Prepared by:
The Dredged Material Management Office
Seattle District, U.S. Army Corps of Engineers

MEMORANDUM FOR RECORD August 2, 2018

SUBJECT: DETERMINATION REGARDING THE SUITABILITY OF PROPOSED DREDGED MATERIAL FROM THE PORT OF PORT ANGELES TERMINAL 3 (NWS-2018-732), EVALUATED UNDER SECTION 404 OF THE CLEAN WATER ACT FOR UNCONFINED IN-WATER DISPOSAL.

1. Introduction. This memorandum reflects the consensus determination of the Dredged Material Management Program (DMMP) agencies (U.S. Army Corps of Engineers, Washington Departments of Ecology and Natural Resources, and the Environmental Protection Agency) regarding the suitability of 12,800 cubic yards (cy) of dredged material from the Port of Port Angeles (Port) Terminal 3 for placement at a DMMP open-water disposal site and for compliance with the State of Washington's antidegradation policy.

2. Background. The Port's Terminal 3 is located on the south shore of the Strait of Juan de Fuca in Port Angeles Harbor (Figure 1). The berth dimensions are approximately 600 feet long by 180 feet wide (Figure 2). The current mudline elevations throughout the berth range from approximately -36 feet mean lower low water (MLLW) along the pier face, to approximately -45 to -46 feet MLLW at the north end of the berth. The Port plans to return the berth to the previously authorized dredge depth of -45 feet MLLW. Approximately 12,800 cy of sediment will be maintenance dredged, including 1.5 feet of overdredge (to -46.5 feet MLLW) and under-pier and side-slope volumes with a 2:1 (H:V) slope (Floyd|Snider, 2018).

   Terminal 3 was constructed in 1966 for use as a log-handling pier, with a berth depth of -35 feet MLLW. The footprint of the terminal was expanded in 1976. Following expansion, maintenance dredging to -45 feet occurred in 1978. Terminal 3 is currently used for logs, lumber, wood pulp and other cargo (Floyd|Snider, 2017).

   The net sedimentation rate in Western Port Angeles Harbor is, in general, very low, and there are no stormwater outfalls that discharge at Terminal 3. However, Tumwater Creek discharges to the harbor west of the western trestle of Terminal 3, delivering between 4,320 to 21,690 cy of sediment to the harbor per year. Vessel operators at the terminal report frequent grounding issues and maintenance dredging is needed to remove accumulated sediment (Floyd|Snider, 2017).

   Historical sediment quality data are provided in Floyd|Snider (2017).

   While the Port's preferred option is to dispose of the dredged material at an upland location, the sediment characterization described in this memorandum was conducted to explore the potential for open-water disposal and to assess the project's compliance with the State of Washington's antidegradation policy.

3. Project Summary. Table 1 includes project summary and tracking information.

Table 1. Project Summary

Project ranking:	High
Proposed dredging volume	12,800 cubic yards
Proposed dredging depth	-46.5 feet MLLW (including overdepth)
Draft sampling and analysis plan (SAP) received	July 21, 2017
Draft SAP returned for revisions	August 8, 2017
Revised SAP received	September 28, 2017
Revised SAP returned for revisions	October 12, 2017
Final SAP received	October 27, 2017
Final SAP approved	October 30, 2017
Sampling dates	December 20-21, 2017
Draft data report received	May 7, 2018
Comments provided on draft report	May 24, 2018
Revised data report received	July 3, 2018
Comments provided on revised report	July 16, 2018
Final data report received	July 31, 2018
DAIS Tracking number	PPAT3-1-A-F-395
EIM Study ID	PPAT317
USACE Permit Application Number	NWS-2018-732
Recency determination (high-rank = 3 years):	December 2020

4. Project Ranking and Sampling Requirements. Terminal 3 is located in the inner harbor of Port Angeles. Projects in the inner harbor are ranked as a "high" concern for potential contamination (DMMP, 2016). Sediment in the berthing area of Terminal 3 is considered to be heterogeneous due to the length of time since it was last characterized and its proximity to potential sources of contamination. The minimum numbers of field samples and dredged material management units (DMMUs) for heterogeneous material in a high-ranked area were calculated using the following guidelines (DMMP, 2016):

- Maximum volume of sediment represented by each field sample = 4,000 cubic yards
- Maximum volume of sediment represented by each surface DMMU (0-4 feet below mudline) = 4,000 cubic yards
- Maximum volume of sediment represented by each subsurface DMMU (> 4 feet below mudline) = 12,000 cubic yards

Based on cross-sections of the dredge prism and early coordination with the Dredged Material Management Office (DMMO), the Port elected to treat all of the material as 'surface' material (Floyd|Snider, 2017). The total project volume in the SAP was 11,450 cy, which included a design depth of -45 ft MLLW plus 1 foot of overdredge (note that the overdredge depth was

subsequently changed to 1.5 feet, which increased the total volume to 12,800 cy). Using the DMMP sampling and testing guidelines above, three DMMUs were required, each represented by a single core sample. However, based on DMMP input, the Port elected to take two core samples from each DMMU in order to increase the spatial representation of the dredged material (Figure 2).

5. Sampling. Field sampling took place December 20-21, 2017 using a vibracore sampler. Figure 2 shows both target and actual sampling locations. Table 2 includes the sampling coordinates, collection dates and mudline elevations. Table 3 includes penetration, recovery, subsampling and compositing data.

   Several problems were encountered during sampling. First, recovery failed to meet the target of 75% at some stations. Per the SAP, at least three attempts were made at each station in an attempt to meet the target recovery. Floyd|Snider contacted DMMO for guidance as to how to proceed with core collection when three attempts failed to produce the target recovery. DMMO coordinated with the other DMMP agencies and the contractor was instructed to retain the core with the highest recovery. Resulting recovery ranged from 55 to 77 percent. Where low recovery was observed, it was likely due to the presence of woody debris, which was identified in all three of the cores with low recovery (Floyd|Snider, 2018).

   The second problem was refusal during coring. Refusal was encountered during one or more of the coring attempts at four of the six sampling stations. When refusal was encountered, the sampling team moved to another location within ten feet of the target coordinates. None of the cores from coring attempts that resulted in refusal were accepted for processing (Floyd|Snider, 2018).

   The third problem was use of predicted tidal elevations rather than verified tidal elevations when calculating tide-corrected mudline elevations prior to processing the cores. The difference between predicted and verified tidal elevations during the time of sampling ranged from 0.5 to 0.7 feet. Use of predicted tidal elevations resulted in samples being collected deeper than the targeted depths.

6. Chemical Analysis. The sediment conventional and chemical testing results are provided in Table 4. The grain-size results are not representative of the sediment composition, due to the presence of woody debris. This is especially true of the gravel fraction, which is shown to range from 46.6 to 64.4 percent. Floyd|Snider (2018) describes sediment samples from the three DMMUs as silty sand with layers of 40 to 60 percent woody debris (up to 3 inches), with trace medium sand, gravel and shell hash. It is likely, therefore, that much of what was retained in the gravel-sized sieves was actually woody debris. The sand fraction (62.5 microns to 2 mm) ranged from 21 to 34 percent, which is likely biased low due to the outsized fraction of “gravel” reported. The fines fraction (<62.5 microns) ranged from only 13 to 20 percent, which is also likely biased low.

   Total organic carbon (TOC) content was relatively high, ranging from 2.6 to 4.2 percent. This is consistent with the presence of woody debris. The total volatile solids (TVS) content was also relatively high, ranging from 6.1 to 14.6 percent. Sulfide concentrations were elevated, as

would be expected in an area with an abundance of woody debris, ranging from 760 to 2,100 mg/kg. Ammonia concentrations were low, ranging from 16 to 25 mg/kg.

Analysis of the DMMP COCs resulted in numerous screening level (SL) and bioaccumulation trigger (BT) exceedances, especially for DMMU MD-2. Of critical importance were the BT exceedances for tributytin (TBT) and dioxins/furans in all three DMMUs. TBT concentrations were unexpectedly high, ranging from 209 to 1,530 ug/kg (BT = 73 ug/kg). Dioxin/furan concentrations ranged from 10.2 to 16.1 ng/kg toxicity equivalence (TEQ). The BT for dioxins/furans is 10 ng/kg TEQ. The BTs for selenium and fluoranthene were also exceeded for MD-2. The concentration of selenium in the duplicate for MD-2 was of 3.16 mg/kg (BT = 3 mg/kg) and the concentration of fluoranthene was 5,740 ug/kg (BT = 4,600 ug/kg). PAHs accounted for the majority of the SL exceedances (the rest were for dioxins/furans), with nine individual PAHs exceeding SL for at least one DMMU.

EcoChem performed Stage 4 validation of the dioxin/furan data. Floyd|Snider conducted Stage 2A data validation of all other chemical data. The data were determined to be of acceptable quality for use as reported by the laboratory, with some laboratory qualifiers being translated into standardized final qualifiers (Floyd|Snider, 2018). The qualifiers shown in Table 4 are the final standardized qualifiers.

7. Biological Testing. The Port elected not to conduct bioassays or bioaccumulation testing.

8. Sediment Exposed by Dredging. Sediment exposed by dredging must either meet the State of Washington Sediment Quality Standards (SQS) (Ecology, 2013) or the State's antidegradation standard (DMMP, 2008). Because the dredged material contained elevated concentrations of COCs, the DMMP agencies required that the Z-samples be tested in order to determine the quality of the sediment that will be exposed by dredging.

   Three Z-sample composites were tested, one for each DMMU. The COCs required for analysis were those that had SL or BT exceedances in the overlying DMMUs. Results from the Z-sample composite testing are shown in Table 4. TOC was inadvertently not analyzed, so it was not possible to compare results to those SQS values that are carbon-normalized. However, as can be seen from the table, the COCs analyzed were either undetected or were present at concentrations below those in the overlying DMMUs, with one minor exception, which is discussed below. Tributyltin concentrations were uniformly low. The dioxin/furan concentrations in the Z-sample associated with DMMUs MD-1 and MD-3 were less than 10 ng/kg TEQ. Selenium was detected in the Z-sample associated with DMMU MD-2, but at approximately half the concentration as in the overlying material and less than the BT for selenium (3 mg/kg). There were no SL or BT exceedances for any of the PAHs.

   The two Z-sample results that bear some discussion are those for dioxins/furans and butyl benzyl phthalate (BBP) in the Z-sample associated with DMMU MD-2:

   Dioxins/furans. The one instance of a COC being found at a concentration higher in the Z-sample than in the overlying material occurred for dioxins/furans in Z-layer Composite 2. The dioxin/furan concentration was 10.3 ng/kg TEQ in the Z-sample, which was slightly

higher than the concentration of 10.2 ng/kg TEQ in DMMU MD-2. It was also slightly higher than the BT. However, the difference between the dioxin/furan concentrations in the DMMU and Z-sample is within the range of variability inherent in field sampling and laboratory analysis and can be considered negligible. With regard to dioxins/furans, the DMMP agencies consider the Z-layer sediment for DMMU MD-2 to be essentially the same as MD-2 itself and not degraded in comparison. Additionally, the antidegradation evaluation for bioaccumulative COCs is typically not a point-by-point comparison, but instead considers an area-weighted average which better represents the exposure to a mobile receptor. Using best professional judgment, the agencies made a case-by-case determination that the marginal exceedance of the BT does not necessitate placement of a sand cover following dredging.

Butyl benzyl phthalate. The initial analysis of the composited Z-sample associated with DMMU MD-2 resulted in a concentration of 837 ug/kg for BBP, which was much higher than the SL (63 ug/kg) and nearly as high as the DMMP maximum level (970 ug/kg). BBP had been undetected in the overlying DMMU. Following discussion with the DMMP agencies regarding the validity of this result, the Port proposed running the two individual samples making up the Z-sample composite in triplicate. After careful examination of the results for the Z-sample from station MD2-SC-1, Freemont Analytical determined that the chemical in question was not BBP but actually ferruginol, a naturally occurring phenol associated with tree sap (Floyd|Snider, 2018). The lab re-examined the original scan for the composited Z-sample and determined that it, too, better matched the spectral components of ferruginol than those of BBP. Both BBP and ferruginol were undetected in the other individual Z-sample (MD2-SC-2). The DMMP agencies examined the scans from the mass spectrometer and agreed with the lab's conclusion that the chemical detected in the composited Z-sample was very likely ferruginol and not BBP. The BBP result for 'Z-Layer Composite 2' in Table 4 (i.e. 34.0 U ug/kg) is based on this re-examination. Corroborating evidence was found in the core logs for MD2-SC-1 and MD2-SC-2. The core log for MD2-SC-1 (in which ferruginol was identified) described a large quantity (70%) of woody debris in the sediment, while the core log for MD2-SC-2 (in which both BBP and ferruginol were not detected) described the sediment as having only 10-20 percent organic material (twigs, roots and wood debris).

Based on the evaluation of data from the Z-samples, the DMMP agencies concluded that the sediment represented by the Z-samples meets the State's antidegradation standard. However, as previously discussed, the Z-samples were collected at an elevation that was deeper than the target elevation. To remedy this situation, the Port proposed increasing the project's overdepth from 1 foot to 1.5 feet. The DMMP agencies agreed with this plan as long as the dredging contract includes an incentive for the dredging contractor to remove the additional half-foot needed to reach the sampled Z-layer. With the additional overdepth, the dredged material volume increased from 11,450 cy to 12,800 cy.

9. Debris Management. All dredged material from this project will be disposed at an upland location. All debris encountered during dredging must also be disposed at an upland location.

10. Suitability Determination. This memorandum documents the evaluation of the suitability of sediment proposed for dredging from the Port of Port Angeles Terminal 3 for open-water disposal. Chemical testing resulted in numerous exceedances of SLs and BTs. The Port elected not to conduct biological testing. In the absence of this testing, the DMMP agencies determined that ***all 12,800 cy are unsuitable for open-water disposal.*** The Port plans to dispose of the dredged material at an upland parcel approximately 2.5 miles southwest of Terminal 3 (Floyd|Snider, 2018).

    A pre-dredge meeting with Ecology and the Corps of Engineers is required at least 7 days prior to dredging. A dredging quality control plan must be developed and submitted to the Regulatory Branch of the Seattle District Corps of Engineers at least 7 days prior to the pre-dredge meeting. Dredging, de-watering, transloading and disposal will all need to be addressed with enough detail to provide assurance to the agencies that the dredge plan will be properly implemented. Contract language that incentivizes removal of all unsuitable material must be provided for review. A bathymetric survey will be required after removal of the unsuitable material to verify completion.

    This determination does ***not*** constitute final agency approval of the project. As part of the project permitting process, a public notice will be issued and resource agencies and the public will have an opportunity to provide input on the overall project. A final USACE permit decision will be made and a water quality certification issued by Ecology after full consideration of public input.

11. References.

Floyd|Snider, 2017. *Terminal 3 Maintenance Dredging - DMMP Sampling and Analysis Plan*. Prepared by Floyd|Snider for the Port of Port Angeles, October 2017.

Floyd|Snider, 2018. *Terminal 3 Maintenance Dredging - DMMP Sediment Characterization Report*. Prepared by Floyd|Snider for the Port of Port Angeles, July 2018.

DMMP, 2008. *Quality of Post-Dredge Sediment Surfaces (Updated).* A Clarification Paper Prepared by David Fox (USACE), Erika Hoffman (EPA) and Tom Gries (Ecology) for the Dredged Material Management Program, June 2008.

DMMP, 2016. *Dredged Material Evaluation and Disposal Procedures (User Manual)*. Prepared by the Seattle District Dredged Material Management Office for the Dredged Material Management Program, August 2016.

Ecology, 2013. *Sediment Management Standards – Chapter 173-204 WAC*. Washington State Department of Ecology, Revised February 2013.

12. Agency Signatures.

Concur:

The signed copy is on file in the Dredged Material Managment Office.

_____	_____
Date	David Fox, P.E. - Seattle District Corps of Engineers
_____	_____
Date	Erika Hoffman - Environmental Protection Agency
_____	_____
Date	Laura Inouye, Ph.D. - Washington Department of Ecology
_____	_____
Date	Celia Barton - Washington Department of Natural Resources

Copies furnished:

DMMP signatories
Pam Sanguinetti, USACE Regulatory
Jessi Massingale, Floyd|Snider
Corey Wilson, Floyd|Snider
Chris Hartman, Port of Port Angeles

Table 2
Sediment Sampling Locations, Measured Water Depth, Tidal Stage, and Mudline Elevation

DMMU Number	Sample Location	Northing	Easting	Collection Date	Measured Water Depth (feet)	Verified Tidal Stage (feet MLLW)	Mudline Elevation (feet MLLW)[1]	Predicted Tidal Stage (feet MLLW)	Mudline Elevation based on Predicted Tidal Stage (feet MLLW)[2]
MD-1	MD1-SC-1	421452.863	1002965.563	12/20/2017	49.0	5.9	-43.1	6.41	-42.6
	MD1-SC-2	421373.122	1002887.158	12/20/2017	45.1	6.25	-38.9	6.82	-38.3
MD-2	MD2-SC-1	421402.416	1003062.123	12/21/2017	47.4	5.9	-41.5	6.53	-40.9
	MD2-SC-2	421314.836	1003017.457	12/21/2017	46.1	6.42	-39.7	7.07	-39.0
MD-3	MD3-SC-1	421334.208	1003175.556	12/21/2017	48.8	5.62	-43.2	6.30	-42.5
	MD3-SC-2	421232.170	1003205.145	12/21/2017	46.8	6.26	-40.5	6.98	-39.8

Notes:

1 The mudline elevation was calculated by subtracting the water depth from the verified tidal stage (verified tidal stage - water depth = mudline elevation).

2 The mudline elevation based on predicted tidal stage was calculated by subtracting the water depth from the predicted tidal stage (predicted tidal stage - water depth = mudline elevation based on predicted tidal stage).

Abbreviations:

DMMU Dredged material management unit

MLLW Mean lower low water

Table 3
Sediment Sampling Locations, Percent Recovery, Elevations, Sampling Intervals, and DMMU Volumes

DMMU Number	Sample Location	Collection Date	Percent Recovery	Penetration Depth (feet bml)	Length of Recovered Core (feet bml)[1]	Elevation (feet MLLW)[2]	Discrete and Z-Layer Sample[3]	Composite or Sample ID for Analysis	Revised DMMU Volume (CY)
MD-1	MD1-SC-1	12/20/2017	57.0%	5.4	0–1.9	-43.1 to -46.4	MD1-SC-1-A	MD1-SC-C1	4,410
					1.9–3.0	-46.4 to -48.4	MD1-SC-1-Z	Z Composite 1	
	MD1-SC-2	12/20/2017	76.5%	9.8	0–2.8	-38.9 to -42.5	MD1-SC-2-A	MD1-SC-C1	
					2.8–5.9	-42.5 to -46.6	MD1-SC-2-B		
					5.9–7.4	-46.6 to -48.5	MD1-SC-2-Z	Z Composite 1	
MD-2	MD2-SC-1	12/21/2017	55.0%	7.3	0–2.8	-41.5 to -46.6	MD2-SC-1-A	MD2-SC-C1	4,040
					2.8–3.9	-46.6 to -48.6	MD2-SC-1-Z	Z Composite 2	
	MD2-SC-2	12/21/2017	75.6%	9.0	0-3.0	-39.7 to -43.6	MD2-SC-2-A	MD2-SC-C1	
					3.0-5.3	-43.6 to -46.7	MD2-SC-2-B		
					5.3–6.8	-46.7 to -48.7	MD2-SC-2-Z	Z Composite 2	
MD-3	MD3-SC-1	12/21/2017	56.9%	5.1	0-2.0	-43.2 to -46.7	MD3-SC-1-A	MD3-SC-C1	4,290
					2.0-2.9	-46.7 to -48.3	MD3-SC-1-Z	Z Composite 3	
	MD3-SC-2	12/21/2017	76.8%	8.2	0–1.7	-40.5 to -42.8	MD3-SC-2-A	MD3-SC-C1	
					1.7–4.8	-42.8 to -46.8	MD3-SC-2-B		
					4.8–6.3	-46.8 to -48.7	MD3-SC-2-Z	Z Composite 3	

Notes:

1 The core lengths representing dredged material and the Z-layer were based on the mudline elevation calculated from the predicted tide.

2 Elevations were calculated using the verified mudline elevations from Table 4.1 and recovery-adjusted core lengths.

3 Following receipt of DMMU sediment analytical results and in coordination with the DMMP, the discrete samples with a "Z" identifier represent the Z-layer 2-foot samples that were collected, archived, composited, and subsequently analyzed Z Composites 1, 2, and 3.

Abbreviations:

bml Below mudline
CY Cubic yards
DMMU Dredged material management unit
MLLW Mean lower low water

Table 4

Summary of DMMU Composite Sample and Z-Layer Analytical Results Compared to the DMMP Marine Guidelines

									DMMU	DMMU MD-1		DMMU MD-2			DMMU MD-3	
									Sample ID	MD1-SC-C1	Z-Layer Composite 1	MD2-SC-C1	MD52-SC-C1[1]	Z-Layer Composite 2	MD3-SC-C1	Z-Layer Composite 3
									Sample Date	12/20/2017	12/20/2017	12/21/2017	12/21/2017	12/21/2017	12/21/2017	12/21/2017
			SMS Criteria		AET		DMMP Criteria									
Analyte	CAS No.	Unit	SCO	CSL	LAET	2LAET	SL	BT	ML							
Grain Size																
Gravel (>2,000 µm)[3]	--	%	--	--	--	--	--	--	--	46.6	NA	64.4	57.9	NA	62.7	NA
Sand (62.5–2,000 µm)	--	%	--	--	--	--	--	--	--	33.7	NA	20.6	24.4	NA	23.9	NA
Total Fines (<62.5 µm)	--	%	--	--	--	--	--	--	--	19.7	NA	14.9	17.6	NA	13.3	NA
Conventionals																
Ammonia (NH_3) as nitorgen (N)	7664-41-7	mg/kg	--	--	--	--	--	--	--	15.9	NA	19.2	25.4	NA	17.8	NA
Sulfide	18496-25-8	mg/kg	--	--	--	--	--	--	--	2,120	NA	1,070	1,400	NA	763	NA
Total solids	--	%	--	--	--	--	--	--	--	54.7	NA	67.9	51.1	NA	47.8	NA
Preserved total solids	--	%	--	--	--	--	--	--	--	52.6	NA	54.1	50.2	NA	49.1	NA
Total volatile solids	--	%	--	--	--	--	--	--	--	10.6	NA	6.12	13.1	NA	14.6	NA
Total organic carbon	7440-44-0	%-dw	--	--	--	--	--	--	--	2.60	NA	2.91	3.21	NA	4.19	NA
Metals by USEPA Methods 6020A & 7471B																
Antimony	7440-36-0	mg/kg	--	--	150	--	150	--	200	0.0185 JQ	NA	0.287 U	0.282 U	NA	0.0259 JQ	NA
Arsenic	7440-38-2	mg/kg	57	93	57	93	57	507.1	700	4.96	NA	6.10	6.87	NA	5.50	NA
Cadmium	7440-43-9	mg/kg	5.1	6.7	5.1	6.7	5.1	--	14	0.474	NA	0.600	0.715	NA	0.724	NA
Chromium	7440-47-3	mg/kg	260	270	260	270	260	--		33.6	NA	38.7	43.5	NA	30.9	NA
Copper	7440-50-8	mg/kg	390	390	390	390	390	--	1,300	29.3	NA	46.1	74.7	NA	39.1	NA
Lead	7439-92-1	mg/kg	450	530	450	530	450	975	1,200	8.24	NA	11.1	12.2	NA	10.1	NA
Mercury	7439-97-6	mg/kg	0.41	0.59	0.41	0.59	0.41	1.5	2.3	0.0832 JQ	NA	0.0776 JQ	0.0684 JQ	NA	0.0899 JQ	NA
Selenium	7782-49-2	mg/kg	--	--	--	--	--	3	--	2.21	NA	2.45	**3.16**	1.60	2.20	NA
Silver	7440-22-4	mg/kg	6.1	6.1	6.1	6.1	6.1	--	8.4	0.104 JQ	NA	0.104 JQ	0.112 JQ	NA	0.104 JQ	NA
Zinc	7440-66-6	mg/kg	410	960	410	960	410	2,783	3,800	70.4	NA	79.8	98.5	NA	93.4	NA
Organometallic Compounds by Krone et al. 1989																
Tributyltin Ion	36643-28-4	µg/kg	--	--	--	--	--	73	--	**209**	3.78 UJ	**1,530**	**1,100**	4.33 J	**1,280**	18.2 J
Organics by USEPA Method 8270D (unless otherwise noted)																
Low Molecular Weight Polycyclic Aromatic Hydrocarbons (LPAHs)																
Total LPAH	--	µg/kg	--	--	5,200	5,200	5,200	--	29,000	898 J	45.1 U	3,850	3,380 J	42.5 U	2,230 J	147
Total LPAH	--	mg/kg-OC	370	780	--	--	--	--	--	34.5 J	--	132	105 J	--	--	--
Acenaphthylene	208-96-8	µg/kg	--	--	1,300	1,300	560	--	1,300	14.5 JQ	45.1 U	25.8	17.5 JQ	42.5 U	17.0 JQ	7.80 UJ
Acenaphthylene	208-96-8	mg/kg-OC	66	66	--	--	--	--	--	0.558 JQ	--	0.887	0.545 JQ	--	--	--
Acenaphthene	83-32-9	µg/kg	--	--	500	500	500	--	2,000	57.3	45.1 U	**822**	**819**	42.5 U	**680**	46.2 U
Acenaphthene	83-32-9	mg/kg-OC	16	57	--	--	--	--	--	2.20	--	**28.2**	**25.5**	--	--	--
Anthracene	120-12-7	µg/kg	--	--	960	960	960	--	13,000	191	45.1 U	**1,300**	593	26.5 UJ	312	72.7
Anthracene	120-12-7	mg/kg-OC	220	1,200	--	--	--	--	--	7.35	--	44.7	18.5	--	--	--
Fluorene	86-73-7	µg/kg	--	--	540	540	540	--	3,600	69.8	45.1 U	318	348	42.5 U	334	28.4 UJ
Fluorene	86-73-7	mg/kg-OC	23	79	--	--	--	--	--	2.68	--	10.9	10.8	--	--	--
Naphthalene	91-20-3	µg/kg	--	--	2,100	2,100	2,100	--	2,400	16.2 JQ	45.1 U	31.6	30.2	42.5 U	133	9.96 UJ
Naphthalene	91-20-3	mg/kg-OC	99	170	--	--	--	--	--	0.623 JQ	--	1.09	0.941	--	--	--
Phenanthrene	85-01-8	µg/kg	--	--	1,500	1,500	1,500	--	21,000	549	45.1 U	1,350	**1,570**	28.3 UJ	753	73.8
Phenanthrene	85-01-8	mg/kg-OC	100	480	--	--	--	--	--	21.1	--	46.4	48.9	--	--	--
2-Methylnaphthalene	91-57-6	µg/kg	--	--	670	670	670	--	1,900	6.52 JQ	45.1 U	19.3 JQ	24.4	42.5 U	113	46.2 U
2-Methylnaphthalene	91-57-6	mg/kg-OC	38	64	--	--	--	--	--	0.251 JQ	--	0.663 JQ	0.760	--	--	--

Table 4

Summary of DMMU Composite Sample and Z-Layer Analytical Results Compared to the DMMP Marine Guidelines

									DMMU	DMMU MD-1		DMMU MD-2			DMMU MD-3	
									Sample ID	MD1-SC-C1	Z-Layer Composite 1	MD2-SC-C1	MD52-SC-C1[1]	Z-Layer Composite 2	MD3-SC-C1	Z-Layer Composite 3
									Sample Date	12/20/2017	12/20/2017	12/21/2017	12/21/2017	12/21/2017	12/21/2017	12/21/2017
			SMS Criteria		AET		DMMP Criteria									
Analyte	CAS No.	Unit	SCO	CSL	LAET	2LAET	SL	BT	ML							
High Molecular Weight Polycyclic Aromatic Hydrocarbons (HPAHs)																
Total HPAH	--	µg/kg	--	--	12,000	17,000	12,000	--	69,000	6,350	182	**17,500**	10,900	366	8,290	2,500
Total HPAH	--	mg/kg-OC	960	5,300	--	--	--	--	--	244	--	601	340	--	--	--
Benz(a)anthracene	56-55-3	µg/kg	--	--	1,300	1,600	1,300	--	5,100	469	34.3 UJ	**1,410**	753	75.8	680	265
Benz(a)anthracene	56-55-3	mg/kg-OC	110	270	--	--	--	--	--	18.0	--	48.5	23.5	--	--	--
Benzo(a)pyrene	50-32-8	µg/kg	--	--	1,600	1,600	1,600	--	3,600	317	20.1 UJ	516	366	38.1 UJ	522	192
Benzo(a)pyrene	50-32-8	mg/kg-OC	99	210	--	--	--	--	--	12.2	--	17.7	11.4	--	--	--
Total benzofluoranthenes	--	µg/kg	--	--	3,200	3,600	3,200	--	9,900	806	20.6 UJ	2,140	828	44.7	1,110	445
Total benzofluoranthenes	--	mg/kg-OC	230	450	--	--	--	--	--	31.0	--	73.5	25.8	--		--
Benzo(g,h,i)perylene	191-24-2	µg/kg	--	--	670	720	670	--	3,200	135	10.6 UJ	143	119	9.38 UJ	257	42.5 UJ
Benzo(g,h,i)perylene	191-24-2	mg/kg-OC	31	78	--	--	--	--	--	5.19	--	4.91	3.71	--	--	--
Chrysene	218-01-9	µg/kg	--	--	1,400	2,800	1,400	--	21,000	589	37.4 UJ	**2,420**	812	120	826	395
Chrysene	218-01-9	mg/kg-OC	110	460	--	--	--	--	--	22.7	--	83.2	25.3	--	--	--
Dibenz(a,h)anthracene	53-70-3	µg/kg	--	--	230	230	230	--	1,900	75.4	45.1 U	79.8	67.1	42.5 U	116	30.9 UJ
Dibenz(a,h)anthracene	53-70-3	mg/kg-OC	12	33	--	--	--	--	--	2.90	--	2.74	2.09	--	--	--
Fluoranthene	206-44-0	µg/kg	--	--	1,700	2,500	1,700	4,600	30,000	**1,750**	30.5 UJ	**5,740**	**4,160**	125	**2,230**	169
Fluoranthene	206-44-0	mg/kg-OC	160	1,200	--	--	--	--	--	67.3	--	**197**	130	--	--	--
Indeno(1,2,3-c,d)pyrene	193-39-5	µg/kg	--	--	600	690	600	--	4,400	152	45.1 U	150	132	16.1 UJ	272	52.1
Indeno(1,2,3-c,d)pyrene	193-39-5	mg/kg-OC	34	88	--	--	--	--	--	5.85	--	5.15	4.11	--	--	--
Pyrene	129-00-0	µg/kg	--	--	2,600	3,300	2,600	11,980	16,000	2,060	182	**4,930**	**3,640**	273	2,280	982
Pyrene	129-00-0	mg/kg-OC	1,000	1,400	--	--	--	--	--	79.2	--	169	113	--	--	--
Miscellaneous Extractables																
Dibenzofuran	132-64-9	µg/kg	--	--	540	540	540	--	1,700	22.5 JQ	67.6 U	181	201	6.73 UJ	260	11.3 UJ
Dibenzofuran	132-64-9	mg/kg-OC	15	58	--	--	--	--	--	0.865 JQ	--	6.22	6.26	--	--	--
Hexachlorobutadiene[4]	87-68-3	µg/kg	--	--	11	120	11	--	270	5.62 U	10.7 U	5.86 U	5.78 U	10.1 U	5.90 U	10.9 U
Hexachlorobutadiene[4]	87-68-3	mg/kg-OC	3.9	6.2	--	--	--	--	--	0.216 U	--	0.201 U	0.180 U	--	--	--
N-Nitrosodiphenylamine[4]	86-30-6	µg/kg	--	--	28	40	28	--	130	2.61 U	4.97 U	2.73 U	2.69 U	4.68 U	2.75 U	5.09 U
N-Nitrosodiphenylamine[4]	86-30-6	mg/kg-OC	11	11	--	--	--	--	--	0.100 U	--	0.0938 U	0.0838 U	--	--	--
Benzoic acid	65-85-0	µg/kg	650	650	650	650	650	--	760	237 U	451 U	248 U	244 U	256 UJ	249 U	200 UJ
Benzyl alcohol	100-51-6	µg/kg	57	73	57	73	57	--	870	47.4 U	20.0 UJ	49.5 U	48.8 U	84.9 U	49.8 U	92.3 U
Hexachloroethane	67-72-1	µg/kg	--	--	--	--	1,400	--	14,000	47.4 U	90.2 U	49.5 U	48.8 U	84.9 U	53.7	92.3 U
Chlorinated Hydrocarbons																
Hexachlorobenzene[4]	118-74-1	µg/kg	--	--	22	70	22	168	230	9.26 U	17.6 U	9.67 U	9.53 U	16.6 U	9.73 U	18.0 U
Hexachlorobenzene[4]	118-74-1	mg/kg-OC	0.38	2.3	--	--	--	--	--	0.356 U	--	0.332 U	0.297 U	--	--	--
1,2-Dichlorobenzene[4]	95-50-1	µg/kg	--	--	35	50	35	--	110	4.97 U	9.44 U	5.18 U	5.11 U	8.89 U	5.22 U	9.67 U
1,2-Dichlorobenzene[4]	95-50-1	mg/kg-OC	2.3	2.3	--	--	--	--	--	0.191 U	--	0.178 U	0.159 U	--	--	--
1,4-Dichlorobenzene	106-46-7	µg/kg	--	--	110	110	110	--	120	35.6 U	67.6 U	37.1 U	36.6 U	63.7 U	37.4 U	69.3 U
1,4-Dichlorobenzene	106-46-7	mg/kg-OC	3.1	9	--	--	--	--	--	1.37 U	--	1.27 U	1.14 U	--	--	--
1,2,4-Trichlorobenzene[4]	120-82-1	µg/kg	--	--	31	51	31	--	64	4.32 U	8.21 U	4.51 U	4.44 U	7.73 U	4.54 U	8.40 U
1,2,4-Trichlorobenzene[4]	120-82-1	mg/kg-OC	0.81	1.8	--	--	--	--	--	0.166 U	--	0.155 U	0.138 U	--	--	--

Table 4
Summary of DMMU Composite Sample and Z-Layer Analytical Results Compared to the DMMP Marine Guidelines

									DMMU	DMMU MD-1		DMMU MD-2			DMMU MD-3	
									Sample ID	MD1-SC-C1	Z-Layer Composite 1	MD2-SC-C1	MD52-SC-C1[1]	Z-Layer Composite 2	MD3-SC-C1	Z-Layer Composite 3
									Sample Date	12/20/2017	12/20/2017	12/21/2017	12/21/2017	12/21/2017	12/21/2017	12/21/2017
			SMS Criteria		AET		DMMP Criteria									
Analyte	CAS No.	Unit	SCO	CSL	LAET	2LAET	SL	BT	ML							
Phthalates																
Bis(2-ethylhexyl) phthalate	117-81-7	µg/kg	--	--	1,300	3,100	1,300	--	8,300	57.5	90.2 U	50.0	57.3	84.9 U	45.8 JQ	92.3 U
Bis(2-ethylhexyl) phthalate	117-81-7	mg/kg-OC	47	78	--	--	--	--	--	2.21	--	1.72	1.79	--	--	--
Butyl benzyl phthalate[5]	85-68-7	µg/kg	--	--	63	900	63	--	970	19.0 U	36.1 U	19.8 U	15.7 JQ	34 U	19.9 U	48.2
Butyl benzyl phthalate	85-68-7	mg/kg-OC	4.9	64	--	--	--	--	--	0.731 U	--	0.680 U	0.489 JQ	--	--	--
Diethylphthalate	84-66-2	µg/kg	--	--	200	1,200	200	--	1,200	47.4 U	90.2 U	49.5 U	48.8 U	84.9 U	49.8 U	92.3 U
Diethylphthalate	84-66-2	mg/kg-OC	61	110	--	--	--	--	--	1.82 U	--	1.70 U	1.52 U	--	--	--
Dimethylphthalate	131-11-3	µg/kg	--	--	71	160	71	--	1,400	19.0 U	36.1 U	19.8 U	19.5 U	34.0 U	19.9 U	36.9 U
Dimethylphthalate	131-11-3	mg/kg-OC	53	53	--	--	--	--	--	0.731 U	--	0.680 U	0.607 U	--	--	--
Di-n-butylphthalate	84-74-2	µg/kg	--	--	1,400	5,100	1,400	--	5,100	10.3 JQ	90.2 U	13.1 JQ	6.83 JQ	84.9 U	6.93 JQ	92.3 U
Di-n-butylphthalate	84-74-2	mg/kg-OC	220	1,700	--	--	--	--	--	0.396 JQ	--	0.450 JQ	0.213 JQ	--	--	--
Di-n-octyl phthalate	117-84-0	µg/kg	--	--	6,200	6,200	6,200	--	6,200	47.4 U	90.2 U	49.5 U	48.8 U	84.9 U	49.8 U	92.3 U
Di-n-octyl phthalate	117-84-0	mg/kg-OC	58	4,500	--	--	--	--	--	1.82 U	--	1.70 U	1.52 U	--	--	--
Polychlorinated Biphenyls (PCBs) by USEPA Method 8082																
PCBs, sum of Aroclors[4]	--	µg/kg	--	--	130	1,000	130	--	3,100	2.44 U	NA	77.7 JQ	15.6 JQ	NA	1.48 U	NA
PCBs, sum of Aroclors[4]	--	mg/kg-OC	12	65	--	--	--	38	--	0.0938 U	NA	2.67 JQ	0.486 JQ	NA	--	NA
Phenols																
Pentachlorophenol	87-86-5	µg/kg	360	690	360	690	400	504	690	47.4 UJ	90.2 U	49.5 UJ	48.8 UJ	84.9 U	49.8 UJ	92.3 U
Phenol	108-95-2	µg/kg	420	1,200	420	1,200	420	--	1,200	14.3 JQ	90.2 U	26.7 JQ	28.6 JQ	17.5 UJ	232	14.5 UJ
2-Methylphenol (o-cresol)	95-48-7	µg/kg	63	63	63	63	63	--	77	19.0 U	36.1 U	19.8 U	19.5 U	34.0 U	19.9 U	36.9 U
3- and 4-Methylphenol (m- and p-cresol)	106-44-5	µg/kg	670	670	670	670	670	--	3,600	47.4 U	90.2 U	49.5 U	48.8 U	84.9 U	49.8 U	92.3 U
2,4-Dimethylphenol[4]	105-67-9	µg/kg	29	29	29	29	29	--	210	2.09 U	3.97 UJ	2.18 U	2.15 U	3.74 U	2.20 U	4.07 UJ
Pesticides by USEPA Method 8081																
4,4´-DDD	72-54-8	µg/kg	--	--	--	--	16	--	--	0.982 U	NA	0.990 U	0.988 U	NA	0.304 JQ	NA
4,4´-DDE	72-55-9	µg/kg	--	--	--	--	9	--	--	0.982 U	NA	0.430 JQ	0.105 JQ	NA	0.997 U	NA
4,4´-DDT	50-29-3	µg/kg	--	--	--	--	12	--	--	0.175 JQ	NA	0.990 U	0.414 JQ	NA	0.175 JQ	NA
Aldrin	309-00-2	µg/kg	--	--	--	--	9.5	--	--	0.982 U	NA	0.366 JQ	0.988 U	NA	0.997 U	NA
Dieldrin	60-57-1	µg/kg	--	--	--	--	1.9	--	1,700	0.107 JQ	NA	0.981 JQ	0.442 JQ	NA	0.422 JQ	NA
Heptachlor	76-44-8	µg/kg	--	--	--	--	1.5	--	270	0.982 U	NA	0.990 U	0.988 U	NA	0.997 U	NA

Table 4

Summary of DMMU Composite Sample and Z-Layer Analytical Results Compared to the DMMP Marine Guidelines

										DMMU	DMMU MD-1		DMMU MD-2			DMMU MD-3	
										Sample ID	MD1-SC-C1	Z-Layer Composite 1	MD2-SC-C1	MD52-SC-C1[1]	Z-Layer Composite 2	MD3-SC-C1	Z-Layer Composite 3
										Sample Date	12/20/2017	12/20/2017	12/21/2017	12/21/2017	12/21/2017	12/21/2017	12/21/2017
			SMS Criteria		AET		DMMP Criteria										
Analyte	CAS No.	Unit	SCO	CSL	LAET	2LAET	SL	BT	ML								
Dioxins/Furans by USEPA Method 1613B																	
2,3,7,8-TCDD	1746-01-6	pg/g	--	--	--	--	--	--	--	0.733 J	0.768 J	0.768 J	0.862 J	0.884 J	1.07	0.561 J
1,2,3,7,8-PeCDD	40321-76-4	pg/g	--	--	--	--	--	--	--	2.07 J	1.08 J	1.93 J	2.06 J	2.45 J	2.90 J	1.88 J
1,2,3,4,7,8-HxCDD	39227-28-6	pg/g	--	--	--	--	--	--	--	3.43 J	1.87 U	2.10 J	2.18 J	2.05 J	2.88 J	1.43 J
1,2,3,6,7,8-HxCDD	57653-85-7	pg/g	--	--	--	--	--	--	--	20.0	5.21	10.7	12.3	16.2	15.7	7.66
1,2,3,7,8,9-HxCDD	19408-74-3	pg/g	--	--	--	--	--	--	--	4.63 J	3.35 J	3.50 J	3.98 J	4.98 J	5.61	3.00 J
1,2,3,4,6,7,8-HpCDD	35822-46-9	pg/g	--	--	--	--	--	--	--	729	83.4	250	266	192	274	130
OCDD	3268-87-9	pg/g	--	--	--	--	--	--	--	4,000	438	2,250	2,420	1,190	1,930	826
2,3,7,8-TCDF	51207-31-9	pg/g	--	--	--	--	--	--	--	2.03	0.393 U	2.39	2.43	2.83	3.54	1.43 J
1,2,3,7,8-PeCDF	57117-41-6	pg/g	--	--	--	--	--	--	--	1.36 J	0.559 J	1.39 J	1.36 J	1.52 J	2.10 J	0.741 J
2,3,4,7,8-PeCDF	57117-31-4	pg/g	--	--	--	--	--	--	--	1.86 J	1.14 J	1.23 J	2.21 J	2.49 J	2.92 J	1.66 J
1,2,3,4,7,8-HxCDF	70648-26-9	pg/g	--	--	--	--	--	--	--	2.26 J	1.21 J	2.15 J	2.62 J	2.45 J	2.45 J	1.87 J
1,2,3,6,7,8-HxCDF	57117-44-9	pg/g	--	--	--	--	--	--	--	1.76 J	0.886 J	1.41 J	1.51 J	1.81 J	1.93 J	1.26 J
1,2,3,7,8,9-HxCDF	72918-21-9	pg/g	--	--	--	--	--	--	--	0.883 J	0.404 U	0.840 J	0.799 J	0.720 J	0.808 J	0.608 J
2,3,4,6,7,8-HxCDF	60851-34-5	pg/g	--	--	--	--	--	--	--	2.92 J	1.10 J	2.01 J	2.37 J	2.83 J	2.85 J	1.82 J
1,2,3,4,6,7,8-HpCDF	67562-39-4	pg/g	--	--	--	--	--	--	--	35.6	17.7	27.8	31.3	43.9	34.2	31.4
1,2,3,4,7,8,9-HpCDF	55673-89-7	pg/g	--	--	--	--	--	--	--	2.25 J	1.35 J	1.89 J	2.19 J	1.93 J	1.82 J	1.47 J
OCDF	39001-02-0	pg/g	--	--	--	--	--	--	--	70.3	45.6	84.8	88.8	91.5	69.8	64.4
Summed dioxin/furan TEQ	--	pg/g	--	--	--	--	4–10	10	--	**16.1 J**	4.55 J	9.12 J	**10.2 J**	**10.3 J**	**12.2 J**	6.76 J
Summed dioxin/furan TEQ with one-half of the detection limit	--	pg/g	--	--	--	--	4–10	10	--	**16.1 J**	4.69 J	9.12 J	**10.2 J**	**10.3 J**	**12.2 J**	6.76 J

Notes:

-- Not applicable.

Normalized to organic carbon.

BOLD Detected exceedance of at least one criterion.

1 Sample MD52-SC-C1 was collected as a homogenate duplicate for MD2-SC-C1.

2 Grain size analysis does not differentiate between gravel and woody debris. Grain size percentages reported as gravel are representative of woody debris percentages.

3 Sample was reanalyzed on March 23, 2018, with the composite samples.

4 Non-detect values reported down to MDL.

5 Butyl benzyl phthalate was initially reported as detected at a concentration of 837 µg/kg for Z-Layer Composite 2. This result was considered anomalous. To address this anomaly, discrete Z-layer samples MD2-SC-C1-Z and MD2-SC-C2-Z from DMMU MD-2 were analyzed in triplicate for butyl benzyl phthalate. Fremont Analytical, Inc., in Seattle, Washington, determined that the analyte in question was not butyl benzyl phthalate, but ferruginol, a naturally occurring chemical associated with tree sap. The lab re-examined the original scan and confirmed that the analyte originally detected was ferruginol. The result for butyl benzyl phthalate for Z-layer Composite 2 was changed to a non-detect at the reporting limit of 34.0 µg/kg. Results for the discrete Z-layer samples MD2-SC-C1-Z and MD2-SC-C2-Z are presented in Table 5.2. A description of the sample analysis and compound identification is described in Section 5.2.4 and Appendix B.2.

Abbreviations:

%-dw Percent of dry weight
2LAET Second Lowest Apparent Effects Threshold
AET Apparent Effects Threshold
BT Bioaccumulation trigger
CAS Chemical Abstracts Service
CSL Cleanup Screening Level
DDD Dichlorodiphenyldichloroethane
DDE Dichlorodiphenyldichloroethene
DDT Dichlorodiphenyltrichloroethane
DMMP Dredged Material Management Program
DMMU Dredged material management unit
HpCDD Heptachlorodibenzo-p-dioxin
HpCDF Heptachlorodibenzofuran
HxCDD Hexachlorodibenzo-p-dioxin
HxCDF Hexachlorodibenzofuran
LAET Lowest Apparent Effects Threshold
µg/kg Micrograms per kilogram
µm Micrometers
MDL Method detection limit
mg/kg Milligrams per kilogram
mg/kg-OC Milligrams per kilogram normalized to organic carbon
ML Maximum level
MLLW Mean lower low water
NA Not analyzed
OCDD Octachlorodibenzodioxin
OCDF Octachlorodibenzofuran
PeCDD Pentachlorodibenzo-p-dioxin
PeCDF Pentachlorodibenzofuran
pg/g Picograms per gram
SCO Sediment Cleanup Objective
SL Screening level
SMS Sediment Management Standards
TCDD Tetrachlorodibenzo-p-dioxin
TCDF Tetrachlorodibenzofuran
TEQ Toxic equivalent quotient

Qualifiers:

J Analyte was detected; concentration is considered an estimate.
JQ Analyte was detected between the reporting limit and detection limit; concentration is considered an estimate.
U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected at the given reporting limit, which is considered an estimate.

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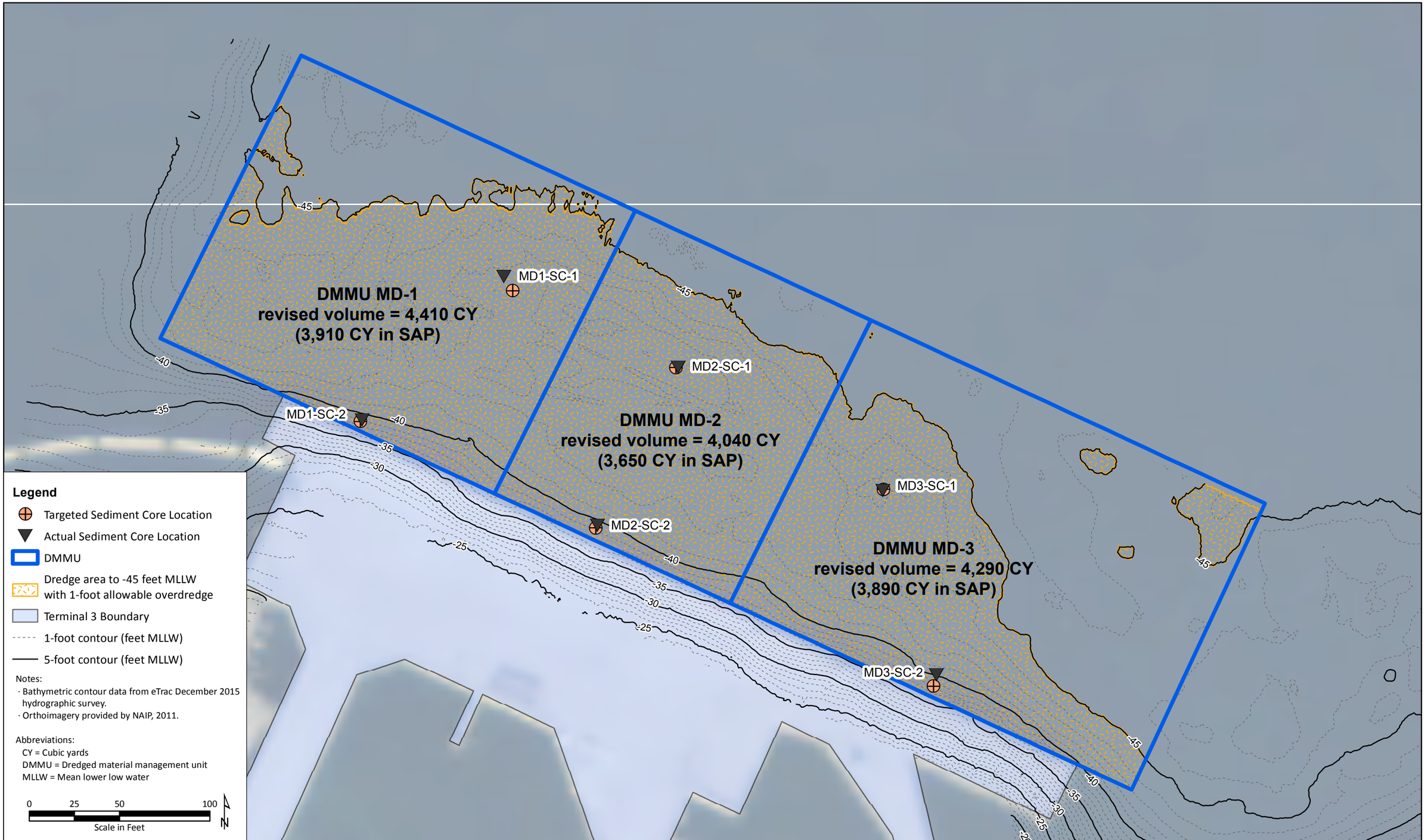
Terminal 3 Maintenance Dredging
DMMP Sediment Characterization Report
Port of Port Angeles
Port Angeles, Washington

Figure 1
Vicinity Map and Upland Dredged Material Placement Area

I:\GIS\Projects\POPA-T3_Permitting\MXD\Figure 1.1 Vicinity Map and Upland Dredged Material Placement Area.mxd
5/3/2018



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Terminal 3 Maintenance Dredging
DMMP Sediment Characterization Report
Port of Port Angeles
Port Angeles, Washington

Figure 2
DMMU Areas and Targeted and Actual Sampling Locations

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4/27/2018