed and verified to determine whether DQOs have been met and that appropriate corrective actions have been taken, when necessary. The project QA/QC Manager or designee will be responsible for the final review of all data generated from analyses of samples.

The first level of review will take place in the laboratory as the data are generated. The Laboratory Manager or designee will be responsible for ensuring that the data generated meet minimum QA/QC requirements and that the instruments were operating under acceptable conditions during generation of data. DQOs will also be assessed at this point by comparing the results of QC measurements with pre-established criteria as a measure of data acceptability.

The analysts and/or laboratory department manager will prepare a preliminary QC checklist for each analytical parameter and for each sample delivery group (SDG) as soon as analysis of a SDG has been completed. Any deviations from the DQOs listed on the checklist will be brought to the attention of the Laboratory Manager to determine whether corrective action is needed, and to determine the impact on the reporting schedule.

Data packages will be checked for completeness immediately upon receipt from the laboratory to ensure that data and QA/QC information requested are present. Data quality will be assessed for all data by a reviewer using this QAPP and National Functional Guidelines (USEPA 1999, 2004, 2005, 2008), by considering the following:

- Laboratory sample receipt
- Holding times
- Instrument performance checks
- Initial calibrations
- Continuing calibrations
- Method blanks
- Surrogate recoveries
- Internal standard results
- Detection limits
- Quantitation limits
- Dual-column confirmation results
- Laboratory control samples
- Matrix spike/matrix spike duplicate samples
- Laboratory replicates
- SRMs

The data will be validated in accordance with the project-specific DQOs described above, analytical method criteria, and the laboratory's internal performance standards based on their Standard Operating Procedures.

6.3 Reconciliation with User Requirements

The QA/QC Manager will review data after each survey to determine if DQOs have been met. If data do not meet the project's specifications, the QA/QC Manager will review the errors and determine if the problem is due to calibration/maintenance, sampling techniques, or other factors and will suggest corrective action as necessary. It is expected that any problem would be able to be corrected by retraining, revision of techniques, or replacement of supplies/equipment; if not, the DQOs will be reviewed for feasibility. If specific DQOs are not achievable, the QA/QC Manager will recommend appropriate modifications.

7 REFERENCES

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TABLES

Table F-2-1
Parameters for Analysis, Screening Criteria, Analytical Methods, and Target Quantitation Limits

Parameter	Management Standards		Model Toxics Control Act	Analytical Method	Quantitation Limit
	Sediment Cleanup Objective	Cleanup Screening Level	Method A for Unrestricted Land Uses		
Metals					
Cadmium	260	270	2000	6010B/6020	0.5
Polycyclic Aromatic Hydrocarbons, µg/kg dry weight					
Total LPAH[a]	---	---	---	8270D SIM	---
Naphthalene	---	---	---	8270D SIM	5.0
Acenaphthylene	---	---	---	8270D SIM	5.0
Acenaphthene	---	---	---	8270D SIM	5.0
Fluorene	---	---	---	8270D SIM	5.0
Phenanthrene	---	---	---	8270D SIM	5.0
Anthracene	---	---	---	8270D SIM	5.0
2-Methylnaphthalene	---	---	---	8270D SIM	5.0
Total HPAHs[b]	---	---	---	8270D SIM	---
Fluoranthene	---	---	---	8270D SIM	5.0
Pyrene	---	---	---	8270D SIM	5.0
Benzo(a)anthracene	---	---	---	8270D SIM	5.0
Chrysene	---	---	---	8270D SIM	5.0
Total benzo(b,j,k)fluoranthenes	---	---	---	8270D SIM	5.0
Benzo(a)pyrene	---	---	10	8270D SIM	5.0
Indeno(1,2,3-cd)pyrene	---	---	---	8270D SIM	5.0
Dibenz(a,h)anthracene	---	---	---	8270D SIM	5.0
Benzo(g,h,i)perylene	---	---	---	8270D SIM	5.0
Total naphthalenes[c]	---	---	5,000	8270D SIM	---
cPAH TEQ	---	---	---	8270D SIM	---
Polycyclic Aromatic Hydrocarbons, mg/kg-OC					
Total LPAH[a]	370	780	---	8270D SIM	---
Naphthalene	99	170	---	8270D SIM	Various
Acenaphthylene	66	66	---	8270D SIM	Various
Acenaphthene	16	57	---	8270D SIM	Various
Fluorene	23	79	---	8270D SIM	Various
Phenanthrene	100	480	---	8270D SIM	Various
Anthracene	220	1,200	---	8270D SIM	Various
2-Methylnaphthalene	38	64	---	8270D SIM	Various
Total HPAHs[b]	960	5,300	---	8270D SIM	---
Fluoranthene	160	1,200	---	8270D SIM	Various
Pyrene	1,000	1,400	---	8270D SIM	Various
Benzo(a)anthracene	110	270	---	8270D SIM	Various
Chrysene	110	460	---	8270D SIM	Various
Total benzo(b,j,k)fluoranthenes	230	450	---	8270D SIM	Various

Table F-2-1
Parameters for Analysis, Screening Criteria, Analytical Methods, and Target Quantitation Limits

Parameter	Management Standards		Model Toxics Control Act	Analytical Method	Quantitation Limit
	Sediment Cleanup Objective	Cleanup Screening Level	Method A for Unrestricted Land Uses		
Benzo(a)pyrene	99	210	---	8270D SIM	Various
Indeno(1,2,3-cd)pyrene	34	88	---	8270D SIM	Various
Dibenz(a,h)anthracene	12	33	---	8270D SIM	Various
Dioxin/Furans, ng/kg dry weight					
Dioxins					
2,3,7,8-TCDD	---	---	---	1613B	1.0
1,2,3,7,8-PeCDD	---	---	---	1613B	5.0
1,2,3,4,7,8-HxCDD	---	---	---	1613B	5.0
1,2,3,6,7,8-HxCDD	---	---	---	1613B	5.0
1,2,3,7,8,9-HxCDD	---	---	---	1613B	5.0
1,2,3,4,6,7,8-HpCDD	---	---	---	1613B	5.0
OCDD	---	---	---	1613B	10
Furans					
2,3,7,8-TCDF	---	---	---	1613B	1.0
1,2,3,7,8-PeCDF	---	---	---	1613B	5.0
2,3,4,7,8,-PeCDF	---	---	---	1613B	5.0
1,2,3,4,7,8-HxCDF	---	---	---	1613B	5.0
1,2,3,6,7,8-HxCDF	---	---	---	1613B	5.0
1,2,3,7,8,9-HxCDF	---	---	---	1613B	5.0
2,3,4,6,7,8-HxCDF	---	---	---	1613B	5.0
1,2,3,4,6,7,8-HpCDF	---	---	---	1613B	5.0
1,2,3,4,7,8,9-HpCDF	---	---	---	1613B	5.0
OCDF	---	---	---	1613B	10

Notes:

a Total LPAH consists of the sum of naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene.

b Total HPAH consists of the sum of fluoranthene, pyrene, benz(a)anthracene, chrysene, benzo(b,j,k)fluoranthenes, benzo(a)pyrene, indeno(1,2,3,-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.

c Total naphthalenes consists of the sum of 1-methylnaphthalene, 2-methylnaphthalene, and napthalene.

µg/kg = micrograms per kilogram

cPAH = carcinogenic polycyclic aromatic hydrocarbon

mg/kg = mliligrams per kilogram

ng/kg = nanograms per kilogram

TEQ = Toxic Equivalents Quotient

Table F-2-2
Data Quality Objectives

Parameter	Precision	Accuracy	Completeness
Sediments			
Total metals	± 30% RPD	75-125% R	95%
Semi-volatile organic compounds	± 35% RPD	70-150% R	95%
Dioxin/Furans	± 35% RPD	50-150% R	95%

Notes:

R = Recovery

RPD = Relative percent difference

Table F-2-3
Field and Laboratory QA/QC Requirements

	Field Quality Assurance Samples				Laboratory Quality Control Elements								
Analysis Type	**Rinsate Blank**	**Field Blank**	**Trip Blank**	**Homogenization duplicate**	**Initial Calibration**	**Ongoing Calibration**	**Replicates**	**LCS/OPR**	**Matrix Spikes**	**SRM**	**Matrix Spike Duplicates**	**Method Blanks**	**Surrogate Spikes**
Metals	1 per equipment type	1 per equipment type	NA	1 per 20 samples collected for analyses	Daily	1 per 10 samples	1 per 20 samples or 1 per batch, whichever is more frequent	1 per 20 samples	1 per 20 samples or 1 per batch, whichever is more frequent	1 per sampling event	NA	1 per 20 samples or 1 per batch, whichever is more frequent	NA
SVOCs/PAHs	1 per equipment type	1 per equipment type	NA	1 per 20 samples collected for analyses	As needed[a]	Every 12 hours	NA	1 per 20 samples	1 per 20 samples or 1 per batch, whichever is more frequent	1 per sampling event	1 per 20 samples or 1 per batch, whichever is more frequent	1 per 20 samples or 1 per batch, whichever is more frequent	Every sample
Dioxin/Furans	1 per equipment type	1 per equipment type	NA	1 per 20 samples collected for analyses	As needed[a]	Every 12 hours	1 per 20 samples or 1 per batch, whichever is more frequent	1 per 20 samples or 1 per batch, whichever is more frequent	NA[b]	1 per sampling event	NA	1 per 20 samples or 1 per batch, whichever is more frequent	Every sample[b]

Notes:

a Initial calibrations are considered valid until the ongoing continuing calibration no longer meets method specifications. At that point, a new initial calibration is performed.

b Isotope dilution with labeled compounds required in every sample.

LCS = laboratory control sample
NA = not applicable
OPR = ongoing precision and recovery
PAH = polycyclic aromatic hydrocarbons
SVOC = semivolatile organic compounds
SRM = standard reference material

Appendix C
ARI Laboratory Report

Appendix D

Data Validation Report

Appendix E

EcoAnalysts Bioassay Laboratory Report

Appendix F
Analytical Data Table

Appendix B
Analytical Data Table

Location ID	BW-01_2009	BW-01_2009	BW-04_2009	BW-04_2009	BW-15_2009	BW-15_2009
Sample ID	BW-01-0-2-200908	BW-01-2-10-200908	BW-04-0-2-200908	BW-04-2-10-200908	BW-15-0-2-200908	BW-15-2-10-200908
Sample Date	9/8/2020	9/8/2020	9/8/2020	9/8/2020	9/8/2020	9/8/2020
Depth	0 - 2 cm	2 - 10 cm	0 - 2 cm	2 - 10 cm	0 - 2 cm	2 - 10 cm
Sample Type	N	N	N	N	N	N
Chemical						
Conventional Parameters (pct)						
Total Solids	69.7	64.49	41.17	45.31	59.31	58.99
Metals (mg/kg)						
Cadmium	0.46 J	0.58 J	1.41 J	1.26 J	0.73 J	0.72 J
Polycyclic Aromatic Hydrocarbons (µg/kg)						
1-Methylnaphthalene	4.34 J	6.40	5.68	6.27	6.32	5.98
2-Methylnaphthalene	5.72	9.89	7.43	7.95	8.04	8.41
Acenaphthene	8.56	9.42	5.77	7.66	9.06	7.28
Acenaphthylene	22.7	20.1	14.0	18.0	19.9	17.0
Anthracene	13.3	14.5	14.1	15.9	15.3	13.8
Benzo(a)anthracene	15.2	14.3	27.1	21.6	19.3	16.0
Benzo(a)pyrene	16.4	19.3	29.1	26.4	22.4	20.8
Benzo(b,j,k)fluoranthenes	31.4	34.9	55.6	50.9	42.9	40.7
Benzo(g,h,i)perylene	23.8 J	27.5 J	29.0 J	30.6 J	33.8 J	34.2 J
Chrysene	22.7	17.8	42.0	47.6	25.8	19.4
Dibenzo(a,h)anthracene	2.99 J	3.47 J	6.17 J	5.22 J	3.88 J	3.50 J
Dibenzofuran	7.27	9.94	4.98 J	6.50	8.95	7.77
Fluoranthene	63.2	58.1	60.6	59.0	104	68.8
Fluorene	7.02	9.20	7.38	7.81	11.0	8.52
Indeno(1,2,3-c,d)pyrene	14.6 J	17.0 J	23.1 J	23.1 J	19.3 J	19.7 J
Naphthalene	82.4	73.7	54.8	70.9	74.9	57.2
Phenanthrene	52.6	45.9	40.6	45.6	80.8	51.5
Pyrene	63.4	59.0	59.6	55.4	97.0	71.2
Total cPAH TEQ (7 minimum CAEPA 2005) (U = 0)	23.0 J	26.4 J	40.7 J	37.0 J	31.2 J	29.0 J
Dioxin Furans (ng/kg)						
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	3.73	8.94 J	21.2 J	21.9 J	9.66 J	8.92
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	75.4	147 J	430 J	516 J	156 J	161
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	2.29	4.46	10.8	10.9	4.93	4.69
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	14	21.2	61.7	67.9	23.0	24.5
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	0.998 U	0.192 J	0.578 J	0.471 J	0.239 J	0.241 J
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	0.242 J	0.374 J	1.06	1.15	0.775 J	0.507 J
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	0.283 J	0.430 J	1.01	1.02	0.505 J	0.534 J
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	0.108 J	0.277 J	0.664 J	0.723 J	0.488 J	0.301 J
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	0.770 J	1.38	3.95 J	3.56	1.60	1.67
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	0.998 U	0.125 J	0.300 J	0.214 J	0.133 J	0.183 J
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	0.390 J	0.683 J	2.46 J	2.01	0.966 J	0.964 J
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	0.434 J	0.532 J	1.53	1.68	0.724 J	0.686 J
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	0.440 J	0.723 J	2.08	1.81	0.797 J	0.748 J
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	0.246 J	0.384 J	0.685 J	0.997 J	0.561 J	0.358 J
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	0.454 J	0.497 J	1.67	1.57 J	0.557 J	0.548 J
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	2.35 J	2.29 J	6.01 J	5.63 J	2.76 J	2.35 J
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	0.254 J	0.342 J	0.674 J	0.741 J	0.312 J	0.261 J
Total Heptachlorodibenzofuran (HpCDF)	5.76	11.6	29.5	31.0	12.2	12.5

Appendix B
Analytical Data Table

Location ID	**BW-18_2009**	**BW-18_2009**	**BW-19_2009**	**BW-19_2009**	**BW-21_2009**	**BW-21_2009**
Sample ID	**BW-18-0-2-200909**	**BW-18-2-10-200909**	**BW-19-0-2-200908**	**BW-19-2-10-200908**	**BW-121-2-10-200909**	**BW-21-0-2-200908**
Sample Date	**9/9/2020**	**9/9/2020**	**9/8/2020**	**9/8/2020**	**9/9/2020**	**9/9/2020**
Depth	**0 - 2 cm**	**2 - 10 cm**	**0 - 2 cm**	**2 - 10 cm**	**2 - 10 cm**	**0 - 2 cm**
Sample Type	**N**	**N**	**N**	**N**	**N**	**N**
Chemical						
Conventional Parameters (pct)						
Total Solids	**34.11**	**36.13**	**31.35**	**35.5**	**36.38**	**33.29**
Metals (mg/kg)						
Cadmium	**1.63**	**2.01**	**2.08 J**	**1.87 J**	**2.24 J**	**2.91 J**
Polycyclic Aromatic Hydrocarbons (µg/kg)						
1-Methylnaphthalene	**8.98**	**13.3**	**12.2**	**12.6**	**10.0**	**5.72**
2-Methylnaphthalene	**11.0**	**17.7**	**15.4**	**14.8**	**12.6**	**7.43**
Acenaphthene	**8.61**	**15.6**	**11.3**	**10.2**	**11.9**	**4.82 J**
Acenaphthylene	**22.5**	**37.1**	**27.9**	**28.6**	**31.6**	**13.0**
Anthracene	**19.4**	**29.7**	**27.5**	**27**	**26.1**	**12.2**
Benzo(a)anthracene	**26.5**	**32.6**	**34.4**	**33.9**	**22.2**	**16.2**
Benzo(a)pyrene	**31.1 J**	**39.7 J**	**42.8**	**42.8**	**30.8 J**	**20.9 J**
Benzo(b,j,k)fluoranthenes	**65.2**	**76.3**	**77.5**	**83.6**	**53.1**	**37.2**
Benzo(g,h,i)perylene	**39.7**	**59.9**	**66.0 J**	**62.0 J**	**53.3**	4.99 U
Chrysene	**44.0**	**45.2**	**41.9**	**48.3**	**30.7**	**18.1**
Dibenzo(a,h)anthracene	4.99 U	5.00 U	**5.67 J**	**7.93 J**	4.99 U	4.99 U
Dibenzofuran	**9.88**	**16.8**	**13.6**	**12.7**	**11.6**	**5.58**
Fluoranthene	**102**	**142**	**136**	**134**	**111**	**69.2**
Fluorene	**11.8**	**19.8**	**16.8**	**17.4**	**14.5**	**7.75**
Indeno(1,2,3-c,d)pyrene	4.99 U	5.00 U	**37.5 J**	**36.7 J**	4.99 U	4.99 U
Naphthalene	**89.1 J**	**137 J**	**93.5**	**101**	**133 J**	**46.7 J**
Phenanthrene	**68.4**	**109**	**95.4**	**94.0**	**90.8**	**46.5**
Pyrene	**97.9**	**147**	**142**	**137**	**129**	**75.7**
Total cPAH TEQ (7 minimum CAEPA 2005) (U = 0)	**40.7 J**	**51.0 J**	**58.7 J**	**59.5 J**	**38.6 J**	**26.4 J**
Dioxin Furans (ng/kg)						
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	**25.6 J**	**28.9 J**	**17.4**	**18.9 J**	**16.0 J**	**16.7 J**
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	**544 J**	**531 J**	**369**	**368 J**	**278 J**	**272 J**
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	**14.5**	**15.0**	**11.6**	**10.8**	**9.68**	**11.0**
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	**81.6**	**88.3**	**55.3**	**53.5**	**49.2**	**51.3**
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	**0.527 J**	**0.784 J**	**0.541 J**	**0.679 J**	**0.513 J**	**0.451 J**
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	**1.58**	**1.68**	**1.30 J**	**1.20**	**1.40**	**1.25**
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	**1.52**	**2.67**	**1.16**	**1.06**	**1.22**	**2.93**
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	**1.06**	**1.20**	**0.845 J**	**0.750 J**	**0.843 J**	**0.872 J**
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	**5.10**	**7.12**	**3.64**	**3.55**	**3.48**	**4.93**
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	**0.462 J**	**0.480 J**	**0.243 J**	**0.299 J**	**0.333 J**	0.999 U
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	**3.19**	**4.99**	**2.31**	**2.10**	**2.19**	**3.42**
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	**1.59**	**2.45**	**1.32 J**	**1.18**	**1.73**	**1.80**
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	**2.29**	**3.54**	**1.82**	**1.64**	**1.84**	**2.78**
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	**1.21 J**	**1.49 J**	**1.02**	**1.03**	**1.04 J**	**1.15**
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	**1.74 J**	**2.58 J**	**1.59**	**1.38**	**1.30**	**1.85**
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	**8.13 J**	**13.3 J**	**3.93 J**	**7.60 J**	**7.42 J**	**5.49 J**
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	**0.689 J**	**1.06**	**0.613 J**	**0.664 J**	**0.721 J**	**0.644 J**
Total Heptachlorodibenzofuran (HpCDF)	**38.6**	**41.2**	**29.9**	**28.8**	**26.6**	**28.8**

Appendix B
Analytical Data Table

Location ID	**BW-21_2009**	**PGSS-29_2009**	**PGSS-29_2009**	**PGSS-70_2009**	**PGSS-70_2009**	**PGSS-77A_2009**
Sample ID	**BW-21-2-10-200908**	**PGSS-29-0-2-200911**	**PGSS-29-2-10-200911**	**PGSS-70-0-2-200908**	**PGSS-70-2-10-200908**	**PGSS-77A-0-2-200908**
Sample Date	**9/9/2020**	**9/11/2020**	**9/11/2020**	**9/8/2020**	**9/8/2020**	**9/8/2020**
Depth	**2 - 10 cm**	**0 - 2 cm**	**2 - 10 cm**	**0 - 2 cm**	**2 - 10 cm**	**0 - 2 cm**
Sample Type	**N**	**N**	**N**	**N**	**N**	**N**
Chemical						
Conventional Parameters (pct)						
Total Solids	**36.24**	**62.42**	**66.7**	**66.21**	**65.28**	**71.81**
Metals (mg/kg)						
Cadmium	**2.66 J**	**0.60 J**	**0.64 J**	**0.38 J**	**0.58 J**	**0.30 J**
Polycyclic Aromatic Hydrocarbons (µg/kg)						
1-Methylnaphthalene	**7.53**	**5.71**	**6.37**	**6.57**	**7.70**	**5.15**
2-Methylnaphthalene	**9.99**	**7.77**	**8.49**	**12.9**	**13.4**	**7.30**
Acenaphthene	**7.61**	**7.15**	**8.58**	**23.4**	**12.0**	**7.95**
Acenaphthylene	**19.0**	**13.6**	**16.6**	**9.31**	**14.0**	**16.1**
Anthracene	**16.0**	**12.5**	**16.9**	**151**	**22.0**	**11.1**
Benzo(a)anthracene	**21.9**	**10.0**	**12.0**	**152**	**28.3**	**10.6**
Benzo(a)pyrene	**28.1 J**	5.00 UJ	**13.5 J**	**135**	**27.4**	**12.2**
Benzo(b,j,k)fluoranthenes	**48.3**	10.0 U	**25.9**	**231**	**57.6**	**22.7**
Benzo(g,h,i)perylene	**41.2**	5.00 U	4.99 U	**98.7 J**	**31.1 J**	**15.9 J**
Chrysene	**26.6**	**10.3**	**14.4**	**147**	**32.4**	**13.3**
Dibenzo(a,h)anthracene	4.99 U	5.00 U	4.99 U	**31.7 J**	**6.05 J**	**1.84 J**
Dibenzofuran	**8.31**	**9.37**	**10.6**	**20.9**	**13.7**	**7.25**
Fluoranthene	**91.1**	**58.6**	**78.6**	**279**	**96.1**	**46.3**
Fluorene	**10.8**	**8.76**	**12.1**	**53.4**	**12.7**	**7.83**
Indeno(1,2,3-c,d)pyrene	4.99 U	5.00 U	4.99 U	**85.7 J**	**20.9 J**	**9.90 J**
Naphthalene	**80.3 J**	**76.8 J**	**101 J**	**42.8**	**56.3**	**81.3**
Phenanthrene	**64.5**	**51.3**	**66.1**	**243**	**66.4**	**37.9**
Pyrene	**99.9**	**61.5**	**84.8**	**225**	**88.1**	**45.6**
Total cPAH TEQ (7 minimum CAEPA 2005) (U = 0)	**35.4 J**	**1.10 J**	**17.4 J**	**187 J**	**39.0 J**	**16.8 J**
Dioxin Furans (ng/kg)						
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	**16.0 J**	**3.94**	**5.76 J**	**7.69 J**	**10.0**	**5.85**
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	**277 J**	**89.2**	**108 J**	**158 J**	**217**	**101**
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	**10.2**	**2.20**	**2.42 J**	**3.62**	**4.43**	**2.66**
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	**48.9**	**13.0**	**13.5**	**22.3**	**29.7**	**14.2**
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	**0.601 J**	0.996 U	0.998 U	**0.237 J**	**0.200 J**	**0.144 J**
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	**1.19 J**	**0.247 J**	**0.351 J**	**0.341 J**	**0.483 J**	**0.332 J**
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	**1.23**	**0.280 J**	0.998 U	**0.337 J**	**0.517 J**	**0.440 J**
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	**0.877 J**	**0.227 J**	**0.229 J**	**0.271 J**	**0.338 J**	**0.184 J**
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	**3.59**	**0.822 J**	**0.635 J**	**1.32**	**1.72**	**1.11**
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	**0.231 J**	0.996 U	0.998 U	0.994 U	0.994 U	0.999 U
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	**2.36**	**0.455 J**	**0.605 J**	**0.688 J**	**0.881 J**	**0.629 J**
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	**1.73**	**0.418 J**	**0.373 J**	**0.507 J**	**0.611 J**	**0.515 J**
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	**2.03**	**0.423 J**	**0.384 J**	**0.559 J**	**0.773 J**	**0.738 J**
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	**1.02 J**	**0.228 J**	**0.177 J**	**0.343 J**	**0.430 J**	**0.188 J**
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	**1.49**	**0.382 J**	**0.414 J**	**0.462 J**	**0.574 J**	**0.391 J**
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	**5.68 J**	**1.48 J**	**2.01 J**	**2.22 J**	**2.28 J**	**1.54 J**
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	**0.693 J**	**0.273 J**	**0.303 J**	**0.279 J**	**0.338 J**	**0.284 J**
Total Heptachlorodibenzofuran (HpCDF)	**26.5**	**5.81**	**3.62**	**11.0**	**13.6**	**2.95**

Appendix B
Analytical Data Table

Location ID	**PGSS-77A_2009**	**PGSS-8_2009**	**PGSS-8_2009**	**PGST-1_2009**	**PGST-1_2009**	**PGST-5_2009**
Sample ID	**PGSS-77A-2-10-200908**	**PGSS-8-0-2-200909**	**PGSS-8-2-10-200909**	**PGST-1-0-2-200911**	**PGST-1-2-10-200911**	**PGST-5-0-2-200911**
Sample Date	**9/8/2020**	**9/9/2020**	**9/9/2020**	**9/11/2020**	**9/11/2020**	**9/11/2020**
Depth	**2 - 10 cm**	**0 - 2 cm**	**2 - 10 cm**	**0 - 2 cm**	**2 - 10 cm**	**0 - 2 cm**
Sample Type	**N**	**N**	**N**	**N**	**N**	**N**
Chemical						
Conventional Parameters (pct)						
Total Solids	**66.39**	**37.76**	**41.23**	**25.73**	**27.42**	**36.77**
Metals (mg/kg)						
Cadmium	**0.34 J**	**1.97 J**	**1.97 J**	**1.95**	**1.95**	**1.34**
Polycyclic Aromatic Hydrocarbons (µg/kg)						
1-Methylnaphthalene	**4.91 J**	**8.29**	**8.31**	**7.09**	**9.40**	**8.20**
2-Methylnaphthalene	**7.55**	**10.9**	**10.6**	**11.2**	**14.0**	**10.4**
Acenaphthene	**9.59**	**11.6**	**12.0**	**5.13**	**7.04**	**10.8**
Acenaphthylene	**15.0**	**30.7**	**26.8**	**10.4**	**13.8**	**29.5**
Anthracene	**12.1**	**21.1**	**19.8**	**14.0**	**23.1**	**17.4**
Benzo(a)anthracene	**14.9**	**25.8**	**22.2**	**21.9**	**33.5**	**20.4**
Benzo(a)pyrene	**15.4**	**29.4 J**	**27.5 J**	**24.5 J**	**35.1 J**	**25.1 J**
Benzo(b,j,k)fluoranthenes	**33.9**	**50.7**	**49.4**	**53.2**	**73.0**	**50.2**
Benzo(g,h,i)perylene	**18.3 J**	**41.5**	**38.3**	4.99 U	**38.2**	5.00 U
Chrysene	**25.6**	**33.0**	**28.4**	**34.8**	**57.9**	**33.3**
Dibenzo(a,h)anthracene	**3.06 J**	5.00 U	5.00 U	4.99 U	5.00 U	5.00 U
Dibenzofuran	**7.95**	**11.1**	**10.8**	**6.41**	**8.56**	**9.95**
Fluoranthene	**59.8**	**96.2**	**95.0**	**55.2**	**82.1**	**89.6**
Fluorene	**7.72**	**14.2**	**12.7**	**8.62**	**12.4**	**10.4**
Indeno(1,2,3-c,d)pyrene	**12.4 J**	5.00 U	5.00 U	4.99 U	5.00 U	5.00 U
Naphthalene	**65.2**	**105 J**	**100 J**	**32.2 J**	**42.1 J**	**116 J**
Phenanthrene	**42.9**	**76**	**71.4**	**39.4**	**59.3**	**70.2**
Pyrene	**52.4**	**102**	**99.4**	**54.5**	**79.9**	**85**
Total cPAH TEQ (7 minimum CAEPA 2005) (U = 0)	**22.1 J**	**37.4 J**	**34.9 J**	**32.4 J**	**46.3 J**	**32.5 J**
Dioxin Furans (ng/kg)						
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	**7.78 J**	**131 J**	**11.1 J**	**35.6 J**	**26.2 J**	**18.9 J**
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	**167**	**483 J**	**175 J**	**845 J**	**603 J**	**403 J**
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	**4.39**	**27.5**	**4.60 J**	**19.9**	**14.0**	**10.8**
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	**23.0**	**81.4**	**22.7 J**	**115**	**83.8**	**62.2**
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	**0.271 J**	**0.805 J**	**0.255 J**	**0.985 J**	**0.730 J**	**0.550 J**
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	**0.521 J**	**1.44 J**	**0.446 J**	**1.74**	**1.46**	**1.16**
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	**0.431 J**	**1.65**	**0.453 J**	**1.81**	**1.37**	**1.43**
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	**0.307 J**	**1.08 J**	**0.349 J**	**1.07 J**	**0.846 J**	**0.861 J**
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	**1.52**	**5.19**	**1.50 J**	**6.37**	**4.69**	**4.44**
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	0.998 U	**0.307 J**	0.998 U	**0.489 J**	**0.306 J**	0.999 U
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	**0.766 J**	**2.89**	**1.02 J**	**3.92**	**2.66**	**2.84**
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	**0.693 J**	**2.05**	**0.586 J**	**1.85 J**	**1.40**	**1.87 J**
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	**0.684 J**	**2.19**	**0.823 J**	**2.47**	**2.05**	**2.36**
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	**0.348 J**	**1.25 J**	**0.395 J**	**1.62**	**1.21 J**	**1.12 J**
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	**0.597 J**	**2.04**	**0.744 J**	**1.83 J**	**1.61**	**1.76 J**
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	**2.63 J**	**6.31 J**	**1.86 J**	**11.9 J**	**6.34 J**	**6.24 J**
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	**0.308 J**	**0.710 J**	0.998 U	**0.813 J**	**0.567 J**	**0.776 J**
Total Heptachlorodibenzofuran (HpCDF)	**12.1**	**102**	**11.6 J**	**53.8**	**38.0**	**29.2**

Appendix B
Analytical Data Table

Location ID	**PGST-5_2009**	**SMA1A-IT_2009**	**SMA1-ST_2009**	**SMA2A-IT_2009**	**SMA2A-ST_2009**	**SMA2A-ST_2009**
Sample ID	**PGST-5-2-10-200911**	**SMA1-IT-0-10-COMP-200910**	**SMA1-ST-0-10-Comp-200910**	**SMA2A-IT-0-10-Comp-200911**	**SMA2A-ST-0-10-Comp-200910**	**SMA2A-ST-100-COMP-200910**
Sample Date	**9/11/2020**	**9/10/2020**	**9/10/2020**	**9/11/2020**	**9/10/2020**	**9/10/2020**
Depth	**2 - 10 cm**	**0 - 10 cm**	**0 - 10 cm**	**0 - 10 cm**	**0 - 10 cm**	**0 - 10 cm**
Sample Type	**N**	**N**	**N**	**N**	**N**	**FD**
Chemical						
Conventional Parameters (pct)						
Total Solids	**41.73**	**42.71**	**79.22**	**82.26**	**77.51**	**77.01**
Metals (mg/kg)						
Cadmium	**1.56 J**	**0.88**	**0.26**	**0.10 J**	**0.09 J**	**0.11 J**
Polycyclic Aromatic Hydrocarbons (µg/kg)						
1-Methylnaphthalene	**12.4**	**16.5 J**	**3.45 J**	**1.81 J**	**4.49 J**	**2.38 J**
2-Methylnaphthalene	**16.5**	**24.2 J**	**5.02 J**	**2.90 J**	**6.49 J**	**3.32 J**
Acenaphthene	**17.3**	**33.9 J**	**4.78 J**	**2.51 J**	**8.77 J**	**4.66 J**
Acenaphthylene	**47.9**	**19.2 J**	**3.37 J**	**3.02 J**	**5.95 J**	**2.33 J**
Anthracene	**31.0**	**53.6 J**	**8.22 J**	**5.39 J**	**11.0 J**	**5.40 J**
Benzo(a)anthracene	**41.2**	**123**	**13.1**	**6.88**	**17.1**	**6.02**
Benzo(a)pyrene	**48.3 J**	**102 J**	**12.5 J**	**7.01 J**	**18.1 J**	**6.01 J**
Benzo(b,j,k)fluoranthenes	**89.3**	**222**	**29.2**	**13.8**	**45.1**	**13.0**
Benzo(g,h,i)perylene	**58.0**	**66.9 J**	**12.1 J**	**7.26 J**	**12.5 J**	**5.99 J**
Chrysene	**55.7**	**164**	**22.0**	**8.10**	**26.2**	**9.69**
Dibenzo(a,h)anthracene	5.00 U	**20.6 J**	**2.36 J**	**1.45 J**	**3.01 J**	**1.04 J**
Dibenzofuran	**16.7**	**36.7**	**5.97**	**2.75 J**	**9.41**	**4.90 J**
Fluoranthene	**157**	**182**	**53.4**	**21.2**	**52.8**	**25.3**
Fluorene	**17.5**	**37.6**	**6.05**	**3.38 J**	**8.32**	**4.47 J**
Indeno(1,2,3-c,d)pyrene	**38.2**	**62.4 J**	**9.63 J**	**5.47 J**	**10.3 J**	**4.53 J**
Naphthalene	**173 J**	**144 J**	**22.9 J**	**18.4 J**	**36.6 J**	**15.4 J**
Phenanthrene	**107**	**113**	**29.0**	**17.1**	**28.6**	**18.0**
Pyrene	**162**	**146**	**42.5**	**21.2**	**55.3**	**23.7**
Total cPAH TEQ (7 minimum CAEPA 2005) (U = 0)	**65.7 J**	**146 J**	**18.1 J**	**9.85 J**	**25.9 J**	**8.57 J**
Dioxin Furans (ng/kg)						
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	**22.4**	**4.59**	**29.4 J**	**3.97 J**	**2.68 J**	**3.79 J**
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	**620**	**128 J**	**844 J**	**104 J**	**69.7**	**91.4 J**
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	**11.2**	**1.83**	**11.5**	**2.31**	**1.12 J**	**2.32**
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	**68.9**	**15.5**	**89.5**	**16.8**	**8.09**	**12.2**
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	**0.459 J**	0.991 U	**0.505 J**	**0.155 J**	0.999 U	0.999 U
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	**1.19**	**0.145 J**	**0.731 J**	**0.388 J**	0.999 U	0.999 U
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	**1.41**	0.991 U	**0.762 J**	**0.354 J**	**0.146 J**	**0.224 J**
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	**0.793 J**	0.991 U	**0.535 J**	**0.216 J**	0.999 U	**0.126 J**
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	**4.53**	**0.500 J**	**3.98**	**1.12**	**0.416 J**	**0.621 J**
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	**0.295 J**	0.991 U	**0.384 J**	1.00 U	0.999 U	0.999 U
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	**2.91**	0.991 U	**1.54**	**0.655 J**	**0.278 J**	**0.322 J**
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	**1.63**	0.991 U	**0.780 J**	**0.325 J**	0.999 U	0.999 U
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	**2.09**	**0.164 J**	**1.21**	**0.459 J**	0.999 U	**0.535 J**
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	**0.806 J**	0.991 U	**0.492 J**	1.00 U	0.999 U	**0.170 J**
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	**1.74**	0.991 U	**0.699 J**	**0.239 J**	0.999 U	**0.253 J**
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	**5.61 J**	**0.635 J**	0.999 UJ	1.00 UJ	**0.403 J**	**0.577 J**
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	**0.726 J**	0.991 U	**0.436 J**	**0.148 J**	**0.217 J**	0.999 U
Total Heptachlorodibenzofuran (HpCDF)	**30.2**	**5.63**	**36.0**	**5.53**	**2.05**	**6.45**

Location ID	**SMA2B-IT_2009**	**SMA2B-ST_2009**
Sample ID	**SMA2B-IT-0-10-Comp-200911**	**SMA2B-ST-0-10-Comp-200911**
Sample Date	**9/11/2020**	**9/11/2020**
Depth	**0 - 10 cm**	**0 - 10 cm**
Sample Type	**N**	**N**
Chemical		
Conventional Parameters (pct)		
Total Solids	**77.8**	**77.94**
Metals (mg/kg)		
Cadmium	**0.21**	**0.09 J**
Polycyclic Aromatic Hydrocarbons (µg/kg)		
1-Methylnaphthalene	**11.0 J**	**3.58 J**
2-Methylnaphthalene	**10.5 J**	**5.62 J**
Acenaphthene	**11.5 J**	**6.29 J**
Acenaphthylene	**16.2 J**	**7.33 J**
Anthracene	**46.5 J**	**7.73 J**
Benzo(a)anthracene	**75.4**	**5.53**
Benzo(a)pyrene	**83.7 J**	**5.35 J**
Benzo(b,j,k)fluoranthenes	**114**	**11.9 J**
Benzo(g,h,i)perylene	**78.5 J**	**7.76 J**
Chrysene	**78.4**	**7.80 J**
Dibenzo(a,h)anthracene	**15.8 J**	**1.42 J**
Dibenzofuran	**15.8**	**6.78 J**
Fluoranthene	**234**	**30.1 J**
Fluorene	**28.8**	**5.93 J**
Indeno(1,2,3-c,d)pyrene	**63.2 J**	**4.77 J**
Naphthalene	**63.8 J**	**54.5 J**
Phenanthrene	**190**	**23.8 J**
Pyrene	**239**	**26.8 J**
Total cPAH TEQ (7 minimum CAEPA 2005) (U = 0)	**111 J**	**7.79 J**
Dioxin Furans (ng/kg)		
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	**3.28 J**	**1.35 J**
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	**60.6**	9.97 U
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	**2.91**	**0.711 J**
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	**9.90**	**4.69**
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	**0.136 J**	0.997 U
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	**0.351 J**	0.997 U
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	**0.176 J**	0.997 U
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	**0.268 J**	0.997 U
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	**0.925 J**	**0.239 J**
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	**0.161 J**	0.997 U
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	**0.422 J**	**0.186 J**
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	**0.332 J**	0.997 U
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	**0.354 J**	**0.175 J**
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	**0.242 J**	0.997 U
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	**0.330 J**	0.997 U
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	0.999 UJ	**0.466 J**
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	0.999 U	0.997 U
Total Heptachlorodibenzofuran (HpCDF)	**7.09**	**0.711**

Appendix B
Analytical Data Table

Location ID	BW-01_2009	BW-01_2009	BW-04_2009	BW-04_2009	BW-15_2009	BW-15_2009
Sample ID	BW-01-0-2-200908	BW-01-2-10-200908	BW-04-0-2-200908	BW-04-2-10-200908	BW-15-0-2-200908	BW-15-2-10-200908
Sample Date	9/8/2020	9/8/2020	9/8/2020	9/8/2020	9/8/2020	9/8/2020
Depth	0 - 2 cm	2 - 10 cm	0 - 2 cm	2 - 10 cm	0 - 2 cm	2 - 10 cm
Sample Type	N	N	N	N	N	N
Chemical						
Total Heptachlorodibenzo-p-dioxin (HpCDD)	**51.4**	**68.7**	**244**	**289**	**80.7**	**83.3**
Total Hexachlorodibenzofuran (HxCDF)	**3.03**	**5.84**	**15.9**	**17.1**	**4.12**	**4.33**
Total Hexachlorodibenzo-p-dioxin (HxCDD)	**12.3**	**26.2**	**84.0**	**79.2**	**26.2**	**27.3**
Total Pentachlorodibenzofuran (PeCDF)	**4.88**	**5.73**	**14.4**	**16.8**	**6.64**	**5.13**
Total Pentachlorodibenzo-p-dioxin (PeCDD)	**5.41**	**14.9**	**31.0**	**21.9**	**9.94**	**12.7**
Total Tetrachlorodibenzofuran (TCDF)	**12.2**	**12.5**	**55.4**	**63.7**	**18.1**	**17.5**
Total Tetrachlorodibenzo-p-dioxin (TCDD)	**9.43**	**25.1**	**46.6**	**42.1**	**17.3**	**20.6**
Total Dioxin/Furan (U = 0)	**101 J**	**190 J**	**546 J**	**638 J**	**204 J**	**208 J**
Total Dioxin/Furan TEQ 2005 (Mammal) (U = 0)	**1.47 J**	**2.13 J**	**5.78 J**	**5.56 J**	**2.41 J**	**2.23 J**

Location ID	**BW-18_2009**	**BW-18_2009**	**BW-19_2009**	**BW-19_2009**	**BW-21_2009**	**BW-21_2009**
Sample ID	**BW-18-0-2-200909**	**BW-18-2-10-200909**	**BW-19-0-2-200908**	**BW-19-2-10-200908**	**BW-121-2-10-200909**	**BW-21-0-2-200908**
Sample Date	**9/9/2020**	**9/9/2020**	**9/8/2020**	**9/8/2020**	**9/9/2020**	**9/9/2020**
Depth	**0 - 2 cm**	**2 - 10 cm**	**0 - 2 cm**	**2 - 10 cm**	**2 - 10 cm**	**0 - 2 cm**
Sample Type	**N**	**N**	**N**	**N**	**N**	**N**
Chemical						
Total Heptachlorodibenzo-p-dioxin (HpCDD)	**290**	**283**	**196**	**191**	**148**	**146**
Total Hexachlorodibenzofuran (HxCDF)	**21.6**	**24.3**	**15.6**	**15.1**	**8.60**	**17.1**
Total Hexachlorodibenzo-p-dioxin (HxCDD)	**129**	**219**	**79.0**	**53.8**	**83.7**	**172**
Total Pentachlorodibenzofuran (PeCDF)	**16.6**	**20.0**	**16.1**	**20.7**	**21.7**	**19.7**
Total Pentachlorodibenzo-p-dioxin (PeCDD)	**41.8**	**148**	**24.3**	**19.6**	**27.2**	**114**
Total Tetrachlorodibenzofuran (TCDF)	**66.5**	**79.4**	**43.4**	**51.6**	**63.3**	**53.3**
Total Tetrachlorodibenzo-p-dioxin (TCDD)	**68.7**	**364**	**37.6**	**30.8**	**45.5**	**315**
Total Dioxin/Furan (U = 0)	**695 J**	**707 J**	**474 J**	**474 J**	**377 J**	**379 J**
Total Dioxin/Furan TEQ 2005 (Mammal) (U = 0)	**6.91 J**	**9.95 J**	**5.18 J**	**5.28 J**	**5.48 J**	**6.75 J**

Appendix B
Analytical Data Table

Location ID	BW-21_2009	PGSS-29_2009	PGSS-29_2009	PGSS-70_2009	PGSS-70_2009	PGSS-77A_2009
Sample ID	**BW-21-2-10-200908**	**PGSS-29-0-2-200911**	**PGSS-29-2-10-200911**	**PGSS-70-0-2-200908**	**PGSS-70-2-10-200908**	**PGSS-77A-0-2-200908**
Sample Date	**9/9/2020**	**9/11/2020**	**9/11/2020**	**9/8/2020**	**9/8/2020**	**9/8/2020**
Depth	**2 - 10 cm**	**0 - 2 cm**	**2 - 10 cm**	**0 - 2 cm**	**2 - 10 cm**	**0 - 2 cm**
Sample Type	**N**	**N**	**N**	**N**	**N**	**N**
Chemical						
Total Heptachlorodibenzo-p-dioxin (HpCDD)	**152**	**47.3**	**55.6**	**90.5**	**120**	**54.6**
Total Hexachlorodibenzofuran (HxCDF)	**10.6**	**3.12**	**3.56**	**5.50**	**6.28**	**3.73**
Total Hexachlorodibenzo-p-dioxin (HxCDD)	**70.7**	**11.7**	**13.7**	**20.6**	**35.0**	**17.2**
Total Pentachlorodibenzofuran (PeCDF)	**22.1**	**2.89**	**3.64**	**5.67**	**3.98**	**5.22**
Total Pentachlorodibenzo-p-dioxin (PeCDD)	**28.2**	**4.21**	**4.18**	**8.61**	**11.2**	**14.0**
Total Tetrachlorodibenzofuran (TCDF)	**51.4**	**10.6**	**14.8**	**17.2**	**17.7**	**16.1**
Total Tetrachlorodibenzo-p-dioxin (TCDD)	**46.7**	**12.2**	**7.89**	**16.9 J**	**21.6**	**46.3 J**
Total Dioxin/Furan (U = 0)	**375 J**	**114 J**	**135 J**	**199 J**	**270 J**	**130 J**
Total Dioxin/Furan TEQ 2005 (Mammal) (U = 0)	**5.52 J**	**1.38 J**	**1.42 J**	**1.86 J**	**2.38 J**	**1.80 J**

Appendix B
Analytical Data Table

Location ID	**PGSS-77A_2009**	**PGSS-8_2009**	**PGSS-8_2009**	**PGST-1_2009**	**PGST-1_2009**	**PGST-5_2009**
Sample ID	**PGSS-77A-2-10-200908**	**PGSS-8-0-2-200909**	**PGSS-8-2-10-200909**	**PGST-1-0-2-200911**	**PGST-1-2-10-200911**	**PGST-5-0-2-200911**
Sample Date	**9/8/2020**	**9/9/2020**	**9/9/2020**	**9/11/2020**	**9/11/2020**	**9/11/2020**
Depth	**2 - 10 cm**	**0 - 2 cm**	**2 - 10 cm**	**0 - 2 cm**	**2 - 10 cm**	**0 - 2 cm**
Sample Type	**N**	**N**	**N**	**N**	**N**	**N**
Chemical						
Total Heptachlorodibenzo-p-dioxin (HpCDD)	**87.9**	**254**	**77.4 J**	**421**	**307**	**231**
Total Hexachlorodibenzofuran (HxCDF)	**6.08**	**18.5**	**5.61**	**29.2**	**19.6**	**14.2**
Total Hexachlorodibenzo-p-dioxin (HxCDD)	**34.5**	**151**	**27.6 J**	**94.8**	**101**	**121**
Total Pentachlorodibenzofuran (PeCDF)	**7.15**	**20.8**	**5.19**	**25.4**	**16.8**	**15.1**
Total Pentachlorodibenzo-p-dioxin (PeCDD)	**12.4**	**38.2**	**14.9**	**34.8**	**21.8**	**45.1**
Total Tetrachlorodibenzofuran (TCDF)	**20.5**	**63.7**	**17.3 J**	**61.6**	**48.0**	**61.8**
Total Tetrachlorodibenzo-p-dioxin (TCDD)	**27.6 J**	**72.0**	**25.0**	**56.1**	**35.6**	**90.7**
Total Dioxin/Furan (U = 0)	**211 J**	**751 J**	**222 J**	**1050 J**	**752 J**	**520 J**
Total Dioxin/Furan TEQ 2005 (Mammal) (U = 0)	**2.17 J**	**6.87 J**	**2.00 J**	**8.40 J**	**6.20 J**	**6.39 J**

Appendix B
Analytical Data Table

Location ID	PGST-5_2009	SMA1A-IT_2009	SMA1-ST_2009	SMA2A-IT_2009	SMA2A-ST_2009	SMA2A-ST_2009
Sample ID	**PGST-5-2-10-200911**	**SMA1-IT-0-10-COMP-200910**	**SMA1-ST-0-10-Comp-200910**	**SMA2A-IT-0-10-Comp-200911**	**SMA2A-ST-0-10-Comp-200910**	**SMA2A-ST-100-COMP-200910**
Sample Date	**9/11/2020**	**9/10/2020**	**9/10/2020**	**9/11/2020**	**9/10/2020**	**9/10/2020**
Depth	**2 - 10 cm**	**0 - 10 cm**	**0 - 10 cm**	**0 - 10 cm**	**0 - 10 cm**	**0 - 10 cm**
Sample Type	**N**	**N**	**N**	**N**	**N**	**FD**
Chemical						
Total Heptachlorodibenzo-p-dioxin (HpCDD)	**241**	**66.0 J**	**441**	**64.4**	**39.4**	**64.8**
Total Hexachlorodibenzofuran (HxCDF)	**18.3**	**1.31 J**	**7.67**	**2.9**	**0.59**	**3.14**
Total Hexachlorodibenzo-p-dioxin (HxCDD)	**132**	**9.25**	**53.2**	**26.9**	**0.146**	**8.89**
Total Pentachlorodibenzofuran (PeCDF)	**19.7**	**0.326**	**9.27**	**2.72**	0.999 U	0.999 U
Total Pentachlorodibenzo-p-dioxin (PeCDD)	**42.2**	**1.25**	**13.3**	**8.36**	**1.34**	**5.94**
Total Tetrachlorodibenzofuran (TCDF)	**58.8**	**1.55 J**	**20.0 J**	**1.69 J**	**0.714 J**	**3.54 J**
Total Tetrachlorodibenzo-p-dioxin (TCDD)	**68.5**	**5.91**	**27.1**	**18.3**	**5.67**	**21.1**
Total Dioxin/Furan (U = 0)	**747 J**	**151 J**	**986 J**	**131 J**	**83.1 J**	**113 J**
Total Dioxin/Furan TEQ 2005 (Mammal) (U = 0)	**6.14 J**	**0.505 J**	**4.00 J**	**1.19 J**	**0.455 J**	**0.989 J**

Appendix B
Analytical Data Table

Location ID	SMA2B-IT_2009	SMA2B-ST_2009
Sample ID	SMA2B-IT-0-10-Comp-200911	SMA2B-ST-0-10-Comp-200911
Sample Date	9/11/2020	9/11/2020
Depth	0 - 10 cm	0 - 10 cm
Sample Type	N	N
Chemical		
Total Heptachlorodibenzo-p-dioxin (HpCDD)	**32.3**	**16.4**
Total Hexachlorodibenzofuran (HxCDF)	**5.00**	**0.879**
Total Hexachlorodibenzo-p-dioxin (HxCDD)	**14.4**	**0.692**
Total Pentachlorodibenzofuran (PeCDF)	**3.00**	0.997 U
Total Pentachlorodibenzo-p-dioxin (PeCDD)	**2.97**	0.997 U
Total Tetrachlorodibenzofuran (TCDF)	**11.2 J**	**1.92 J**
Total Tetrachlorodibenzo-p-dioxin (TCDD)	**4.76**	**1.57**
Total Dioxin/Furan (U = 0)	**80.4 J**	**7.82 J**
Total Dioxin/Furan TEQ 2005 (Mammal) (U = 0)	**0.866 J**	**0.319 J**

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Appendix B
Analytical Data Table

Notes:
Horizontal coordinate datum is NAD 1983 State Plane Washington North FIPS 4601 (US Survey Feet).
All undetect results are reported at the reporting limit or, for high-resolution analyses, at the estimated detection limit.
Totals are calculated as the sum of all detected results (U=0). If all results are not detected, the highest limit value is reported as the sum.

Total cPAH TEQ (7 minimum CAEPA 2005) calculation includes benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene and indeno(1,2,3-c,d)pyrene. Per MTCA cleanup Regulation, Table 708-2 "Toxicity Equivalency Factors for Minimum Required Carcinogenic Polyaromatic Hydrocarbons (cPAHs) under WAC 173-340-708(e).

Total dioxin/furan is the sum of all individual dioxin/furans (non-homolog) listed in this table.
Dioxin/furan TEQ values were calculated with 2005 WHO TEF values for mammals.

Bold: Detected result
--: results not reported or not applicable
mg/kg: milligrams per kilogram
ng/kg: nanograms per kilogram
pct: percent
µg/kg: micrograms per kilogram
J: estimated value
U: compound analyzed, but not detected above detection limit
UJ: Compound analyzed, but not detected above estimated detection limit
N: normal environmental sample
cPAH: carcinogenic polycyclic aromatic hydrocarbon
PAH: polycyclic aromatic hydrocarbons
SE: sediment matrix
TEQ: toxic equivalency

FINAL VALIDATED DATA