RECORD OF DECISON

For

AREA 1 UPLAND AND IN-WATER AREAS FORMER POPE AND TALBOT WOOD-TREATING SITE ST. HELENS, OREGON

September 1, 2023

State of Oregon
DEQ Department of Environmental Quality

This document was prepared by
Oregon Department of Environmental Quality
Cleanup Program, Northwest Region
700 NE Multnomah Street, Suite 600
Portland Oregon, 97232

Contact: Katie Daugherty
Phone: 503-860-3943
www.oregon.gov/deq

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800-452-4011 | TTY: 711 | deqinfo@deq.oregon.gov

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ACRONYMS

AST	above ground storage tank
bgs	below ground surface
bml	below mudline
BMP	best management practice
BTEX	benzene, toluene, ethylbenzene, and xylenes
BWUD	beneficial water use determination
CEPCs	contaminants of potential ecological concern
C_{free}	freely dissolved water concentrations
CMMP	contaminated media management plan
COC	chemical of concern
COPC	contaminants of potential concern
CSM	conceptual site model
CTE	Central Tendency Exposure
CULs	cleanup levels
DNAPL	dense non-aqueous phase liquid
DEQ	Oregon Department of Environmental Quality
DSL	Division of State Lands
E&E	Ecology and Environment, Inc.
EES	easement and equitable servitudes
ECSI	environmental cleanup site information
ENR	enhanced natural recovery
EPA	Environmental Protection Agency
EPH	extractable petroleum hydrocarbon
ERA	ecological risk assessment
Etc.	etcetera
FCV	final chronic value
HI	Heavy Industrial
HLA	Harding Lawson Associates
HHRA	human health risk assessment
IC	institutional control
in/yr	inches per year
IW	interstitial water
LDPE	low density polyethylene
LOEs	lines of evidence
LOF	Locality of Facility
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MNA	monitored natural attenuation
MNR	monitored natural recovery
NAPL	non-aqueous phase liquid
NAVD88	North American Vertical Datum of 1988
NFA	no further action
No.	number
NPDES	National Pollutant Discharge Elimination System
OAR	Oregon Administrative Rules
O&M	operations and maintenance
OHA	Oregon Health Authority
OHWM	Ordinary High-Water Mark
OPAHs	Oxygenated PAHs
ORS	Oregon Revised Statutes
OSU	Oregon State University
PA	Preliminary Assessment
PAA	Priority Action Area
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCP	pentachlorophenol
PDI	pre-design investigation
PEC	probable effects concentration
PHSS	Portland Harbor Superfund Site
PRB	permeable reactive barrier
PRGs	Preliminary Remediation Goals
PVC	polyvinyl chloride
RAA	remedial action alternative
RALs	remedial action levels
RAOs	remedial action objectives
RBCs	risk-based screening concentrations
RD/RA	Remedial Design/ Remedial Action
RME	Reasonable Maximum Exposure
ROD	Record of Decision
SLVs	screening levels values
SPME	solid-phase microextraction
SQGs	sediment quality guidelines
ΣIWTU	sum of IW TU
ΣGWTU	sum of groundwater TUs
ΣSWTU	sum of surface water TU
SVOCs	semi-volatile organic compounds
TEC	threshold effects concentration
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TU	toxic unit
µg/L	micrograms per liter
U.S.	United States
USACE	U.S. Army Corps of Engineers
UST	underground storage tank
VOCs	volatile organic compounds
VPH	volatile petroleum hydrocarbon
°F	degrees Fahrenheit
%	percent
≥	greater than or equal to
>	greater than
<	less than

1. INTRODUCTION

1.1 INTRODUCTION

This Record of Decision (ROD) presents the Oregon Department of Environmental Quality's selected cleanup remedy (remedial action) for Area 1 Upland and contaminated sediments located in Upper Milton Creek and Scappoose Bay adjacent to the former Pope and Talbot wood-treating facility located at 1550 Railroad Avenue in St. Helens, Oregon (Site) (Figure 1). The Site has been divided into several areas. DEQ issued a no further action determination for Area 2 Upland (tax lot 302) on April 16, 2012. This ROD is applicable to the Area 1 Upland (tax lot 300) and four priority sediment areas (Area 1 Dock, Area 2 Dock, Cove Area, and Upper Milton Creek) which are defined in Section 2.1.1 and shown on Figure 2. The selected remedial action includes riverbanks located within the priority sediment areas. The selected remedial action was developed in accordance with Oregon Revised Statutes (ORS) 465.200 *et seq*. and Oregon Administrative Rules (OAR) Chapter 340, Division 122, Sections 0010 through 0115, and is based on the administrative record for this Site.

This ROD summarizes information contained in the DEQ Staff Report (DEQ, 2023), as well as the Remedial Investigation, Updated Supplemental Risk Assessment, Human Health Risk Assessment, Ecological Risk Assessment, and Remedial Investigation/Feasibility Study reports completed under DEQ Order of Consent Number (No.) WMCSR-NWR-95-05 signed April 13, 1995, by Port of St. Helens (now Port of Columbia County) and DEQ. DEQ's environmental cleanup site information (ECSI) system designates the Site as No. 0959. A copy of the Administrative Record Index is attached as Section 13.

In selecting the remedial action presented in this ROD, DEQ considered public input following a comment period on the Staff Report.

1.2 SCOPE AND ROLE OF THE SELECTED REMEDIAL ACTION

The selected remedial action addresses both upland and in-water contamination. In the upland, the selected remedial action addresses the presence of creosote non-aqueous liquid (NAPL) and dissolved phase chemical of concerns (COCs) in groundwater and soil in the Area 1 Upland priority action area (PAA). In the in-water areas, the selected remedial action addresses sediment, porewater and surface water impacted by polycyclic aromatic hydrocarbons (PAHs), metals, creosote sheen, and contaminated woody debris in surface and subsurface sediments within the sediment PAAs and adjacent riverbanks where contaminated soils pose a future recontamination risk. The areas with the greatest potential for impacts to human health and the environment are the focus of the feasibility study and a key focus on the selected remedial action. Additional in-water areas (e.g., with light petroleum sheen) may need further investigation and cleanup in the future (e.g., Lower Milton Creek).

The selected remedial action for Area 1 Upland includes placement of an impervious surface cap over the entire Area 1 Upland PAA and a permeable reactive barrier (PRB) at the top of the riverbank, adjacent to the Cove Area PAA. The selected upland remedial action is intended to address risks associated with direct contact to soil in the upland, limit stormwater infiltration into the NPAL source area in Area 1 Upland, and limit contaminant migration from the upland source area into the in-water areas via groundwater seeps. The long-term effectiveness of the selected remedial action for Area 1 Upland is contingent upon Institutional Controls (ICs) to mitigate risks to potential future industrial, excavation, and construction workers in the upland.

The selected in-water remedial action is intended to address areas with the highest levels of sediment contamination (hot spots, specifically areas with creosote NAPL and heavy to moderate petroleum sheen). Remedial action objectives (RAOs) were developed to focus treatment in areas with the highest contamination levels posing unacceptable risks to humans and ecological receptors. DEQ anticipates further investigations to support remedial design will be performed.

Contamination in upland soil and groundwater pose unacceptable direct contact and vapor inhalation risks to human health (specifically to potential future industrial, excavation, and construction workers). Sediment contamination within the in-water PAAs exceeds acceptable risk levels for both human health (specifically to subsistence fishers) and for aquatic ecological receptors. In addition to risks associated with dissolved phase COCs, the presence of creosote NAPL and moderate to heavy petroleum sheen presents unacceptable risk to human health and aquatic ecological receptors. "Hot spots" (elevated levels of contamination) are present in all of the PAAs.

The following general actions will be components of the selected remedial action:

- Placement of an impervious surface cap over the entire Area 1 Upland PAA and a PRB at the top of the riverbank, adjacent to the Cove Area PAA.

- Establishment of an easement and equitable servitudes (EES) in the upland to maintain the cap in perpetuity, and implementation of ICs to prevent potential risks to future industrial, excavation, and construction workers associated with groundwater and subsurface soil contamination in Area 1 Upland.

- Treatment, containment, or removal of sediment that contains NAPL and/or emanates moderate to heavy petroleum sheen.

- Treatment, containment, or removal of erodible riverbank soils considered to pose a risk of recontamination to sediments.

- Monitored natural recovery (MNR), which consists of the natural burial of surface sediment contamination posing a lower risk through deposition of suspended sediment from Milton Creek, Columbia, and Multnomah Channel watersheds.

- An Oregon Health Authority (OHA) advisory regarding consumption of fish, shellfish, and crayfish in Multnomah Channel and Scappoose Bay to minimize potential risk to human health until contamination levels protective of human health and fish are achieved.

- Long-term monitoring to assess and document progress of active remedial measures and MNR in achieving RAOs and cleanup levels (CULs) long-term and to address any residual risk.

- Periodic land and water use review.

The selected remedial action consists of the following PAA-specific elements:

- In the Area 1 Upland PAA, placement of an impervious surface cap with an engineered stormwater management system over the entire Area 1 Upland to reduce infiltration in combination with an organoclay PRB to intercept and sequester contaminants in the groundwater: preventing recontamination of the in-water remedy.

- Within the Area 1 Dock PAA, timber pilings and impacted surficial woody debris will be removed and an amended isolation cap will be placed across the sediment containing the highest levels of contamination posing unacceptable risks to human health and aquatic ecological receptors.

- In the Area 2 Dock PAA, impacted surficial woody debris will be removed, shallow surface sediment will be removed near the shoreline, and a sand cap will be placed over residual contamination for enhanced natural recovery (ENR).

- In the Cove Area and Upper Milton Creek PAAs, the shallow sediment with the highest concentrations (creosote NAPL and/or moderate to heavy sheen) will be excavated for off-site disposal and an engineered, amended isolation cap will be placed over the sediment within the PAAs along with protective armoring. The riverbank adjacent to these PAAs will be regraded to remove impacted soil and further reduce the potential for recontamination of the in-water remedy.

The selected remedial action will restore the Site to conditions protective of risks to upland Site workers, people who consume fish and shellfish for recreational and subsistence purposes or are directly exposed to contaminated sediment, and aquatic ecological receptors that consume prey from the Site or are directly exposed to contaminated sediment. The selected remedial action is protective of beneficial water uses from releases of petroleum sheen and prevents recontamination of the in-water remedy from the adjacent groundwater seeps and erodible riverbank soils.

2. SITE HISTORY AND DESCRIPTION

2.1 SITE LOCATION AND LANDUSE

The Site consists of approximately 42 acres of industrial zoned land situated within the southern limits of the City of St. Helens. DEQ approved subdividing the upland portion of the Site into two areas (Area 1 and Area 2) in 2008. Area 1 is 25.15 acres and Area 2 is 17.32 acres. The Site also includes adjacent riverbanks and sediment areas. The United States (U.S.) Army Corps of Engineers (USACE) Ordinary High-Water Mark (OHWM) divides the upland and in-water areas. Land above the OHWM is considered upland and the portions of riverbanks and sediments below the OHWM are considered to be in–water. The selected remedial action is specific to Area 1 Upland PAA and four in-water PAAs discussed further in Section 2.1.1. DEQ's ECSI system designates the Site as No. 0959.

The Site lies on the northwestern bank of Scappoose Bay, near the confluence of Scappoose Bay and the Multnomah Channel. The Multnomah Channel is a 21.5-mile distributary, or branch, of the Willamette River. The channel flows to the north adjacent to the west side of Sauvie Island until it meets the Columbia River near St. Helens. Scappoose Bay is a low-energy surface water embayment just west of Multnomah Channel that includes former and current industrial sites. The confluence of the Multnomah Channel and the Columbia River is approximately 1.3 miles downriver from the Site. Milton Creek is a perennial stream located on the Site's western boundary. Milton Creek discharges to Scappoose Bay at the southwest corner of the Site.

2.1.1 Areas of the Site

The upland ground surface across most of Area 1 is generally between 22 to 25 feet North American Vertical Datum of 1988 (NAVD88). The Site's top of bank elevation with Milton Creek and Scappoose Bay are between 19 and 21 feet NAVD88. The OHWM at the Site generally corresponds to a vertical elevation of approximately 14 feet relative to the NAVD88. As previously discussed, riverbanks above the OHWM are included in Area 1 and riverbanks below OHWM are included with adjacent in-water areas. The riverbanks along Scappoose Bay and Milton Creek have steep to vertical banks. Portions of the riverbank, especially along Milton Creek, have potentially erodible soils that pose a recontamination risk to in-water remedies.

2.1.1.1 Area 1 Upland Priority Action Area

Geographically, Area 1 Upland is located approximately one mile east of Highway 30. Area 1 has a street address of 1550 Railroad Avenue in St. Helens, Oregon, and is tax lot 300 located in Section 9, Township 4 North, Range 1 West of the Willamette Baseline and Meridian in Columbia County (Figure 1). The latitude is 45.8413 degrees North, longitude 122.8094 degrees West. Area 1 Upland is accessed by and located at the eastern end of Railroad Avenue. Area 1 Upland covers 25.15 acres of the southwest portion of the Site and is generally flat with a peak elevation of approximately 27 feet above mean sea level. Nearly all of Area 1 Upland is located within the 100-year floodplain. Area 1 Upland is primarily vacant industrial land with a tenant occupying the former office/shop building. The Area 1 Upland boundary is shown on Figure 2.

The former wood-treating plant facilities, above ground storage tanks (ASTs), transfer tables, loading platforms, and underground portion of the creosote pipeline were located within Area 1 Upland (see Figures 3A and 3B). All facilities except for the former office/shop and a storage shed were removed from Area 1 in the early 1960s. Dredge material generated during the deepening of the Columbia River was placed on Area 1 Upland in the early 1970s. The fill material averages 7 to 8 feet thick over the native soil. Creosote NAPL observed in Area 1 Upland riverbanks adjacent to Milton Creek and Scappoose Bay indicates that some lateral movement of NAPL occurs beneath the Site. The progression of Site features from 1919 through 2013 are shown on Figures 4 through 16. A generalized cross-section showing the relationship between the dredge fill material and native soil and basalt bedrock is shown on Figure 17.

2.1.1.2 Area 1 Dock Priority Action Area

The Area 1 Dock PAA consists of an approximately 700-foot section of shoreline adjacent to Area 1 Upland and in-water area located between the former hog fuel loading hopper and downriver terminus of the former transfer table dock (see Figure 2). The wood decking and lateral bracing was removed from both dock structures in 2013. Over 435 the creosote-treated timber pilings remain, and the wood debris is present in the upper 1 to 2 feet of sediment and as deep as 11 feet below the mudline (bml; "mudline" generally refers to the surface water/sediment interface). The source of surface sediment exhibiting moderate to heavy sheen in the Area 1 Dock PAA is creosote-contaminated and/or treated wood debris associated with historical overwater activities, which has been encountered within 1.85 acres of surface sediment underneath and surrounding the former dock structures.

The Area 1 Dock PAA is closer to the main channel of Scappoose Bay and is subjected to stronger river current, as evidenced by the coarser sandy sediments encountered within the intertidal zone. The area's shoreline appears to be relatively stable to eroding. This indicates the environment is generally preventing the deposition of newer clean sediments and the burial of historical contamination.

2.1.1.3 Area 2 Dock Priority Action Area

The Area 2 Dock PAA consists of an approximately 600-foot section of shoreline adjacent to Area 2 Upland and in-water area located near the downriver property boundary and terminus of the former creosote pipeline, AST, and historical off-loading dock (see Figure 2). The wood decking and lateral bracing was removed from both dock structures. Hundreds of closely spaced creosote-treated timber pilings remain. Moderate to heavy petroleum sheen has been observed near timber pilings within the upper 12 inches of sediment. Residual creosote contaminated wood debris has been encountered within 0.3 acres of surface sediment in the former dock structure area.

The main stem of the Multnomah Channel is reportedly 100 to 150 feet offshore with a bottom elevation of approximately -15 feet NAVD88 immediately downstream of the Site. Based on the presence of contamination in surface sediment only (i.e., upper 12 inches) and the hard compact nature of the mudflats with relatively steep slopes towards the channel, the Area 2 Dock PAA appears to be relatively stable to eroding.

2.1.1.4 Cove Priority Action Area

The Cove PAA consists of approximately 300 feet of shoreline adjacent to Area 1 Upland, the island, and around the peninsula (see Figure 2). The Cove PAA is immediately downgradient of the former wood-treating plant operations. The cove is a manmade area created between 1948 and 1953 by extensive dredging and filling of lowlands. The Cove PAA consisted of a partially vegetated slough prior to dredging.

The elevation of the river bottom within the manmade cove and shallow inlet immediately downriver of the peninsula ranges between approximately 0 and 10 feet NAVD88 within approximately 100 to 300 feet of the shoreline before sloping steeply towards the main channel of Scappoose Bay. The main channel of Scappoose Bay adjacent to the Cove PAA widens to approximately 150 feet with bottom elevations between -7 and -5 feet NAVD88.

The Cove PAA is protected from the erosional effects of large storm and tidal surge and is a sediment depositional area. In 1960, wood treating plant operations ceased which has led to the deposition and burial of the old operational sediment surface throughout the Cove PAA. A sediment deposition rate of 0.2 to 1.4 inches per year (in/yr) is implied based on the presence of 1 to 7 feet of relatively clean fine textured sediment above the old contaminated operational sediment surface.

Creosote-impacted groundwater seeps exhibiting moderate to heavy sheen have been intermittently observed along the Cove PAA riverbank, located west of the peninsula. Some sediments within certain areas of the Cove PAA have been observed to exhibit moderate to heavy or slight petroleum sheen. NAPL within the Cove PAA varies vertically from a few inches to 12 feet bml, with much of the historical creosote contamination located 2 to 3 feet below deposited relatively clean sediment.

2.1.1.5 Upper Milton Creek Priority Action Area

Milton Creek discharges to Scappoose Bay at the southwest corner of the Site (see Figure 2). The Upper Milton Creek PAA consists of a 200-foot section of the east bank of Milton Creek where groundwater seeps exhibiting moderate to heavy creosote sheen are present within a layer of sand near the base of the streambank.

The upper portion of Milton Creek adjacent to the Site is characterized by relatively steep embankments (e.g., up to 1.5H:1V with “H” the cutback distance and “V” the depth). The elevation difference between the top and bottom of the streambank is approximately 15 feet along this portion of Milton Creek. Scouring of the creek channel by seasonal runoff and diurnal tidal cycles appears to limit the accumulation of sediment in this portion of the creek. The sediment bed profile generally consists of 0 to 1 foot of silty organic-rich fluff overlying a hardpan layer of clayey silt with gravel and cobbles.

2.1.1.6 Lower Milton Creek Sediment Area

The lower portion of Milton Creek generally includes the confluence of Milton Creek with Scappoose Bay and is characterized by a depositional sediment environment, with 3 to 10 feet of soft silt and varying amounts of sand overlying Columbia River Basalt Bedrock. Because this area generally has not had observations of creosote NAPL in sediments and is depositional, the area is not considered a PAA. Additional sampling in this and other areas where petroleum sheen has been observed outside of the PAAs may be needed in the future.

2.1.2 Current and Reasonably Anticipated Future Land Uses

The Upland Area is currently zoned for Heavy Industrial (HI) use as part of the Railroad Avenue Industrial Park. The current and reasonably anticipated future uses of the Upland Area remain Heavy Industrial.

Adjacent land uses include railroad tracks and undeveloped land to the north and City-owned industrial development (former Boise White Paper Mill) to the northeast. Northwest of the Site and north of the railroad tracks are several single-family homes. Milton Creek forms the western Site boundary with the former St. Helens Fiberboard Plant and the Columbia County transfer station located on the west side of Milton Creek. Scappoose Bay and the Multnomah Channel of the Willamette River form the southern and eastern Site boundaries.

2.1.3 Adjacent Cleanup Sites

The Site is bordered to the east and northeast by the more than 200-acre former Boise Cascade Mill/Boise White Paper Mill site (ECSI No. 0014) located at 1300 Kaster Road in St. Helens (Figure 18). The former Boise White Paper Mill property is current and former industrial land with various buildings that were previously the location of pulping, bleaching, and milling operations. The former Boise White Paper Mill property issued a Record of Decision in 2023 for the 15-acre In-Water Sediment area. Additional investigation is anticipated to be performed during Remedial Design.

The former St. Helens Fiberboard Plant site (ECSI No.0091) is located at 1645 Railroad Avenue, west of the Site (Figure 18). The inactive former St. Helens Fiberboard Plant site has been used to manufacture a variety of mineral fiber and wood fiber building products. The site is divided into two operable units: Upland area and Lowland/In-water area. Remedial action in the upland area is complete. An interim remedial action measure is underway at the St. Helens Fiberboard Plant site in the Lowland/In-water area.

2.2 PHYSICAL SETTING

2.2.1 Climate

St. Helens has a temperate marine climate characterized by short, dry summers and wet winters. Between 1981 and 2010,[1] the average annual precipitation in St. Helens was 46.6 inches. Most precipitation falls between November and May, with average monthly totals ranging from 0.72 to 7.22 inches and the highest in December. The mean annual temperature ranges from approximately 37.1 to 67.2 degrees Fahrenheit (°F).

[1] National Oceanic & Atmospheric Administration, St. Helens Station.

2.2.2 Geology

Regionally, the Site lies in the Puget-Willamette Lowland, a broad structural and topographic depression located between the Coast Range to the west and the Cascade Range to the east. St. Helens lies in the northern portion of the Portland Basin, one of several complexly faulted basins comprising the Willamette Valley segment of the Puget-Willamette Lowland. The Portland Basin is interpreted to be a pull-apart basin between two *en echelon* right-lateral strike-slip faults (Evarts, 2004) caused by regional compression and shear associated with oblique subduction of the Juan de Fuca Plate beneath the North American Plate off the Oregon coast. In the deepest part of the Portland Basin, up to 1,800 feet of sediment has accumulated since the late Miocene.

The Site is on the west side of Multnomah Channel. The topographic highlands to the north expose Miocene flood basalts of the Grand Ronde Formation, deeply weathered in places. Chemistry and magnetostratigraphy data indicate the basalt is equivalent to the Member of Sentinel Bluffs, which is dated to approximately 15.6 million years. In the area of the Site, the Multnomah Channel is separated from the Columbia River by a peninsula marking the northernmost extent of Sauvie Island. The islands, floodplains and point bars of Multnomah Channel and the Columbia River east of the Site are comprised of Quaternary alluvium (i.e., primarily fine sand and silt).

Soil encountered at the Site consists of fill underlain by native soil, which in turn is underlain by basalt bedrock. The fill ranges from 4 to 12 feet below ground surface (bgs) and consists predominantly of dredge sand with localized areas of silt, coarse gravel, cobbles, wood chips, and metal and brick debris. The native soil, beneath the fill, ranges from 4 to 24 feet bgs and consists primarily of silt with varying amounts of clay and organic matter, and minor amounts of sand and gravel. Basalt bedrock was generally encountered at depths between 6 and 35 feet bgs in the upland area and at depths of 2 to 26 feet beneath river sediment in the offshore area. Bedrock beneath the Site is part of the Grande Ronde flows of the Columbia River Basalt. Detailed cross-sections were prepared for transects through the upland and in-water areas shown on Figure 19. The cross-sections are presented as Figures 20 through 27. The top of basalt surface elevation contours for the upland and in-water area are shown on Figure 28.

2.2.3 Hydrogeology

Regionally, shallow groundwater occurs in the surface fill materials, alluvium, and where the basalt bedrock is near the surface, in the weathered upper flow surfaces. Deeper groundwater zones are located in the more permeable interflow zones between the unweathered basalt flows and are not hydraulically connected to shallow groundwater.

In 1996, 17 monitoring wells, 13 located in Area 1, were installed as part of the risk investigation (Figure 29). Five monitoring wells were installed as pairs (depicted by A/B) with one deeper, though located in same water bearing zone, than the other for a total of 22 monitoring wells. One additional monitoring well was installed in 1998. The monitoring wells were constructed to depths ranging from 9 to 20 feet bgs depending on when bedrock was encountered. Well screens within the 2-inch diameter polyvinyl chloride (PVC) well casings ranged from 5 feet in length to 10 feet.

Following installation and development, depth to water measurements were regularly collected from the monitoring wells from August 1996 to March 1999. Groundwater was measured at depths ranging from 2 to 8.5 feet bgs and fluctuates seasonally. Groundwater generally flows towards the nearest water body. Groundwater discharge to surface water is strongly influenced by seasonal rainfall and fluctuations in river stage. Groundwater contours for high and low water conditions are shown on Figure 29.

2.2.4 Surface Water and Stormwater

The Site lies on the northwestern bank of Scappoose Bay near the confluence of Scappoose Bay and the Multnomah Channel of the Willamette River. The confluence of the Multnomah Channel and the Columbia River is approximately 1.3 miles downriver from the Site. Milton Creek is a perennial stream located on the Site's western boundary and discharges to Scappoose Bay at the southwest corner of the Site. The Upper Milton Creek PAA is located in and adjacent to Milton Creek. The main channel of Scappoose Bay is offshore of Area 1 Upland. The Cove Area and Area 1 Dock PAAs are located in Scappoose Bay. Area 2 Dock PAA is located in the Multnomah Channel, downstream of Scappoose Bay. The locations of the PAAs and surface water bodies are shown on Figure 2. Bathymetry contours from 2010 and 2017 surveys are shown on Figures 30 and 31.

Based on a review of bathymetric maps generated in 2010 and 2017, the main channel of Scappoose Bay is a stable feature in the vicinity of Area 1. Tidal fluctuations of water levels occur daily in Scappoose Bay and Multnomah Channel, in addition to seasonal fluctuations in water levels as a result of runoff events in the watershed. The Site's shoreline is routinely inundated above the OHWM (14 feet NAVD88) during high tides (typically between April and July). Mudflats are commonly visible along the Site's shoreline between approximately 5 to 10 feet NAVD88. Depending on shoreline conditions, basalt topography, and channel dimensions, portions of the Site's shoreline experience sediment deposition (e.g., flat, soft bottom cove areas), while riverbank areas closer to the main channel appear to exhibit localized erosion of sediment from large storm events and/or tidal cycles. Specific conditions of each in-water PAA are described below.

2.2.4.1 Area 1 Dock

The 700-foot-long Area 1 Dock shoreline and in-water area is closer to the main channel of Scappoose Bay and is subject to stronger river current. The main channel of Scappoose Bay widens and deepens adjacent to and within the Area 1 Dock. Specifically, the bottom of the main channel ranges between 200 and 250 feet NAVD88 wide and between -10 and -5 feet NAVD88 deep. The river bottom slopes steeply downward within 50 to 100 feet of the shoreline. The Area 1 Dock shoreline is relatively stable to eroding, which generally prevents the deposition of newer clean sediments and the burial of historical contamination.

Deteriorating creosote-treated timber pilings, remnants of dock structures, are present throughout this area. Finer textured wood debris, described as "pulverized wood" in sampling logs and is interpreted to be hog fuel (e.g., wood shavings/chips) likely spilled from the hog fuel conveyor, is also present in sediment. The distribution and thickness of the woody debris is highly variable in this area, ranging from completely absent to more than 11 feet thick.

Contaminated sediments in the Area 1 Dock have been characterized to an approximate depth of -25 NAVD88 or about 25 feet bml. Sediments in the western portion of the area, in the vicinity of the hog fuel conveyor and loading hopper, were characterized as sand to sandy silt. Sediment in the eastern portion of the area, in the vicinity of the transfer table and dock, were characterized as silt. Basalt bedrock was encountered at various depths throughout the Area 1 Dock. Cross-sections along transects B-B', G-G', and H-H' (see Figure 19 for cross-section locations) are included as Figures 21, 26, and 27.

2.2.4.2 Area 2 Dock

The 600-foot long and 150-foot-wide Area 2 Dock shoreline and in-water area is in the Multnomah Channel. Bathymetry data is not available for this area. Only a limited bml investigation of the Area 2 Dock has been performed. Surface sediments generally consist of silty sand with varying amounts of creosote wood debris.

Based on the presence of contamination in surface sediment and the hard compact nature of the mudflats with relatively steep slopes towards the channel, the Area 2 Dock shoreline appears to be relatively stable to eroding. Creosote-treated timber pilings, remnants of dock structures, define this area. The main stem of the Multnomah Channel is 100 to 150 feet offshore with a bottom elevation of approximately -15 feet NAVD88 immediately downstream.

2.2.4.3 Cove Area

Prior to development, the Cove Area consisted of a partially vegetated slough. The Cove Area was created between 1948 and 1953 through extensive dredging and filling of historical lowlands (see Figures 7, 8, and 9). The Cove Area is a depositional area, protected from erosional effects of large storm and tidal surges.

The elevation of the river bottom within the cove and shallow inlet immediately downriver of the peninsula ranges between approximately 0 and 10 feet NAVD88 within approximately 100 to 300 feet of the shoreline before sloping steeply towards the main channel of Scappoose Bay. The main channel of Scappoose Bay adjacent to the Cove Area widens to approximately 150 feet with bottom elevations between -7 and -5 feet NAVD88.

After operations ceased in 1960, deposition and burial of the old operational sediment surface occurred throughout the Cove Area. A sediment deposition rate of 0.2 to 1.4 in/yr is implied based on the presence of 1 to 7 feet of fine textured sediment above the old contaminated operational sediment surface characterized by creosote wood debris.

The buried layer of creosote wood debris is interpreted to be the former in-water surface during plant operation. The creosote wood debris ranges from 1 to 7 feet bml beneath much of the Cove Area. The thickness of the creosote wood debris progressively thins and diminishes in magnitude further from the shoreline.

Contaminated sediments in the Cove Area have been characterized to an approximate depth of -25 NAVD88 or about 25 feet bml. Sediments were characterized as silt. Basalt bedrock was encountered at various depths through the Cove Area. Cross-sections along transects A-A', D-D', F-F', and G-G' (see Figure 19 for cross-section locations) are included as Figures 20, 23, 25, and 26.

2.2.4.4 Upper Milton Creek

Upper Milton Creek's sediment profile consists of up to 1 foot of silty organic-rich material overlying a 1- to 6-foot layer of gray, stiff, clayey-sandy silt with gravel and cobbles. Scouring of the creek channel by seasonal runoff and tidal cycles limits accumulation of sediment in this portion of the creek. The shoreline is generally a relatively steep embankment covered with vegetation.

2.2.4.5 Stormwater

No stormwater management features were identified during a review of historical facility maps.

2.3 PLANT OPERATIONS

The Site was first developed for industrial purposes in 1912 when St. Helens Creosoting Company established a wood treating facility. A sawmill operated in the northeast portion of the Site from 1915 to the mid-1930s (see Figure 3B). Companies acquired by Pope and Talbot, Inc. purchased the property in 1938 and continued to operate the wood treating facility until 1960. The plant was dismantled in the fall of 1960. The Port of St. Helens (now the Port of Columbia County) purchased the property in 1963.

The Site was vacant between 1960 and 1974. Dredge material generated from deepening of the Columbia River was placed on the property in the early 1970s in an effort to level and raise the property's surface grade by several feet (see Figure 12). Since 1974, the Site has either been vacant or leased for the following industrial uses:

- Pole peeling and pole storage facility (1974 to 1991).
- Storage yard for a marine construction/dredging company (1993 to 1998).
- Small private wood-working business (2000 to 2005).
- Marine log salvage and sawmill (2006 to 2008).
- Log storage, pole peeling, and sawmill (2009 to 2012).
- Miscellaneous small-scale private businesses (2014 to present).

Figures showing facility features during different periods are included as Figures 4 through 16.

2.3.1 Physical Plant

While multiple companies have operated at the Site, there have been two primary physical plant layouts.

2.3.1.1 Wood-Treating Facility

The original wood-treating facility constructed in 1912 consisted of a creosote AST, pipeline, a retort/pump house, creosote retorts, transfer table, tram tracks, and dock. The mill consisted of a mill building, power house, and vent burner. By 1929 the wood-treating facility had expanded to include three large volume creosote ASTs, with removal of the original creosote AST, two fuel oil ASTs, a crane fuel AST, blacksmith/machine shop, boiler house, experimental kilns, hog fuel bin, conveyor and hopper, a barge house, and additional docks. An above and below ground pipeline conveyed creosote from the largest creosote AST to the eastern dock (Area 2 Dock). This facility configuration essentially remained until the plant was dismantled in 1960. Figures 3A and 3B shows historical features.

Creosote was delivered to the Site via ships which transferred their contents at the Area 2 dock. An aboveground pipeline pumped the creosote to a large AST from which creosote was pumped to several smaller ASTs. Open “process recovery tanks” collected condensed water from the Boulton treatment process. This process consists of enclosing wood in a treatment cylinder, introducing hot creosote or pentachlorophenol (PCP) solution and establishing a vacuum at 220°F in the cylinder. This process removes water from the wood as water vapor that is condensed outside the cylinder. The collected water then passed through a series of chambers with skimmers to recover any treatment solution with filtered process water discharging to Scappoose Bay (See Figure 3A). All other waste materials were recycled.

2.3.1.2 Post-Peeling Facility

An office and maintenance shop were built in 1974 or 1975 for the pole-peeling operation. Two underground storage tanks (USTs) and two waste oil ASTs were present. The 10,000-gallon diesel fuel UST and the 1,000-gallon gasoline UST were installed in 1975 adjacent to the maintenance shop building. Both USTs were decommissioned in-place in 1990. DEQ assigned UST Facility No. 5196 to the USTs. Figures 3A and 3B shows historical features.

2.3.2 Chemical Use and Waste Generation and Management

The follow section discusses the available information for the two primary operations that were present on the Site.

2.3.2.1 Wood-Treating Facility

Products that were treated included pilings, poles, cross arms, paving blocks, pipe and tank staves, structural timbers, and railroad cross ties. The primary wood-treating formula used was creosote. PCP was reportedly used in 1953 and 1954. Chromated copper arsenate, a wolmanizing salt, was reportedly used in 1953. No other information on chemical use and waste generation and management from the wood-treating facility has been located.

2.4 REGULATORY HISTORY

Investigations have been performed at the Site and adjacent in-water areas since 1988. The investigations are documented in the administrative file (ECSI No. 959). Information is also available online through DEQ's ECSI database.

2.4.1 Preliminary Assessment (1988) and Site Inspection (1990)

DEQ performed a Preliminary Assessment (PA) of the Site in 1988. The PA identified unanswered questions related to past site uses and disposal practices that may have impacts on sensitive environments and requested the U.S. Environmental Protection Agency (EPA) perform a Site Inspection.

E&E, on behalf of the EPA, performed a Site Inspection from July 1989 to May 1990. The Site Inspection was performed to further assess potential source areas, evaluate contaminant migration pathways and identify areas warranting additional investigation. E&E collected eight subsurface soil samples, one surface soil sample, three seep solid samples, four surface water samples, and five sediment samples. Additional samples were collected off-Site for background purposes. Sample locations are shown on Figure 32. Samples were analyzed for one or more of the following: volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), phenols, and metals.

PAHs associated with creosote were detected in subsurface soil, seep solid, sediment, and surface water samples collected at or immediately downgradient of the former wood treating facilities. PCP was detected in one subsurface soil sample collected near the former PCP and wolmanizing salts retorts.

2.4.2 Site Investigation (1993)

Harding Lawson Associates (HLA) performed a site investigation above the groundwater table from March to April 1993. The site investigation was performed to further assess potential source areas. HLA advanced 32 soil borings, the majority located in Area 1. A total of 51 subsurface soil samples, five surface soil sample, and one seep solid samples were analyzed. Sample locations are shown on Figure 32.

Samples were analyzed for contaminants including gasoline, diesel, heavy oil, VOCs, PAHs, and metals. Gasoline, diesel, heavy oil, VOCs, PAHs (mainly PAHs and PCP), and/or metals were detected in subsurface soil samples. The site investigation concluded the majority of contaminated soil is present in the vicinity of the former wood treating facilities and in the native soil located below the dredge fill material. Concentrations of arsenic were determined to be typical of background with the possible exception of arsenic detected in immediate vicinity of the former wood treatment building.

2.4.3 1995 Consent Order & 2008 Orphan Declaration

DEQ issued an Order on Consent (Consent Order) to Pope and Talbot, Inc. and the Port of St. Helens (now Port of Columbia County). The Consent Order required the parties to conduct a Remedial Investigation and prepare a Feasibility Study.

Pope and Talbot, Inc. declared bankruptcy in November 2007 and ceased performing work under the Consent Order. The Port of St. Helens ceased work shortly after due to financial constraints. DEQ declared the Site an Orphan on April 28, 2008. The Port of St. Helens later identified insurance policies and tendered claims to the insurance companies. The Port of St. Helens then continued the work required under the Consent Order. The insurance policies are expected to cover a portion of the selected remedial action but not the entire cost.

2.4.4 2000 Remedial Investigation

Investigations were performed at the Site in two phases between 1996 and 1998. This investigation included both Area 1 and Area 2. The results of the investigations are included in the April 7, 2000 Remedial Investigation report prepared by GeoEngineers, Inc. The investigations were performed to evaluate the nature, extent, and risk associated with historic releases of hazardous substances at the Site. A summary of samples collected, analysis performed, and matrices sampled throughout the remedial investigation period (1996 through 2017) is provided on Table 1.

2.4.4.1 Phase 1 Investigation (1996 to 1997)

The initial phase of investigation was performed between July 1996 and November 1997. The investigation consisted of upland soil and groundwater and in-water sediment and surface water immediately adjacent to the Site's shorelines. A total of 31 soil borings were advanced, generally until basalt bedrock was encountered, at the Site in July 1996. Monitoring wells were constructed in 22 of the soil borings. Boring and well locations are shown on Figure 32.

Groundwater elevation measurements were collected on a monthly basis with groundwater samples collected quarterly. Six groundwater monitoring events were performed during Phase 1.

Surface water (SW1 through SW4) and sediment samples (SHI01S, SHI01B through SHI12B) were collected adjacent to the Site in Milton Creek, Scappoose Bay, and Multnomah Channel in October and November 1996. Surface water and sediment sample locations are shown on Figure 32.

2.4.4.2 Phase 2 Investigation (1998)

Additional investigation of surface soil, subsurface soil, groundwater, riverbank seeps, surface water, and bedrock was performed in 1998. A total of 26 soil borings (GP1 through GP26) were advanced at the Site in September 1998. One additional monitoring well (MW-18) was constructed. Three borings (RCB-1, RCB-2, RCB-3) were advanced into the basalt to evaluate hydraulic characteristics of the basalt formation. Boring and well locations are shown on Figure 33.

Groundwater from monitoring wells, surface water (SW-MC1, SW-MC2, SW-SB1 through SW-SB7), and a surface soil sample (Bank1) near a seep were collected in September 1998. Seep water samples (Seep1, Seep2, Seep3) were collected in October 1998. Surface samples (SS1 through SS24) were also collected to evaluate the gravel roadways in October 1998. Soil sample and seep locations are shown on Figure 33.

2.4.4.3 Phase 1 & 2 Investigation Results

A visible creosote-petroleum product (NAPL) was observed in subsurface soil samples and in groundwater monitoring wells in Area 1 Upland. In borings completed within close proximity of the former wood-treating operations, creosote impacts were observed throughout the entire thickness of the native soil unit (depths ranging between about 5 to 18 feet bgs). The vertical thickness of creosote-impacted soil appears to decrease with distance from the wood treatment plant and ASTs.

All media samples were submitted for chemical analysis for one or more of the following contaminants of potential concern (COPC): total petroleum hydrocarbons (TPH); VOCs; SVOCs, chlorinated phenols; dioxins and furans; and select metals (arsenic, cadmium, chromium, copper, lead, and zinc). Sediment samples were also analyzed for grain size, sulfides, and total organic carbon (TOC). Bioassay tests were performed on two sediment samples.

In general, TPH, VOCs, and SVOCs associated with creosote were detected in groundwater samples obtained from monitoring wells and soil borings completed in the vicinity of the former wood treating operations. Benzene, toluene, ethylbenzene, and xylenes (BTEX) represents the majority of VOCs detected in groundwater samples. PAHs represent the majority of the SVOCs detected in groundwater samples. Relatively low levels of metals and chlorinated phenols were detected in Area 1 Upland groundwater samples.

During periods of low surface water, small, localized groundwater seeps have been observed along the steeper sections of the Scappoose Bay and Milton Creek shoreline adjacent to Area 1 Upland. Many of these seeps appear to daylight near the fill and native soil interface. Creosote-impacted seeps occasionally are accompanied by a sheen or visible NAPL, although at times the sheen has been a natural (organic) sheen not related to creosote. BTEX and PAHs were detected in October 1998 seep water samples obtained from the Scappoose Bay and Milton Creek shorelines.

Shallow sediment conditions (upper 10 centimeters) along the Area 1 Upland shoreline at the Site were explored by obtaining a series of discrete and composite sediment samples along eight transects and background locations. PAHs were detected in the sediment samples.

Subsequent investigations were conducted to further evaluate the nature and extent of contaminants in sediments in preparation for completion of human health and ecological risk assessments.

2.4.5 Interim Remedial Investigations (1999-2006)

This section discusses actions conducted after the data set collected for the 2000 Remedial Investigation report and before the start of the supplementation remedial investigation data collection.

Annual groundwater monitoring was conducted in 1999, 2000, 2001, 2003, 2004, 2005, and 2006. Groundwater samples were analyzed for TPH, BTEX, PAHs, and dissolved metals (arsenic, cadmium, chromium, copper, lead, and zinc).

Sediment sampling was completed in 2003 (SD-100 through SD-120 and SD-BG-01 through SD-BG05), 2004 (SD-103, SD-104, SD-105, SD-112, SD-117, SD-119, SD-121 to SD-124, SD-MC-A through SD-MC-E), and 2005 (SD-125 through SD-141) as part of an ecological risk assessment (ERA). Offshore surface sediment samples obtained adjacent to the Site and from background locations were analyzed for one or more of the following constituents: PAHs, arsenic, dioxin and furans, TOC, total sulfides, ammonia, grain size distribution, and bioassay testing. Sample locations are shown on Figure 32.

A baseline human health risk assessment (HHRA) and ERA was completed in 2006. The results of the HHRA and ERA are discussed in Sections 3.2.3 and 3.2.4, respectively.

2.4.6 Supplemental Remedial Investigation (2010 – 2018)

The 2000 Remedial Investigation Report presented data collected at the Site through 1998. The initial phases of the remedial investigation were focused on the upland portions of the Site, with only limited characterization of surface water and surface sediment along its 4,500 linear feet of shoreline of Milton Creek, Scappoose Bay, and the Multnomah Channel. Unlike the site-wide assessment described in the 2000 Remedial Investigation Report, the supplemental remedial investigation findings are focused on the Area 1 Upland, offshore areas adjacent to Area 1 within Milton Creek and Scappoose Bay, and the offshore area adjacent to Area 2 within Multnomah Channel near the terminus of the former creosote pipeline and residual pilings associated with a historical dock. Multiple investigations were performed between 2010 through 2018 as part of the supplemental remedial investigation. The actions performed are summarized below. Sample locations are shown on Figure 33.

2.4.6.1 Investigations Performed

Quarterly groundwater monitoring of Area 1 wells was performed between September 2010 and August 2012. Groundwater samples were analyzed for TPH, BTEX, PAHs, and dissolved metals.

Multiple phases of shoreline inspections were conducted during low water conditions (generally in late September and early October) in 2010, 2011, 2012, 2017, and 2018 to designate specific areas where NAPL (i.e., creosote sheen, product, and/or tar body) was observed in near-surface sediment, and to refine the locations and boundaries of visible creosote-impacted groundwater seeps in the bank. Surface sediment samples were collected at areas of obvious or suspected creosote impact and were analyzed for TOC, TPH, PAHs, VOCs, extractable petroleum hydrocarbon (EPH) and volatile petroleum hydrocarbon (VPH) constituents, and total metals (arsenic, cadmium, chromium, copper, lead, and zinc).

Two phases of upland and offshore NAPL delineation were conducted in 2010 and 2011. The initial delineation in 2010, generally consisted of soil boring equipment equipped with TarGOST® laser-induced fluorescence technology. The second delineation effort consisted of direct observations of sampling cores and sediment, soil, and basalt sample collection for analysis from borings. Soil samples were submitted for TPH and PAHs analysis. Sediment samples were analyzed for TPH, PAHs, TOC, and grain size.

Additional monitoring wells (MW-2A, MW-19, MW-20, MW-21, MW-22, MW-23, MW-24, and MW-25) were installed in 2011 within Area 1 Upland to better delineate the upland extent of creosote NAPL. Groundwater monitoring was performed in July 2011.

In 2012, sediment and porewater sampling was conducted adjacent to Area 1 in Scappoose Bay and Milton Creek to assess the bioavailable or bioaccessible concentrations of PAHs associated with creosote within and near the base of the benthic (biologically active) sediment environment.

To evaluate potential temporal variability resulting from changes in river stage and groundwater elevation, porewater sampling was conducted in July 2012 (high river stage and high groundwater elevation) and October 2012 (low river stage and low groundwater elevation). Whole or bulk sediment samples were analyzed for 18 parent PAH compounds and 16 groups of alkylated PAH homologues, TOC, and black carbon. Sediment porewater samples were analyzed for 34 PAHs (parent and alkylated PAHs)

In August 2013, the dilapidated wooden deck of the former transfer table dock was removed to facilitate the October 2013 delineation of creosote-related contamination within the underlying nearshore soil and sediment. Soil and sediment samples from varying depths (dependent upon field observations) were visually screened for creosote NAPL and submitted for TPH and PAHs analysis.

A phased offshore data gap investigation consisting of a high-accuracy bathymetric survey, offshore groundwater discharge survey, sheen mapping in surface sediment, and in situ porewater and surface water passive sampling was completed between April 2017 and November 2018, to further assess the offshore extent of creosote NAPL and the risks that bioavailable fractions of PAHs and TPH pose to aquatic invertebrate receptors outside the inferred NAPL areas. Surface sediment samples were analyzed for 34 PAHs, VPH, EPH, VOCs, TOC, and black carbon. Time integrated (20 days) surface water (1 foot above mudline) and sediment porewater (two depth intervals of 3 to 8 inches and 24 to 29 inches bml) were sampled using passive sampling devices and analyzed for freely dissolved PAHs (34 and 63 compounds), VPH, oxygenated PAHs (OPAHs), and hopane and cholestane compounds.

2.4.6.2 Investigation Results

The conceptual site model (CSM) was refined to better account for offshore sediment contamination (particularly NAPL along the Site's shorelines), as well as upland NAPL migration and dissolved-phase contaminant transport. A schematic CSM is included as Figure 34.

The lateral and vertical extent of NAPL in offshore sediment adjacent to the Site was defined. Wood debris in surface sediment along 700 feet of the Area 1 shoreline is a source of NAPL beneath the former hog fuel dock and transfer table dock structures and extends approximately 75 feet offshore. The creosote contaminated wood debris beneath the former transfer table dock extends approximately 200 feet offshore.

Although upland groundwater discharges to sediment porewater and surface water within Milton Creek and Scappoose Bay, the risk to human health and ecological receptors from dissolved-phase constituents transported via groundwater appears to be low outside the observed areas of direct NAPL seepage.

The updated supplemental HHRA indicated low potential risk to human receptors other than direct contact with NAPL and Area 1 groundwater by excavation workers and direct contact with NAPL by shoreline anglers and/or transients.

The updated supplemental ERA indicates that the presence of creosote NAPL (inclusive of moderate to heavy petroleum sheen) presents unacceptable ecological risk to benthic invertebrates and fish where it is observed in surface sediment. In general, the 2017 surface sediment porewater sampling indicated dissolved-phase constituents in deeper sediment and/or upland groundwater do not adversely impact benthic invertebrates outside the prior remedial action areas.

The hot spot evaluation indicated that groundwater and sediment within the delineated extent of NAPL and NAPL-affected groundwater seeps are hot spots in accordance with DEQ guidance. Dissolved-phase creosote constituents in porewater and surface water that cause unacceptable risk to benthos and fish are also potential hot spots.

3. RESULTS OF INVESTIGATION(S)

3.1 NATURE AND EXTENT OF CONTAMINATION

As summarized previously, investigations of the Site commenced in 1988 and continued through 2018. While the early investigations (e.g., 1988 PA, 1990 Site Inspection, 1993 Site Investigation, 2000 Remedial Investigation) included sampling in the entire Upland Area, the Supplemental Remedial Investigation focused primarily on Area 1 Upland, offshore areas adjacent to Area 1 within Milton Creek and Scappoose Bay, and the offshore area adjacent to Area 2 within Multnomah Channel near the terminus of the former creosote pipeline and residual pilings associated with a historical dock. The results of the Supplemental Remedial Investigation included the identification of five PAAs by contaminants including creosote (TPH) and PAHs. The nature and extent of contaminants are summarized below.

The Locality of Facility (LOF) is defined as any point where a human or ecologic receptor contacts or is reasonably likely to come into contact with contaminants from the Site. The LOF takes into account the likelihood of the contaminants migrating over time. For the purpose of this ROD, the LOF is the soil and shallow water-bearing zone above Basalt Bedrock within Area 1 Upland and portions of sediment and surface water in Milton Creek and Scappoose Bay. The extent of the LOF is shown on Figure 2.

3.1.1 Non-Aqueous Phase Liquid

Creosote NAPL has been encountered in soil, groundwater, groundwater seeps, and sediment at the Site. The NAPL composition is dominated by diesel- and oil-range hydrocarbons (although chromatograms do not match a diesel or oil fingerprint) and PAHs (naphthalene, phenanthrene, 2-methylnaphthalene, and others). The majority of creosote NAPL appears to have been trapped by capillary forces within the native soil before reaching the basalt bedrock. The total thickness of creosote impact varies from 1 to 8 feet, and the impacted intervals typically occur at depths greater than 10 feet bgs (below the Fill Zone). The estimated lateral extent of NAPL and creosote sheens are shown on Figures 35, 36, and 37.

3.1.1.1 Area 1 Upland Non-Aqueous Phase Liquid

The Area 1 Upland extent of NAPL, although not continuous throughout, has been generally defined within an approximately 4-acre area. The distribution of NAPL beneath the former operations area appears to be a function of subsurface migration from the former creosote storage tanks, plant, and retorts as well as direct releases from other ancillary operations (e.g., the transfer table).

Potentially mobile creosote is present in the native soil at various depths below the fill and above the basalt bedrock and within distinct stratigraphic layers that are less than 18 inches thick. The total thickness of creosote varies from 1 to 8 feet. In general, this vertical layering or profile of NAPL becomes thinner and deeper within the native soil farther from the former operations area at depths greater than 10 feet bgs.

The inferred extent of NAPL indicates that topographical highs on the basalt surface, such as the ridge to the east of the former operations area along the Scappoose Bay shoreline, appear to influence the subsurface distribution of NAPL. The bedrock appears to be a barrier to downward vertical migration of the NAPL.

3.1.1.2 Area 1 Dock Non-Aqueous Phase Liquid

Between the former hog fuel dock and northeastern (downriver) terminus of the former transfer table dock (Area 1 Dock), discontinuous, isolated pockets of creosote NAPL have been observed in many locations at or near the sediment surface.

The source of sediment contamination is creosote contaminated and/or treated wood debris. This debris differs in character from debris found in the Cove Area. Much of the wood debris is finer textured and is described as "pulverized wood" in sediment sampling logs. The pulverized wood is interpreted to be hog fuel (i.e., wood shavings/chips) likely spilled from the hog fuel conveyor and during over-water transfers from ships/barges to the hog fuel hopper and conveyor system. Some of this material appears to have become saturated with creosote and accumulated along the shoreline and in sediment surrounding, and downstream of, the former hog fuel dock.

Additionally, some of the contaminated wood debris appears to be related to deterioration of the creosote-treated dock structures (i.e., timber piles, lateral bracing, decking) that existed along this portion of the Area 1 shoreline. The distribution and thickness of the woody debris is highly variable in this portion of the Site, ranging from completely absent to more than 11 feet thick (sediment boring SB-16). The lateral extent of surface sediment and/or wood debris capable of producing a creosote-related sheen on the overlying water surface when disturbed extends approximately 75 feet offshore between the former hog fuel dock and transfer table dock structure.

Within the western half of the primary wood dock structure of the former transfer table, thick sequences of contaminated wood debris are intermingled with dimensional lumber, logs, metal ties, and other debris. Heavy sheens are easily generated by disturbing the surface sediment around many of the remaining log pilings.

Creosote NAPL associated with wood debris was primarily observed in the upper 24 inches of sediment within the central and western portions of the former transfer table dock area. Deposited wood and creosote-related contamination were observed from the surface to approximately 9 feet bml in the far western portion of the former transfer table dock. In general, the thickness of the wood mass decreased to the northeast away from the southwest area of the former transfer table dock and is not present in significant thickness to the north of boring DAI-HA-02 or to the east of location DAI-PH-11. The lateral extent of surface sediment creosote contaminated wood debris extends approximately 200 feet offshore within the footprint of the former transfer table dock.

An upland and slightly in-water area of subsurface creosote staining and isolated blebs of NAPL were encountered in the native soil beneath the northwest corner of the former transfer table dock. Creosote impacted soil with residual NAPL decreases in thickness and is encountered at deeper intervals within the native soil as distance increases in all directions from the northwest corner of the former transfer table dock. This corner of the former transfer table dock is covered by recently deposited sand (natural deposition) and there is no visible surface evidence of impacted groundwater seeps from this upland area of NAPL.

3.1.1.3 Area 2 Dock NAPL

In October 2017, DEQ staff inspected the Area 2 shoreline and observed creosote-impacted surface sediment near the terminus of the former creosote pipeline and residual piling associated with a historical dock (Area 2 Dock). Creosote sheen occurrence was mapped in surface sediment along the approximately 900-foot-long portion of the Scappoose Bay shoreline. Moderate to heavy petroleum sheens were noted only in borings amongst the pilings near the shoreline that encountered creosote-contaminated wood debris within the upper 12 inches of sediment. Sediment poling beyond 50 feet of the shoreline (even amongst the pilings), did not produce a visible sheen. The lateral extent of creosote contaminated wood debris covers an approximately 200-foot-long by 50-foot-wide section (0.2 acre) of the Area 2 shoreline beneath and immediately downriver of the former dock and creosote AST.

3.1.1.4 Cove Area NAPL

Creosote and fuel oil ASTs were immediately upland of the Cove Area and a hog fuel boiler and pole peeling station operated along the shoreline. Based on historical photographs and information on plant operations and its subsequent demolition, significant amounts of creosote contaminated hog fuel, tree bark, and dimensional lumber appear to have accumulated in the Cove Area. NAPL has migrated from these upland source areas into approximately 0.8 acre of the Cove Area.

Heavy petroleum sheens are visible in seasonal groundwater seeps along a 300-foot section of bank seepage west of the peninsula. Near-shore Cove Area borings typically encountered 6 to 8 feet of NAPL impacted sediment, with a maximum thickness of 12 feet observed in SB-11. The near-shore presence of moderate to heavy petroleum sheens in surface sediment appears to be related to the NAPL/groundwater seeps, the presence of creosote-treated wood debris, and gas ebullition resulting from biodegradation of organic matter in deeper sediments.

Moderate to heavy petroleum sheens have been detected in subsurface sediment up to 220 feet offshore beneath the Cove Area (borings SB-04 and SB-09). In general, creosote-impacted sediment decreases in thickness and is encountered at deeper intervals within the Cove Area as distance increases from the shoreline. Outside the inferred extent of upland NAPL, the vertical mobilization of sheen via ebullition has not been observed in the Cove Area.

Riverward of the solid red NAPL boundary depicted on Figure 37, the source of subsurface sediment contamination transitions to creosote contaminated wood debris. This buried layer of creosote wood debris is interpreted to be the old in-water operational surface while the plant was active and during its demolition. Creosote-impacted wood debris ranges from 1 to 7 feet bml beneath much of the Cove Area, and progressively thins and diminishes in magnitude outward from the shoreline. Vertically, contaminant levels attenuate rapidly within the sediment stratigraphic layers. Sediment within the western portion of the Cove Area is generally unimpacted by upland NAPL migration and/or creosote contaminated wood debris.

Light or slight petroleum sheens have been intermittently observed in the relatively clean, more recently deposited surface sediment beyond the solid NAPL boundary depicted on Figure 37. Based on the results of bulk sediment and depth-discrete porewater sampling, these slight surficial sheens appear to be attributed to localized particles of creosote-treated wood debris in the surface sediment and do not appear to be attributed to NAPL migration from the underlying sediment.

3.1.1.5 Upper Milton Creek Area NAPL

Groundwater seepage with a creosote-related sheen has been observed along a 200-foot section of the east bank of the Upper Milton Creek and analytical results of bank samples indicate contact with NAPL. The Upper Milton Creek in-water area is located over 350 feet west of any known historical wood-treating features and/or operations. Field evidence of NAPL was generally not observed in borings.

The primary sources of contamination to the Upper Milton Creek in-water area are heavy petroleum sheens seeping from a relatively thin (1-foot-thick or less) sand layer situated at an approximate depth of 19 to 20 feet below the top of the bank. Biogenic sheens also seep from the eastern bank of Milton Creek and are intermingled with petroleum sheens. The platy relatively odorless biogenic sheens, which are easily distinguished from the fluid, odoriferous creosote related petroleum sheens likely emanate from areas where upland creosote contamination and wood debris is more completely degraded.

3.1.2 Groundwater

Groundwater monitoring has been performed frequently enough to provide understanding of groundwater conditions. Residual NAPL continues to be a source for dissolved-phase creosote-related constituents in shallow groundwater beneath the Site. The extent of PAH and TPH groundwater contamination is shown on Figures 38 and 39, respectively.

The highest concentrations of PAHs and TPH in groundwater were generally detected in monitoring wells MW 22, MW-2A, and MW-3A, within the inferred NAPL area, followed by detections in wells at the southeastern and northeastern edges (MW-23, MW-24, and MW-25) of the former wood treating operations area. Detections of PAHs were generally lower in wells to the west of and outside of the inferred upland NAPL area and in wells at the far eastern edge of Area 1. Analytical results from groundwater samples collected during the supplemental remedial investigation are representative of current Site conditions and are summarized below.

Total PAHs were detected in groundwater samples collected within or near the former operations area, with a similar distribution of relative concentrations as TPH. Total PAHs detected in groundwater ranged in concentration from 0.35 micrograms per liter (µg/L) at well MW-18 to a maximum of approximately 26,800 µg/L at well MW-3A in 2010; NAPL was also detected at MW-3A during the 2010 monitoring event. The maximum total PAHs in groundwater in 2011/2012 was approximately 22,500 µg/L in well MW-22.

Petroleum hydrocarbons indicative of creosote were detected in groundwater samples collected within or near the former operations area. TPH detections were primarily in the diesel range. The maximum diesel-range hydrocarbon concentration was detected in well MW-3A at 374 milligrams per liter (mg/L) in 2010. NAPL was also detected at MW-3A and sampled during the 2010 monitoring event. The maximum diesel-range hydrocarbon concentration in 2011/2012 was 116 mg/L at MW-3A. The maximum concentration of TPH in the oil range was 103 mg/L at MW-3A in 2010; the maximum oil-range hydrocarbon concentration in 2011/2012 was 3.81 mg/L at MW-2A.

Metals detected in groundwater were arsenic, chromium, copper, lead, and zinc. The distribution of metal detections does not generally correlate with NAPL or the former wood treating operations area. Arsenic was detected in every well sampled at concentrations up to 17.5 µg/L at MW-23. Chromium was detected infrequently just above reporting limits in MW-3B and MW-5, and at slightly higher concentrations (maximum of 5.83 µg/L) at MW-2A. Copper was detected at MW-5 at a maximum concentration of 18.5 µg/L; the only other detection of copper was just above the reporting limit at MW-4B. Lead was detected infrequently in wells MW-3B, MW-5, and MW-9, at levels up to 3.48 µg/L. The maximum zinc detection, 683 µg/L, was at MW-20 in 2011; other detections at MW-20 were below 10 µg/L. Well MW-5, located near the northern property boundary, has had consistent detections above 200 µg/L. All other zinc concentrations were below 200 µg/L, with most below 10 µg/L.

3.1.3 Soil

The fill and native soil contact generally represents the original ground surface at the time of wood-treating facility operation. This results in the creosote-impacted soil in the vicinity of the former wood-treating facilities being generally limited to the native soil unit, located beneath 5 to 10 feet of dredge sand fill. In borings completed in close proximity to the former wood-treating plant and former creosote ASTs, varying degrees of creosote impact have been observed throughout the entire thickness of the native soil unit with depths ranging between about 5 feet to approximately 23 feet bgs at the basalt bedrock contact. In general, creosote-impacted soil decreases in vertical thickness and is encountered at deeper intervals within the native soil stratum as distance increases from the former wood-treating operations.

Creosote-related hydrocarbons (diesel and oil ranges) were detected in soil samples collected from 19 of 28 explorations completed in Area 1, with a maximum concentration of 6,320 mg/kg (sum of diesel- and oil-range hydrocarbons) in the MW-24 boring. Concentrations of total PAHs in soil ranged from not detected to a maximum of 3,410 milligrams per kilogram (mg/kg) in boring MW-24.

3.1.4 Sediment

The in-water areas were divided into multiple areas during the remedial investigations. However, this ROD focuses on the four in-water PAAs (Area 1 Dock, Area 2 Dock, Cove Area, and Upper Milton Creek). Since the 2000 remedial investigation report, over three hundred additional sediment samples from the Scappoose Bay and Milton Creek shorelines along Area 1 have been analyzed for PAHs, TPH, VPH/EPH, VOCs, TOC, and/or black carbon. Additionally, subsurface information was obtained via the 67 borings and depth discrete sampling, various sediment sampling events, and multiple shoreline inspections. Analytical results from sediments samples collected during the supplemental remedial investigation are representative of current Site conditions and are summarized below. Sample locations are shown on Figures 32 and 33.

Petroleum hydrocarbons were detected in sediment samples collected along the Scappoose Bay shoreline. These were primarily diesel-range hydrocarbons with some oil-range hydrocarbon detections. A maximum of 14,000 mg/kg of diesel-range hydrocarbons was detected in sample SB-11 at 4 feet bml. Sample SB-11 was located within the estimated NAPL extent just west of the peninsula.

Total PAHs in the 2011 to 2013 surface sediment samples ranged from not detected to a maximum of approximately 4,800 mg/kg in SSED-6 located east of the former hog fuel dock within an area of creosote wood debris. Total PAHs in the 2017 surface sediment samples, all obtained outside inferred NAPL areas, ranged from 1.58 mg/kg (PWS-090517-6) to 53.54 mg/kg (PWS-090517-9). As stated above, the highest relative total PAH concentrations were found within the old buried operational surface and/or within the inferred areas of offshore NAPL.

TOC concentrations in surface sediment samples ranged from 520 mg/kg at SB-23 to 150,000 mg/kg at SSED-6. These locations were east of the former hog fuel dock and within 25 feet of each other. The average TOC concentration was approximately 21,000 mg/kg. TOC content varied across the investigated area, and there does not appear to be a discernable pattern of high or low concentrations by locality. In general, samples with higher TOC were observed to contain wood debris, including wood chips, sticks, and roots.

The percentage of black carbon in surface sediment samples ranged from 0.10 to 0.34 (with the exception of one location at which black carbon was not detected), with an average of 0.18 percent (%) black carbon. Similar to TOC, black carbon content varied across the investigated area with no discernable pattern of high or low concentrations by locality.

As expected, the highest concentrations of PAHs in sediment occurred within the area of the inferred extent of NAPL, although NAPL was not observed in all samples collected within this area. Although TPH was not tested in sediment as frequently as PAHs, the highest TPH detections were also observed within the inferred extent of offshore NAPL.

3.1.5 Sediment Porewater

Sediment porewater samples were only collected during the supplemental remedial investigation. The majority of porewater samples were collected outside of the offshore inferred NAPL areas or outside of the in-water PAAs.

All sediment porewater concentrations reported from the ex-situ Solid-Phase Microextraction (SPME) and in-situ low density polyethylene (LDPE) passive samplers, are freely dissolved water concentrations (C_{free}). In accordance with EPA guidelines, the direct measurements of the freely dissolved 34 PAH concentrations in sediment porewater or interstitial water (IW) are used along with their expected final chronic value (FCV) water/lipid partitioning behavior to calculate a hazard quotient, referred to as a toxic unit (TU). The narcosis based Tus are considered additive, and evaluation of the sum of the Tus requires that all 34 PAH analytes be included in the sum of IW TU (ΣIWTU). Calculations of ΣIWTU have been used on this project as a benchmark for predicting the toxicity of PAHs to benthic invertebrates with a potential for unacceptable risk when the ΣIWTU is greater than or equal to (≥) 1.

The results of depth-discrete porewater sampling were used to evaluate dissolved phased mass flux from deeper impacted sediment. In general, detected concentrations of dissolved PAHs in "deep" sediment porewater beneath the biologically active zone (i.e., 24 to 29 inches bml) were higher than those measured in the overlying "shallow" sediment and surface water. Porewater sampling conducted beyond the delineated areas of NAPL indicate that creosote constituents attenuate rapidly in the sediment pore space between 2 and 1 foot bml.

3.1.6 Surface Water

Surface water analytical results from 2017 are representative of current Site conditions and were used to determine nature and extent. Low levels of C_{free} PAHs were detected in all eight 2017 surface water samples. Total PAHs measured on the in-situ LDPE passive samples after 20 days in surface water ranged from 0.0192 µg/L (surface water sample co-located with PWS-090517-3) to 0.0797 µg/L (surface water sample co-located with PWS-090517-10).

The 18 parent PAH and 16 alkylated PAH homologue compounds (34 PAHs) results in surface water were compared to the FCVs and their corresponding Tus summed (ΣSWTU). Surface water samples co-located with PWS-090917-9, PWS-090517-10, PWS-090617-12, and PWS-090617-13 produced a sum of surface water toxic unit (ΣSWTU) ≥ 1.

In general, 34 PAH levels in the 2017 surface water samples were either consistent or slightly higher than detected concentrations in co-located shallow sediment porewater. The two notable exceptions to this data trend are PWS-090617-2 and PWS-090617-12 (located in Lower Milton Creek and the Area 1 Dock, respectively), where detected concentrations of PAHs in shallow porewater are higher than levels measured in the overlying surface water samples.

3.1.7 Air

Airborne dust transport is not a likely significant contaminant migration pathway. The original ground surface at the time the former wood-treating facility operated is currently located beneath 5 to 10 feet of non-contaminated dredge sand fill.

Gravel roads built atop the clean fill (at current ground surface) reportedly had oil applied to them between 1974 and 1991 for dust suppression. PCBs were detected in surface soil samples collected from former oiled gravel roadbeds at the Site.

3.2 RISK ASSESSEMENT

The standards for a protective cleanup are defined in the ORS and OAR. ORS 465.315 sets standards for degree of cleanup required, risk protocol, hot spots of contamination, etcetera (etc.). OAR 340-122-0084 describes the requirements for risk assessments while OAR 340-122-0115 provides additional definition of protectiveness.

Baseline risk assessments were initially conducted in 2006 to evaluate risks to human health and ecological receptors. The results of the baseline risk assessments are summarized in the Baseline Human Health Risk Assessment (Bridgewater Group and Kennedy/Jenks Consultants, 2006a) and the Baseline Ecological Risk Assessment Summary Report (Bridgewater Group and Kennedy/Jenks Consultants, 2006b). Updated supplemental HHRA and ERAs, incorporating new data as well as additional exposure scenarios, were completed in 2020 and are summarized in Appendices F and G of the Updated Supplemental Remedial Investigation Report, respectively (Cascadia Associates, 2020a; Cascadia Associates, 2020b).

The results of the risk assessments that have been conducted for human health and ecological receptors at the former Pope & Talbot site are summarized below. The residual risk associated with the selected remedy is summarized in Section 10.2.

3.2.1 Conceptual Site Model

This ROD addresses contamination in Area 1 Upland as well as within the nearshore sediment areas adjacent to the Site within Scappoose Bay and Milton Creek. The primary source of contamination at the Site is releases from historical industrial activities during plant operation (see Section 2.3). As discussed in Section 3.1, creosote is the primary contaminant in soil, groundwater, and sediment samples collected in the vicinity of the former wood-treating facilities. During plant operations, leaks and spills of creosote NAPL seeped into the ground and collected in the native soil above the basalt bedrock within an approximately 4-acre portion of the Area 1 Upland. A schematic of the CSM is shown on Figure 39.

Creosote is a multi-component NAPL that contains many hydrocarbons, primarily PAHs, phenolic compounds, and carrier fluids such as diesel. In the approximately 60 years since the plant closure, subsurface creosote (either as free phase NAPL, sorbed onto solids, or dissolved in water) appears to have undergone compositional changes due to weathering (e.g., loss of more soluble or biodegradable components). Subsequently, residual Site contamination consists predominantly of creosote-derived PAHs (i.e., no light NAPL or evidence of carrier fluids).

Another significant source of in-water impacts is residual creosote-contaminated wood debris from historical operations and historical infrastructure (timber piling and dock structures). Much of this wood debris appears to have been shed from the upland, over-water operations, and/or from log rafts historically moored along the shoreline. The woody material, much of it saturated with creosote, settled out over time and eventually was incorporated into the offshore sediment profile. In general, Site use and tenant activities since the wood treating operations ceased in 1959 do not appear to have significantly caused or contributed to the contamination levels encountered during recent investigations.

Current contamination sources in the upland include contaminated groundwater and soil. Volatile compounds in groundwater have the potential to volatilize into indoor and outdoor air. Contaminated groundwater has the potential to migrate to surface water, sediment, sediment porewater, and surface water in the in-water area. Current contamination sources in the in-water area include sediment/beach soil and contaminated woody debris.

The **CSM for evaluation of human health risks** is summarized in Figure 40. The following human health exposure scenarios are considered potentially complete for the Site:

- Industrial workers through ingesting and coming into direct contact with upland surface soil; inhaling contaminants volatilized from upland surface and subsurface soil; ingesting upland surface soil; and inhaling contaminants volatilized from upland groundwater.

- Excavation workers through ingesting and coming into direct contact with upland surface and subsurface soil; inhaling contaminants volatilized from upland surface and subsurface soil; ingesting upland surface and subsurface soil; and direct contact with upland groundwater.

- Construction workers through ingesting and coming into direct contact with upland surface and subsurface soil; inhaling contaminants volatilized from upland surface and subsurface soil; ingesting upland surface and subsurface soil; and direct contact with upland groundwater.

- Sport fishers through ingesting fish and shellfish impacted by contaminants bioaccumulated from surface water; ingesting and coming into direct contact with beach soil/sediment; inhaling contaminants volatilized from beach soil/sediment; and ingesting surface water.

- Subsistence fishers through ingesting fish and shellfish impacted by contaminants bioaccumulated from surface water; ingesting and coming into direct contact with beach soil/sediment; inhaling contaminants volatilized from beach soil/sediment; and ingesting surface water.

- Recreational trespassers, transients, and adult boaters through ingesting and coming into direct contact with beach soil/sediment; inhaling contaminants volatilized from beach soil/sediment; coming into direct contact with surface water; ingesting surface water; and coming into direct contact with sediment/sediment porewater.

The **CSM for evaluation of ecological risks** is summarized in Figure 41.

The following **terrestrial** ecological exposure scenarios are considered complete or potentially complete for the Site:

- Upland plants through direct contact with upland surface and subsurface soil.

- Soil invertebrates through ingestion of and direct contact with upland surface and subsurface soil.

- Herbivorous birds and mammals through ingestion of and direct contact with upland surface and subsurface soil; ingestion of upland biota; ingestion of and direct contact with beach soil/near-shore sediment; and ingestion of and direct contact with surface water.

- Insectivorous birds and mammals through ingestion of and direct contact with upland surface and subsurface soil; ingestion of upland biota; ingestion of and direct contact with beach soil/near-shore sediment; and ingestion of and direct contact with surface water.

- Carnivorous birds and mammals through ingestion of and direct contact with upland surface and subsurface soil; ingestion of upland biota; ingestion of and direct contact with beach soil/near-shore sediment; and ingestion of and direct contact with surface water.

The following **aquatic** ecological exposure scenarios are considered complete or potentially complete for the Site:

- Wetland and aquatic plants through direct contact with beach soil/near-shore sediment, offshore sediment, sediment porewater, and surface water.

- Benthic invertebrates through ingestion of and direct contact with beach soil/near-shore sediment, offshore sediment, and surface water; direct contact with sediment porewater; and ingestion of aquatic biota.

- Fish, through ingestion of and direct contact with beach soil/near-shore sediment, offshore sediment, and surface water; direct contact with sediment porewater; and ingestion of aquatic biota.

- Insectivorous birds, through ingestion of and direct contact with upland surface soil, beach soil/near-shore sediment, and surface water; and ingestion of upland and aquatic biota.

- Piscivorous mammals and birds through ingestion of and direct contact with upland surface and subsurface soil; ingestion of upland biota; ingestion of and direct contact with beach soil/near-shore sediment, ingestion of and direct contact with surface water; and ingestion of aquatic biota.

3.2.2 Human Health Risk Screening

The HHRA evaluated PAHs, TPH, select VOCs, select metals, PCBs in soil, and dioxins and furans in sediment, as requested by DEQ (Cascadia Associates, 2020a). The constituent classes evaluated in the human health risk screening for each environmental medium are summarized below:

Air. No air data have been evaluated from the Site.

Sediment inside the area of inferred NAPL. The Updated Supplemental HHRA does not evaluate data from sediment samples collected within areas of inferred NAPL because exposure to NAPL is considered to have unacceptable risk and therefore does not require further evaluation.

Sediment outside the area of inferred NAPL. PAHs, TPH, and dioxins and furans were evaluated. The 2006 HHRA evaluated discrete and composite sample results collected in 1996, as well as a small number of samples collected in 2005, but it excluded multiple sediment samples collected in 2003 and 2004. Therefore, DEQ determined that a comprehensive quantitative assessment of all available sediment data was appropriate in the supplemental HHRA (DEQ, 2014a).

Soil. To adequately reflect current risk assessment guidance, risk from PCBs in upland soil was re-evaluated in the supplemental HHRA using current risk-based criteria (DEQ, 2010) for all Site receptors (industrial worker, excavation worker, and construction worker). Per DEQ's request, risk from select COPCs to construction workers was also reassessed.

Sediment Porewater. Human receptors are not exposed to sediment porewater as a separate media and a separate evaluation of porewater was not conducted (DEQ, 2014b), except to compare porewater concentrations to screening levels values (SLVs) protective of people consuming fish that have accumulated Site-related chemicals.

Surface Water. Eight surface water samples were collected concurrently with porewater samples in 2017 and analyzed for 34 PAHs. These concentrations were screened against Preliminary Remediation Goals (PRGs), as shown in Table F-2E of the Supplemental HHRA (Cascadia Associates, 2020a). Surface water samples were also evaluated for protection of people consuming fish from carcinogenic PAHs by comparing them to the same Site-specific SLVs as for porewater.

Groundwater. The 2006 HHRA evaluated groundwater data collected between 1996 and 2004 and concluded that the potential exposure scenario of groundwater exposure by an excavation worker resulted in risk estimates exceeding DEQ acceptable risk levels. PAHs were therefore retained as a COC in groundwater based on the findings of the 2006 HHRA (Bridgewater Group and Kennedy/Jenks Consultants, 2006a). The Updated Supplemental HHRA evaluated all groundwater data collected from Area 1 Upland between 2005 and 2012, including those collected from monitoring wells within the inferred extent of subsurface NAPL. Monitoring well locations and inferred extent of subsurface NAPL are shown on Figure 39. Groundwater from Area 2 Upland was not evaluated because this portion of the Site received an NFA determination from DEQ in 2008.

The 2020 Supplemental HHRA evaluated risks associated with PAHs, TPH, BTEX, and select metals (arsenic, cadmium, chromium, lead, and zinc) in groundwater.

3.2.3 Human Health Risk Assessment

The 2006 Baseline HHRA and 2020 Supplemental HHRA (Bridgewater Group and Kennedy/Jenks Consultants, 2006a; Cascadia Associates, 2020a) describe in detail the procedures used to evaluate the potential risks to human health associated with the chemicals in the media described above. The findings of the HHRAs are summarized below.

Chemicals of Potential Concern.

The HHRAs identified the following COPCs for each of the contaminated media on the Site:

Sediment. All PAHs, TPH, and dioxins and furans detected in sediment were retained as sediment COPCs.

Soil. COPCs from the 2006 HHRA were retained as COPCs in the Updated HHRA (acenaphthene, methylene chloride, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, indeno(1,2,3-cd)pyrene, 2-methylnaphthalene, fluoranthene, fluorene, naphthalene, phenanthrene, pyrene, PCP, arsenic, and lead). A full list of selection criteria for COPCs is provided in Table 1 of the Baseline HHRA (Bridgewater Group and Kennedy/Jenks Consultants, 2006a). PCBs were also retained as COPCs in soil in the Supplemental HHRA.

Surface Water. PAHs were retained as surface water COPCs.

Groundwater. The selection of groundwater COPCs from the supplemental HHRA is illustrated in Table F-1 of the Supplemental HHRA (Cascadia Associates, 2020a). Eleven PAHs and TPH were retained as groundwater COPCs. No metals or VOCs were retained as groundwater COPCs.

Pathway Analysis. The Baseline HHRA identified the following primary human health exposure pathway of concern: potential future on-site excavation workers exposed to PAHs in contaminated groundwater in Area 1 Upland of the Site. The Supplemental HHRA further evaluated exposures to recreational and subsistence anglers consuming fish from Scappoose Bay, in addition to the rest of the exposure scenarios listed in Section 3.2.1, incorporating more recent data and subsequent input from DEQ.

Cumulative Risk. The Supplemental HHRA evaluated cancer risk using the Central Tendency Exposure (CTE) and Reasonable Maximum Exposure (RME) methods to evaluate risks to human health associated with the Site for on-site industrial workers, on-site excavation workers, on-site construction workers, recreational trespassers in Scappoose Bay, recreational trespasser in Milton Creek, sport and subsistence fishers in Scappoose Bay, and sport and subsistence fishers in Milton Creek (see Table 2).

3.2.3.1 Cumulative Human Health Risk Estimates

To evaluate cumulative cancer risk, the Total Lifetime Excess Cancer Risk was calculated for each receptor. To evaluate non-cancer risk, the total hazard indices were calculated for each receptor. Resulting cumulative cancer and non-cancer risk estimates for each receptor are discussed in detail in Section 6 of the Supplemental HHRA and are presented in Table 2.

Excess lifetime cancer risk estimates did not exceed Oregon's environmental cleanup standard of 10^{-6} for exposure to individual carcinogenic substances or 10^{-5} for multiple carcinogenic substances for the following human health exposure scenarios: industrial workers, excavation workers, construction workers, recreational trespassers in Scappoose Bay, recreational trespassers in Milton Creek, or sport fishers in Scappoose Bay. Excess cancer risk estimates were not derived for sport or subsistence fishers in Milton Creek due to insufficient sediment data.

Non-cancer hazard indices did not exceed Oregon's environmental cleanup standard of one for the following exposure scenarios: recreational trespassers in Scappoose Bay, recreational trespassers in Milton Creek, sport fishers in Scappoose Bay, subsistence fishers in Scappoose Bay, sport fishers in Milton Creek, or subsistence fishers in Milton Creek.

The following section summarizes risk estimates exceeding Oregon's environmental cleanup standard for exposure to carcinogenic and non-carcinogenic substances for each receptor exposure scenario.

Cumulative Cancer Risk Estimate Exceedances.

Adult/child subsistence fishers in Scappoose Bay. For adult/child subsistence fishers in Scappoose Bay, the excess cancer risk estimate exceeded Oregon's environmental cleanup standard of 10^{-6} for exposure to individual carcinogenic substances or 10^{-5} for multiple carcinogenic substances. The total excess cancer risk estimate was $6x10^{-5}$ and $3x10^{-5}$ for RME and CTE (see Table 2). The HHRA recognized that both recreational and subsistence anglers could provide fish to children so both adult and child receptor scenarios were considered. These risk estimates are based on bioaccumulation of COPCs from sediment, surface water, and/or porewater. There is unacceptable risk for the subsistence fisher from the consumption of fish exposed to Site-related dioxins and furans in the Scappoose Bay area; exceedances were mostly limited to detected concentrations in samples collected from within the extent of known petroleum sheen and are therefore anticipated to be co-located with hydrocarbons in the areas of petroleum sheen (Cascadia Associates, 2020a, Section 6.6; Table F-2C). Exposure scenarios for bioaccumulation from surface water and sediment indicate a low level of concern for bioaccumulation of carcinogenic PAHs. Bioaccumulation from porewater is considered a secondary line of evidence (LOE) and was used as a supplement to evaluate risk.

Cumulative Non-Cancer Risk Estimate Exceedances.

Industrial workers. For industrial workers, the total hazard index exceeded Oregon's environmental cleanup standard of one. The total hazard indices were 770 and 54 for RME and CTE, respectively (see Table 2).

Elevated risk estimates are dominantly associated with industrial workers inhaling contaminants volatilizing from groundwater into indoor and outdoor air in the upland. The risks associated with this pathway are based on exposure to volatilization of petroleum hydrocarbon concentrations in localized groundwater samples (MW-3A and MW-22) within the extent of inferred subsurface NAPL in Area 1 Upland (Cascadia Associates, 2020a, Tables F-6A, F-6B, F-6C, F-6D). The inhalation risk associated with volatilization to outdoor and indoor air contributes nearly 100% of the potential risk to the total non-cancer risk estimates for industrial workers.

Direct contact with surface soil also poses potential risk to industrial workers. This risk is based on exposure to PCBs in a limited number of soil samples collected in the upland (SS-08, SS-10, SS-19, SS-22, and SS-24). The direct contact with soil pathway contributes relatively little to the cumulative estimated non-cancer risk to industrial workers. Specifically, hazard indices for this pathway were 2 and 0.5 for RME and CTE, respectively (Cascadia Associates, 2020a, Tables F-13E and F-13F).

Excavation workers. For excavation workers, the total hazard index exceeded Oregon's environmental cleanup standard of one. The total hazard indices were 390 and 28 for RME and CTE, respectively (see Table 2).

Estimated non-cancer risks to the excavation worker are dominated by direct contact with and inhalation of petroleum hydrocarbons in groundwater (Cascadia Associates, 2020a, Tables F-7A, F-7B). Direct contact with surface soil, and direct contact, ingestion, and inhalation of subsurface soil also contribute to the cumulative estimated risk to potential excavation workers (Cascadia Associates, 2020a, Tables F-13C, F-13D).

No unacceptable risks were estimated for direct exposure to soil, or for indirect exposure to contaminants in soil from inhalation outside the inferred NAPL areas, with the exception of an exceedance of risk calculated due to the localized high concentration of arsenic in one deep soil sample (MW-10). The potential risks from direct exposure to groundwater in an excavation were not quantified because the COPCs are semi-volatile. DEQ does not recommend a quantitative assessment of dermal exposures to SVOCs because their dermal permeability coefficients are outside of the effective predictive domain used to model this exposure factor. Instead, a qualitative discussion was provided in the uncertainty section of the Supplemental HHRA and concluded that:

- It is reasonable to assume there are unacceptable risks or hazards from dermal contact with groundwater where NAPL is present.

- It is not possible to accurately quantify the magnitude of the risk from dermal contact with water containing appreciable levels of PAHs or other semi-volatile compounds (such as TPH consisting of weathered creosote) in areas where NAPL is not present.

- Thus, an administrative or engineering control should be applied to the Site to control future exposures to groundwater. Administrative and engineering controls have already been established for Area 2 and similar controls could easily be applied to Area 1 of the Site.

Construction workers. For construction workers, the total hazard index exceeded Oregon's environmental cleanup standard of one. The total hazard indices were 17 and 0.6 for RME and CTE, respectively (see Table 2).

Estimated non-cancer risks to the construction worker are dominated by direct contact, ingestion, and inhalation of subsurface soil (Cascadia Associates, 2020a, Tables F-13A, F-13B). Direct contact with surface soil also contributes to the cumulative estimated risk to potential excavation workers (Cascadia Associates, 2020a, Tables F-13A, F-13B). This risk estimate is based on exposure to the localized high concentration of arsenic in one deep soil sample (MW-10). With the exception of this one sample from MW-10, no unacceptable risks were estimated for a potential construction worker's direct exposure to soil, or from indirect exposure to contaminants in soil, outside the inferred NAPL areas.

3.2.4 Ecological Risk Assessment

The ERA reports (Bridgewater Group and Kennedy/Jenks Consultants, 2006b; Cascadia Associates, 2020b) describe in detail the procedures used to evaluate the potential risks to ecological receptors at the Site. A Level II ERA was conducted to evaluate terrestrial and aquatic ecological exposures associated with Site-related contamination (Bridgewater Group and Hart Crowser, 2003). The 2003 Level II ERA identified contaminants of potential ecological concern (CEPCs) and appropriate ecological assessment endpoints. The Level II ERA concluded that no CPECs are present in surface soil and therefore that no further ERA activities for terrestrial receptors are necessary at the Site. The Level II ERA identified potential unacceptable risk to ecological receptors in the in-water areas of Scappoose Bay and Milton Creek adjacent to the Site (Bridgewater Group and Hart Crowser, 2003; Bridgewater Group and Kennedy/Jenks Consultants, 2006b, Section 2).

Based on the conclusions of the Level II ERA, the 2006 ERA Report evaluated risks to aquatic ecological receptors associated with contaminant data for Scappoose Bay sediment, surface water, and seeps. This assessment concluded that contaminant concentrations in Scappoose Bay seeps may pose unacceptable risk to ecological receptors and identified that preventing ecological receptors from direct contact with Scappoose Bay seeps should be a preliminary remedial action goal for the Site (Bridgewater Group and Kennedy/Jenks Consultants, 2006b, Section 3).

At DEQ's request, the 2020 Supplemental ERA re-evaluated the CSM for the entire site; evaluated ecological risks using sediment, porewater, and surface water data collected since 2005; and applied new methods and research to the data evaluation as additional LOEs supporting ecological risk conclusions. The presence of NAPL is presumed to present an unacceptable risk for ecological receptors. Therefore, ecological risks associated with media within the estimated extent of NAPL were not quantitatively evaluated in the Supplemental ERA (Cascadia Associates, 2020b).

3.2.4.1 Ecological Risk Assessment Lines of Evidence

The Supplemental ERA used multiple LOEs to evaluate ecological risk. The first and primary LOE was the presence or absence of a surface sheen. Additional LOEs included comparisons of environmental concentrations in various environmental media to SLVs based on toxic responses of aquatic organisms (e.g., benthic organisms and fish) to individual chemical constituents. The LOEs used in the Supplemental ERA are discussed below:

Presence or absence of sheen: The presence of NAPL and/or a petroleum sheen was used as a primary LOE in evaluating risk to aquatic receptors. The presence of NAPL or a sheen is a violation of narrative water quality criteria and is considered an unacceptable risk to ecological receptors due to the potential for fouling of membranes and gills or ingestion of accumulated product on feathers or fur during preening. Multiple field events (2010, 2011, 2012, 2013, 2017, and 2018) were conducted to properly delineate the boundary of NAPL/sheen, and the results are shown on Figure 42.

Sediment toxicity:

Total PAHs: Bulk sediment concentrations of total PAHs were compared with the threshold effects concentration (TEC) and probable effects concentration (PEC) to evaluate risk to benthic organisms associated with direct contact with sediment (Macdonald et al., 2000). TECs and PECs were developed from a number of published sediment quality guidelines (SQGs). TECs reflect lower limits of sediment toxicity where toxicity is not predicted to occur; PECs reflect upper limits, above which adverse effects are predicted to have a high probability of occurring. Evaluating bulk sediment concentrations against both TECs and PECs provides a bracket for expected toxicity and provides a secondary LOE in assessing risk of sediment toxicity to the benthos. Concentrations of total PAHs and a comparison to PEC and TEC values are presented in Table G-10 of the Supplemental ERA (Cascadia Associates, 2020a).

Total petroleum hydrocarbons: PECs and TECs do not exist for TPH. TPH fractions were screened against criteria developed as part of the Portland Harbor Superfund Site's (PHSS's) ERA (Windward, 2013), with values updated to correct a calculation error. Use of PHSS's SLVs are considered a secondary LOE in risk evaluation. Concentrations and SLVs are presented in Table G-10 of the Supplemental ERA (Cascadia Associates, 2020a).

Porewater toxicity:

PAHs: Concentrations of total PAHs in porewater samples were converted into total TU values, specifically the ΣIWTU, to evaluate the potential for narcotic risk to benthic invertebrates. Each individual PAH congener concentration was divided by its unique final chronic value (based on narcotic effects to benthic organisms) to calculate the TU. The sum of all Tus for a sample was calculated as the ΣIWTU. ΣIWTU values ≥1 indicate potential risk to benthic organisms. ΣIWTU values are presented in Table G-6a and Table G-11a of the Supplemental ERA (Cascadia Associates, 2020a).

VPH: Concentrations of VPH in 2017 porewater samples were used as a secondary LOE for determining risk at the Site. Concentrations were compared to PHSS's ERA SLVs and presented in Table G-11b of the Supplemental ERA (Cascadia Associates, 2020a).

OPAHs: OPAHs were measured in 2017 porewater samples to provide a secondary LOE for determining risk at the Site. The presence of oxygen atoms in OPAH molecules makes OPAHs more polar and hydrophilic than PAHs, often resulting in higher freely dissolved concentrations of OPAHs than PAHs in sediment porewater. No SLVs exist for OPAHs, so there was no quantitative assessment of risk based on OPAH concentrations. Concentrations of OPAHs in surface water samples are presented in Table G-12a of the Supplemental ERA (Cascadia Associates, 2020a).

Surface water toxicity:

PAHs: As with porewater, concentrations of PAHs in surface water samples were converted to Tus. The sum of all Tus for a given sample were calculated as the sum of surface water TU (ΣSWTU). A ΣSWTU greater than 1 indicates the potential risk to benthic organisms, and these calculations were used as a primary LOE in risk evaluation. ΣSWTUs are presented in Table G-6b and G-12a of the Supplemental ERA (Cascadia Associates, 2020a). Concentrations of C_{free} PAHs in surface water were also compared to published SLVs for individual PAHs where available and presented in Table G-12b of the Supplemental ERA (Cascadia Associates, 2020a).

OPAHs: As with porewater, OPAHs were measured in a number of samples to further define risk from PAHs. Concentrations of OPAHs in surface water were not screened against any SLVs, as no risk-based screening criteria exists. Total OPAH concentrations are presented in Table G-12a of the Supplemental ERA (Cascadia Associates, 2020a).

Groundwater toxicity: Groundwater was evaluated to determine if upland dissolved phase constituents have the potential to adversely affect Scappoose Bay. Dissolved phase concentrations in groundwater were evaluated based on the same approach used for surface water and porewater. This approach was completed for nearshore groundwater wells and did not account for any potential change in concentrations during migration to Scappoose Bay.

PAHs: As with porewater and surface water, concentrations of PAHs in groundwater were converted to Tus. The sum of all Tus in a given sample were calculated as the ΣGWTU. A ΣGWTU greater than 1 indicates the potential risk to benthic organisms. As mentioned above, benthic organisms are not directly exposed to groundwater; thus, this analysis is strictly used to examine the potential for risk to benthic organisms following upland groundwater migration to Scappoose Bay. PAH concentrations and ΣGWTUs are presented in Table G-13 of the Supplemental ERA (Cascadia Associates, 2020a). Concentrations of individual PAHs in groundwater were compared to DEQ Level II SLVs (DEQ, 2001b) to evaluate potential risk after upland groundwater migration to Scappoose Bay. Concentrations and associated SLVs are presented in Table G-13 of the Supplemental ERA (Cascadia Associates, 2020a).

TPH: Concentrations of diesel- and gasoline-range hydrocarbons were compared to Freshwater Ecotox Aquatic Habitat Goal Levels from San Francisco Bay Regional Water Quality Control Board (SFBRWQCB, 2019). As described above, this approach was used as a conservative analysis of potential risk to Scappoose Bay from upland groundwater migration. Concentrations and comparisons to SLVs are presented in Table G-13 of the Supplemental ERA (Cascadia Associates, 2020a).

3.2.4.2 Ecological Risk Assessment Conclusions

The following conclusions were drawn from the Supplemental ERA:

- The presence of creosote NAPL and moderate to heavy petroleum sheen present unacceptable risk to ecological receptors where they are observed in surface sediment, porewater, and surface water. Areas exhibiting moderate to heavy petroleum sheen in surface sediment are shown on Figure 42.

- Issues with the 2012 measurement of PAHs C_{free} in sediment porewater centered around elevated detection limits, particularly high molecular weight PAHs, and a perceived low bias for detecting select low molecular weight PAHs (e.g., naphthalene and its alkylated isomers). This uncertainty to confidently assess porewater toxicity led DEQ to consider other LOEs. Subsequently, passive samplers were deployed in 2017 within offshore areas where prior efforts to assess porewater toxicity and habitat impairment posed by Site -related contamination had been inconclusive. The quantitation of chemicals in sediment porewater using LDPE passive sampling devices developed by the Food Safety and Environmental Stewardship program at Oregon State University (OSU) is more robust and precise than the 2012 direct measurements of freely dissolved PAHs in sediment porewater. For example, naphthalene, a key component of PAH contamination in upland groundwater, was detected in 26 of 30 porewater samples collected using passive samplers in 2017, compared to only 4 out of 59 porewater samples analyzed by the ASTM International SPME approach in 2012.

- The 2017 porewater data demonstrate low or nonexistent potential narcotic risk to benthic organisms outside of delineated offshore NAPL areas. Specifically, the ΣIWTU exceeded in only one of the 15 Phase 3 locations, PWS-090617-2, based on porewater measurements obtained within the biologically active zone (i.e., upper 12 inches of sediment). Sediment porewater sample PWS-090617-2 was obtained in Lower Milton Creek near the confluence with Scappoose Bay. This area is not currently included in the in-water PAAs and therefore may need to be addressed via additional sampling and action moving forward.

- Like porewater, surface water samples with a ΣSWTU $\geq$ 1 are considered unacceptable. Four of the eight 2017 surface water passive sampling sites (PWS-090917-9, PWS-090517-10, PWS-090617-12, and PWS-090617-13) resulted in a ΣSWTU slightly above 1 (1.07). Detected concentrations of alkyl PAHs C4-naphthalene appear to be the primary ecological risk driver in surface water.

- Risk to fish is negligible for the Scappoose Bay exposure area from either direct exposure to surface water or from the bioaccumulation of fluoranthene or pyrene.

- A screening of monitoring wells along Scappoose Bay indicates dissolved phase constituents may pose a risk to aquatic receptors from discharge of upland groundwater to surface water based on exceedances of select SLVs for PAHs and TPH and ΣGWTU values greater than 1. There is still a large degree of uncertainty associated with this pathway; further evaluation is needed, including additional sampling at the Site of groundwater discharge.

Taken together, along with the results of earlier ERAs, bioassay results, and the multiple lines of evidence considered over more than two decades of investigation, the 2020 ERA demonstrates:

- The presence of NAPL and/or petroleum sheen present unacceptable risk for ecological receptors.

- Dissolved phase groundwater constituents may pose risk to aquatic receptors from discharge of upland groundwater to the aquatic environment; consistent with the findings presented in the 2006 ERA, unacceptable risk to ecological receptors from direct contact with groundwater migrating to Scappoose Bay via seeps should be a preliminary remedial action goal for the Site.

- There is low or nonexistent potential risk to ecological receptors at the Site outside of delineated areas of NAPL and petroleum sheen.

3.2.5 Human Health and Ecological Risk Summary and RAOs to Address Risk

This section connects the unacceptable risks identified in the HHRAs and ERAs with RAOs developed to focus the remediation on addressing those risks. In this section the RAOs are referenced in context of the risks they aim to mitigate; the RAOs are described in more detail in Section 5.1.2.

3.2.5.1 Human Health Risk Summary

The HHRA identified unacceptable risks associated with Area 1 Upland related contamination in the following human health exposure scenarios:

- Adult/child subsistence fishers in Scappoose Bay.
- Industrial workers working in the upland area of the Site.
- Excavation workers working in the upland area of the Site.
- Construction workers working in the upland area of the Site.

3.2.5.2 RAOs to Address Human Health Risk

Below is a summary of RAOs selected for the remedy to address unacceptable risks to human health:

Adult/child subsistence fishers in Scappoose Bay.

A core focus of the remediation is on limiting bioaccumulation of COPCs in sediment that drive the excess lifetime cancer risk estimate for subsistence fishers, and on limiting bioaccumulation of carcinogenic PAHs in surface water and sediment that contribute risk to subsistence fishers. **RAO 1a, RAO 1c, and RAO 2** all directly address this goal by: preventing releases of creosote NAPL (defined as moderate to heavy petroleum sheen) to the aquatic environment; preventing unacceptable risk to aquatic receptors associated with direct contact with NAPL in riverbank seeps, surface sediment, and surface water; and protecting aquatic receptors from exposure to contaminants in surface sediment (as defined as the top 12 inches of sediment and associated porewater) and surface water, respectively. **RAO 4** also addresses risk associated with in-water receptors bioaccumulating contaminants migrating from the groundwater in the upland to the aquatic environment by preventing recontamination of the in-water remedy from the defined NAPL riverbank seep areas and contaminated groundwater discharge. **RAO 1b** also addresses potential risk to adult/child fishers and other recreational users by preventing unacceptable risk to recreational users associated with direct contact to NAPL seeps in surface sediment. The selected remedial alternative for the Area 1 Upland, Area 1 Dock PAA, Area 2 Dock PAA, and Cove Area PAA address this risk by limiting contaminants migrating from the upland into the in-water areas via seeps and soil erosion, and through a combination of removing and capping hot spots of contamination in the in-water PAAs.

Industrial workers working in the upland area of the Site.

RAO 8 directly addresses risk to industrial workers by protecting Site workers from vapor intrusion into buildings that causes unacceptable risk. The selected remedy for Area 1 Upland will cap upland soil contamination and address contaminant migration into the aquatic environment. The remedy does not, however, actively remove contamination in upland groundwater or soil in the source area. The long-term effectiveness of the selected Area 1 Upland remedy is therefore dependent on institutional and engineering controls to mitigate risks to potential industrial workers in the upland. The selected remedy for the upland assumes that an EES would be made between the Port of Columbia County and DEQ. The EES would include requirements to follow a contaminated media management plan (CMMP), require installation of engineering controls to prevent vapor intrusion into any future structures, land use restrictions, water use restrictions, identification and maintenance of engineered barriers, and long-term monitoring requirements.

RAO 6 directly addresses risk to industrial workers in areas of unacceptable risk related to PCB contamination in soil. The selected upland remedy will cap surface soil contamination in the Upland PAA, mitigating this risk to potential industrial workers.

Excavation workers working in the upland area of the Site.

RAOs 5, 6, and 7 directly address risk to excavation workers by protecting construction/excavation workers when working in upland area(s) of inferred NAPL and/or near monitoring well boring MW-10; preventing industrial workers in areas of unacceptable risk related to PCB contamination in gravel roadways; and preventing exposure to groundwater in Area 1 Upland by Site workers, respectively. As described above, the selected remedy for Area 1 Upland will cap soil contamination and address contaminant migration into the aquatic environment but will not actively remove contamination in upland groundwater or subsurface soil in the source areas. The long-term effectiveness of the selected remedial action is therefore dependent on institutional and engineering controls to mitigate risks to potential excavation workers in the upland. To be protective of a potential future excavation worker, this EES would need to mitigate or prevent: direct contact with and inhalation of contaminants from upland groundwater; and direct contact, ingestion, and inhalation of subsurface soil.

Construction workers working in the upland area of the Site.

RAO 5 directly addresses potential risk to construction workers by protecting construction/excavation workers when working in upland area(s) of inferred NAPL and/or near monitoring well boring MW-10. As described above, the selected remedy for the Area 1 Upland will cap upland soil contamination and address contaminant migration into the aquatic environment but will not actively remove contamination in upland subsurface soil. The long-term effectiveness of the Area 1 Upland selected remedial action is therefore dependent on institutional and engineering controls to mitigate risks to potential construction workers in the upland. To be protective of a potential future construction worker, this EES would need to mitigate or prevent direct contact, ingestion, and inhalation of subsurface soil.

3.2.5.3 Ecological Risk Summary

Based on the conclusions of the 2020 Supplemental ERA and an evaluation of all available LOEs, the following Site conditions were organized into primary and secondary indicators of aquatic ecological risk in the Feasibility Study (GeoEngineers, 2022):

Primary LOEs:

- Observations of a moderate to heavy petroleum sheen (i.e., creosote NAPL) in surface sediment (1 foot bml).
- Surface water concentrations representing a $\Sigma SWTU \geq 1$ based on the direct measurement of 34 PAHs.
- Surface sediment porewater concentrations representing a $\Sigma IWTU \geq 1$ based on the direct measurement of 34 PAHs.

Secondary LOEs

- Observations of a slight petroleum sheen in surface sediment and subsurface sediment porewater (greater than [>]1 foot bml) concentrations representing a $\Sigma IWTU \geq 1$.
- Bulk sediment total 34 PAH concentrations ≥ PEC of 22.8 mg/kg.
- Significant concentrations of total TPH in bulk sediment relative to fraction-specific SLVs.
- Bulk sediment total 34 PAH concentrations >10 mg/kg, representing the mid-point between the TEC of 1.6 mg/kg and the PEC of 22.8 mg/kg.
- Total TPH porewater concentrations greater than fraction-specific SLVs
- Porewater concentrations in surface sediment representing one-half of a TU.
- Relative magnitude of C_{free} 63 PAHs > 0.5 µg/L (not risk-based).
- Relative magnitude of C_{free} total OPAHs concentrations > 0.5 µg/L (not risk-based).

Based on these primary and secondary LOEs, the following conclusions were drawn in the Feasibility Study concerning ecological risk (GeoEngineers, 2022):

- Presence of creosote NAPL and moderate to heavy petroleum sheen presents unacceptable risk to ecological receptors where it is observed in surface sediment and surface water.

- Risk to ecological receptors in sediment porewater and surface water are largely driven by lighter end and more soluble PAHs, including naphthalene and methylnaphthalenes, C-3 and C-4 naphthalenes, C-2 and C-3 fluorenes, and C-2, C-3 and C-4 phenanthrenes/anthracenes. This conclusion is consistent for multiple pathways, including direct toxicity (e.g., comparison with Tier II final chronic values), narcosis (i.e., measured by toxic units), and bioaccumulation (i.e., using food chain multipliers) (DEQ, 2020).

- The presence of slight petroleum sheens in surface sediment and ΣIWTU ≥ 1 in subsurface sediment has the potential to result in unacceptable risk due to transformation of PAHs to more biologically active metabolites, and variability in the depth of the biologically active zone (DEQ, 2020).

- Total dissolved parent and alkylated PAHs in groundwater should be used to determine levels discharging to offshore sediment and surface water via colloidal groundwater transport, in addition to freely dissolved concentrations and NAPL migration.

3.2.5.4 RAOs to Address Ecological Risk

Based on the findings of the ERAs, the primary focus of the in-water remedy is on limiting aquatic ecological receptors' exposure to NAPL and petroleum sheen. **RAO 1a** directly addresses estimated ecological risk by preventing releases of creosote NAPL, defined as moderate to heavy petroleum sheen, to the aquatic environment. **RAO 1c** directly addresses this risk by preventing unacceptable risk to aquatic receptors associated with direct contact with NAPL in riverbank seeps, surface sediment, and surface water. **RAO 2** addresses this risk by protecting aquatic receptors from exposure to contaminants in surface sediment (as defined as the top 12 inches of sediment and associated porewater) and surface water that result in toxic effects, respectively. **RAO 3** addresses this risk by preventing recontamination of the in-water remedy from adjacent contaminated riverbank soils, further ensuring long-term protection of aquatic ecological receptors. **RAO 4** also addresses risk to in-water receptors associated with migration of contaminants from the groundwater in the upland by preventing recontamination of the in-water remedy from the defined NAPL riverbank seep areas and contaminated groundwater discharge.

3.3 BENEFICIAL USE AND HOT SPOT DETERMINATION

The criteria used to evaluate Remedial Action Alternatives (RAAs) for groundwater and surface water depend on whether a "hot spot" is present or not, as determined by a loss of "current or reasonably likely future" beneficial use of the water resource.

OAR 3401-122-0115(9) defines beneficial uses of water as any current or reasonably likely future beneficial use of groundwater or surface water by humans or ecological receptors.

OAR 340-122-0115(32) defines hot spot of contamination as:

> (a) For groundwater or surface water, hazardous substances having a significant adverse effect on beneficial uses of water or waters to which the hazardous substances would be reasonably likely to migrate and for which treatment is reasonably likely to restore or protect such beneficial uses within a reasonable time, as determined in the feasibility

study; and (b) For media other than groundwater or surface water, (e.g., contaminated soil, debris, sediments, and sludges; drummed wastes; "pools" of dense, non-aqueous phase liquids submerged beneath groundwater or in fractured bedrock; and non-aqueous phase liquids floating on groundwater), if hazardous substances present a risk to human health or the environment exceeding the acceptable risk level, the extent to which the hazardous substances:

(A) Are present in concentrations exceeding: (i) 100 times the acceptable risk level for human exposure to each individual carcinogen; (ii) 10 times the acceptable risk level for human exposure to each individual noncarcinogen; or (iii) 10 times the acceptable risk level for exposure of individual ecological receptors or populations of ecological receptors to each individual hazardous substance. (B) Are reasonably likely to migrate to such an extent that the conditions specified in subsection (a) or paragraphs (b)(A) or (b)(C) would be created; or (C) Are not reliably containable, as determined in the feasibility study.

3.3.1 Groundwater Beneficial Use Determination

A beneficial water use determination (BWUD) was prepared as part of the 2000 remedial investigation and updated as part of the 2018 supplemental remedial investigation. The findings of the 2000 BWUD indicated that beneficial water uses were limited to aquatic habitat, recreation, and aesthetic quality. Surface water could be used to provide irrigation and/or industrial process/cooling water in the future.

No direct beneficial uses of groundwater occurred at or adjacent to the Site. Potable water at the Site is provided by the City of St. Helens' municipal system. According to the Oregon Water Resource Department database, some domestic wells are present within 1 mile of the Site, none of which are located within the LOF. The nearest wells are located approximately 0.5 mile cross-gradient from the Site.

The BWUD concluded that based on the poor yield of the shallow aquifer (less than 0.5 gallon per minute) and the availability of municipal water supply, future direct beneficial uses of groundwater within the LOF are not expected.

Regarding the cleanup of sediments in Milton Creek, Scappoose Bay, and the Multnomah Channel, the reasonably likely future beneficial use of groundwater is limited to discharge through riverbank seeps and/or sediments which provides habitat for plants, mammals, birds, fish and/or benthic organisms.

3.3.2 Surface Water Beneficial Use Determination

Surface water in the vicinity of the Site includes Milton Creek, Scappoose Bay, and the Multnomah Channel. Groundwater likely discharges to surface water in the area of the Site. Surface water within the LOF is currently used for recreation and aquatic and terrestrial habitat. The Boise Cascade (ECSI No. 0014) facility downstream of the Site was identified as using surface water for facility processes. Plant operations have significantly decreased since 2015 with only tissue manufacture remaining. The use of surface water in current operations is unknown but would be significantly less than when pulp and paper operations were active. Reasonably likely future beneficial water uses were determined to include recreational, habitat, and limited industrial use.

3.3.3 Hot Spots

This ROD evaluates soil, groundwater, sediment, porewater, and surface water potential hot spots in the Area 1 Upland and the four in-water PAAs.

3.3.3.1 Non-Aqueous Phase Liquid

Creosote NAPL is present in the subsurface soil beneath the former wood treatment operations area and represents a hot spot. Creosote NAPL at the Site has migrated from the historical ground surface in the former wood-treating operations area to deeper soil and groundwater, affecting near-shore sediment, porewater, and surface water adjacent to Area 1 Upland.

The presence of NAPL in monitoring well MW-3A and downgradient riverbank seeps represents a mobile hot spot to the Cove Area. Riverbank seeps exhibiting a moderate to heavy petroleum sheen are considered mobile hot spots that serve as an ongoing source of contamination to sediment, porewater, and surface water in Upper Milton Creek and Cove Area.

3.3.3.2 Impacts to Beneficial Water Uses

Riverbank groundwater seeps exhibiting a visible creosote sheen is an indication of unacceptable direct contact risk to human health and ecological receptors and is considered a mobile hot spot that serves as an ongoing source of contamination to sediment, porewater, and surface water. Dissolved phase creosote constituents in porewater and surface water that cause unacceptable risk to benthos and fish are considered hot spots. Further assessment during remedial design will be needed to determine if total dissolved creosote constituents in groundwater is a hot spot.

3.3.3.3 Soil/Sediment

The inferred extent of creosote NAPL in upland subsurface soil, riverbank seeps, and near-shore surface sediment represent a soil/sediment hot spot. Subsurface sediment exhibiting a moderate to heavy petroleum sheen may be considered a hot spot if it is not reliably containable. Subsurface sediment exhibiting a creosote sheen outside the in-water PAAs boundaries appears to be reliably contained and is not currently considered a sediment hot spot.

3.3.3.4 Contaminated Debris

Creosote contaminated wood debris is present in surface sediment near and beneath the former overwater operations. Moderate to heavy petroleum sheens are easily generated by disturbing the surface sediment containing this wood debris. Therefore, shoreline and offshore areas of surficial creosote contaminated wood debris is considered a sediment hot spot. Subsurface creosote contaminated wood debris appears to be reliably contained and is not considered a sediment hot spot.

3.4 ESTIMATE OF CONTAMINATION VOLUME

Estimated volumes of contaminated media including soil, sediment, and wood debris are presented on Table 6.

4. PEER REVIEW SUMMARY

This ROD is based on technical documents that have been reviewed by a technical team at DEQ. The team consists of the project manager, a hydrogeologist, environmental engineer, and human health and environmental toxicologist. The team unanimously supports the selected remedial action.

5. DESCRIPTION OF REMEDIAL ACTION ALTERNATIVES

5.1 REMEDIAL ACTION OBJECTIVES & PRELIMINARY REMEDIATION GOALS

The process for selection of a remedial action by DEQ is outlined in OAR 340-122-0090, focusing on selection of an action that: a) is protective of present and future public health, safety, and welfare of human health and the environment; b) is based on balancing of remedy selection factors; and c) satisfies requirements for hot spots of contamination. DEQ's Guidance for Conducting Feasibility Studies (1998, updated 2006 and 2017) provides more detailed guidance on the remedy selection process, including the development of RAOs, identification of general response actions, identification and screening of remedial technologies, and assembly of RAOs for evaluation. Each of these steps were considered by DEQ, and discussed below, in the selection of a remedial action for the Area 1 Upland and four sediment in-water PAAs.

RAOs and acceptable risk levels, as defined in OAR 340-122-0115(1) through (6), were developed based on the identified beneficial uses, exposure pathways, and the findings of the risk assessments. RAOs are media-specific goals for protecting human health, safety, and the environment and were developed to address the standards established in OAR 340-122-0040. Specifically, the remedial action must achieve the numeric standards for protectiveness that correspond to acceptable risk levels; treat or remove hot spots to the extent feasible; prevent or minimize future releases and migration of hazardous substances in the environment; and provide long-term care or management as necessary and appropriate.

RAOs provide the framework for developing and evaluating RAAs, as any remedy DEQ selects or approves must achieve these Site-specific goals. The RAOs are listed in Section 5.1.2.

5.1.1 Acceptable Risk Levels

Risk-based concentrations (RBCs) and screening levels used to draw conclusions about potential risks to human and ecological health are described in detail in the HHRA and ERA reports. Protectiveness levels were developed for different media at the Site to guide remedy selection during the Feasibility Study (GeoEngineers 2022, Feasibility Study, Section 2.8.2). These protectiveness levels were established to ensure humans and ecological receptors were protected from the potential risks identified in the risk assessments that are summarized in Section 3.2.5 above. Specifically, the Feasibility Study established acceptable risk levels for: PCBs and arsenic in upland soil to protect construction workers and industrial workers working in the upland; naphthalene in groundwater to protect industrial and/or occupational workers from vapor intrusion into buildings; carcinogenic PAHs and TPH in sediment to protect subsistence fishers; and PAHs in porewater and surface water to protect ecological receptors. The Feasibility Study also establishes that the presence of NAPL and/or moderate to heavy petroleum sheen present unacceptable risk to humans and ecological receptors in upland soil, groundwater, sediment, porewater, and surface water (GeoEngineers 2022, Feasibility Study, Section 2.8.2). CULs to inform decision-making during and after remedial implementation will be developed during the remedial design process.

5.1.2 Site-Specific Remedial Action Objectives

Site-specific RAOs were developed for soil and groundwater in Area 1 Upland and sediment, porewater, and surface water in the four sediment in-water PAAs. The RAOs describe what the remedial action is expected to achieve to protect human health, ecological receptors, and beneficial uses, as required by OAR 340-122-0040. The RAOs for the Site are as follows:

Area 1 Upland PAA RAOs:

- RAO 3: Prevent recontamination of in-water remedy from adjacent contaminated riverbank soils.
- RAO 4: Prevent recontamination of in-water remedy from the defined NAPL riverbank seep areas and contaminated groundwater discharge.
- RAO 5: Protect construction and/or excavation worker receptors when working in upland area(s) of inferred NAPL and/or near monitoring well boring MW-10.
- RAO 6: Protect industrial workers in areas of unacceptable risk related to PCB contamination found in gravel roadways.
- RAO 7: Prevent direct exposure to groundwater at Area 1 by Site workers.
- RAO 8: Protect Site workers from vapor intrusion into buildings that cause unacceptable risk.

In-Water Sediment PAA RAOs:

- RAO 1a: Prevent releases of creosote NAPL, defined as moderate to heavy petroleum sheen, to aquatic environment.
- RAO 1b: Prevent unacceptable risk to recreational users associated with direct contact with NAPL in riverbank seeps and surface sediment.
- RAO 1c: Prevent unacceptable risk to aquatic receptors associated with direct contact with NAPL in riverbank seeps, surface sediment, and surface water.
- RAO 2: Protect aquatic receptors from exposure to contaminants in surface sediment (as defined as the top 12 inches of sediment and associated porewater) and surface water that result in toxic effects.

5.1.3 Preliminary Remediation Goals

PRGs were developed for Area 1 Upland and the four sediment in-water PAAs using available Site information to identify endpoint concentrations or risk levels that are believed to be sufficiently protective of human health and the environment. The PRGs describe Site conditions or concentrations in specific media that are designed to be protective of certain receptors from exposure to COCs through particular pathways within a reasonable amount of time. The PRGs for the Site are as follows:

Area 1 Upland PRGs

- Protect construction and excavation workers from direct exposure to NAPL and contaminated groundwater.

- Remove, contain, or treat surface (0 to 3 feet bgs) soil with total PCBs greater than 0.74 mg/kg.

- Protect building occupants from vapor intrusion that results in unacceptable risk.

In-Water Sediment PAAs PRGs

- Remove, contain, or treat NAPL, including heavy to moderate sheen, in surface sediment.

- If not contained, remove, contain, or treat NAPL, including heavy to moderate sheen, in subsurface sediment.

- Remove, contain, or treat NAPL, including heavy to moderate sheen, in shoreline seeps.

- Achieve ΣIWTU less than (<) 1 in surface sediment porewater within 10 years of removal, containment, or treatment of NAPL in surface sediment and riverbank seeps.

- Achieve all applicable water quality criteria in surface water within 10 years of removal, containment, or treatment of NAPL in surface sediment and riverbank seeps.

5.1.4 Remedial Action Levels and Cleanup Levels

RAOs and PRGs were developed to inform technology evaluations for Area 1 Upland and the four Sediment PAAs. Remedial action levels (RALs) are contaminant-specific concentrations used to identify where an active remedial technology should be applied to reduce risks more effectively than MNR alone. CULs are contaminant-specific concentrations that should not be exceeded following remedial action. RALs and CULs will be developed during remedial design, if necessary.

5.1.5 Priority Action Areas

Area 1 Upland and four sediment in-water PAAs were established for the Site (see Figure 2). PAAs were identified as areas that are highly likely to require active remediation and are characterized by:

- NAPL and/or moderate to heavy petroleum sheen in surface sediment and riverbank seeps.

- Contaminant concentrations that result in unacceptable human and ecological risk with a high degree of certainty.

The Area 1 Upland and four sediment in-water PAAs are discussed in more detail in Section 2.1.1.

5.2 REMEDIAL ACTION ALTERNATIVES FOR SEDIMENT

RAAs were developed and evaluated during the Feasibility Study, and presented in DEQ's Staff Report along with the recommended remedial action. The RAAs are based on general response actions that include: 1) no action, 2) engineering controls and/or ICs, 3) treatment, 4) excavation and offsite disposal, 5) excavation and on-site disposal, 6) and any combination of the general response actions, as appropriate. Several remedial action technologies were evaluated for each general response action. The technologies were screened in accordance with OAR 340-122-0085(4), which requires meeting the threshold criterion of protecting human health and the environment and considering their relative merits/drawbacks with respect to the remedy selection factors. Tables 3, 4, and 5 provide the rationale for eliminating or carrying forward general response actions and technologies based on Site characteristics, environmental media conditions, and contaminant type. Viable response actions and technologies that can meet the threshold criterion were assembled into RAAs. Given the Site contains hot spots of soil and sediment contamination in Area 1 Upland and in-water areas, the Feasibility Study included an evaluation of a treatment based alternative and/or an excavation and offsite disposal alternative per OAR 340-122-0085.

5.2.1 General Response Actions and Applicable Technologies

Technologies that were carried forward after the initial screening and combined to develop comprehensive RAAs are summarized below:

Engineering and/or Institutional Controls. Engineering controls are physical measures to prevent or minimize exposure to hazardous substances or reduce the mobility or migration of hazardous substances. ICs include legal or administrative actions to reduce exposure to hazardous substances. IC examples include land use restrictions, long-term Site management plans (cap inspection/maintenance and contingency plans), and public access restrictions.

Natural Recovery. Natural recovery relies on ongoing, naturally occurring processes such as sedimentation, biodegradation, and dispersion to contain, reduce, or destroy the toxicity or availability of the contaminants. Monitored natural attenuation (MNA) includes monitoring of these natural processes to assess the rate at which the contaminant concentrations are being reduced. MNA does not include active remedial measures. ENR is the process of accelerating MNA, typically through addition of a thin layer of clean material (e.g., sand). However, natural recovery should not be considered as a viable treatment option for hot spots.

Treatment. Treatment is the permanent and substantial elimination or reduction in the toxicity, mobility, or volume of hazardous substances with the use of in-situ or ex-situ remedial technologies. In-situ treatment for contaminated soils may include solidification/stabilization, enhanced bioremediation, or phytoremediation. In-situ treatment for contaminated sediments may include the addition of reactive materials to conventional sediment caps, such as organoclay, activated carbon, biochar, or an oleophobic biobarrier. Ex-situ technologies for contaminated soils or sediments may include solidification/stabilization or thermal treatment.

Containment. Containment of soils and sediments includes capping, an engineering control that involves the placement of material over the contaminated area. Cap material can be tailored to Site-specific needs. Common cap types include engineered, armored, and reactive caps. The primary functions of a cap are: 1) physical isolation of the contaminated sediment from human and ecological receptors; 2) stabilization of contaminated soil or sediment; and 3) reduction of the flux of dissolved contaminants into the water column (sediments). Capped areas can be engineered in a manner to achieve long-term stability, which may require additional reinforcement. Containment of groundwater can include hydraulic containment using pumping systems, impermeable barrier walls, or permeable reactive barriers that removes contaminants as water flows through.

Removal and Disposal. This technology involves the physical removal (full or partial) of contaminated soil and sediment by excavation or dredging. Material may be disposed offsite to a permitted landfill that is authorized for such disposal under state and federal law. Disposing material offsite would prevent mobility and minimize risk to receptors. Material may also be disposed on-site in a pre-determined upland consolidation disposal facility and managed according to local, state, and federal law. For sediments, some form of dewatering is typically required prior to disposal.

5.2.2 Estimate of Contaminated Media

The estimates for the quantities of contaminated media considered for each of the general response actions above is summarized in Table 6.

5.2.2.1 Estimate of Upland Contamination

The upland source area is approximately 3.45 acres (150,370 square feet) and is currently covered by an average depth of 8 feet of clean fill. Below the clean fill, creosote NAPL in present in the subsurface soil between depths below 8 ft bgs and 25 feet bgs, which results in an estimated total volume of 95,000 cubic yards of creosote-impacted soil.

5.2.2.2 Estimate of In-water Contamination

<u>Area 1 Dock PAA</u>: Wood-related creosote NAPL in surface sediment underneath and surrounding the previous dock structures has been defined by an area approximately 1.85 acres (80,586 square feet). The area has an estimated 435 timber piles. The assumption is these piles are an average of 25 feet long, resulting in a total estimate of 163 tons of wood waste. The estimated depth of the area where hot-spot material is present in the shallow surface sediment with the impacted surficial woody debris is approximately 3,000 cubic yards. In general, the concentrations increase with depth in this area, with elevated concentration reaching depths of 11 feet bml in some area, resulting in a total volume of impacted sediment of 32,800 cubic yards of sediment.

Area 2 Dock PAA: The creosote-impacted wood debris in surface sediments in the Area 2 Dock PAA is approximately 0.34 acres (15,000 square feet) and the total volume of the shallow (mudline to 1 foot bml) impacted sediment is approximately 560 cubic yards. The area has an estimated 235 piles. The assumption is these piles are approximately 25 feet in length and result in approximately 88 tons of wood waste. The combined total for the estimated sediment and wood waste is 519 tons of hazardous waste and 222 tons of non-haz (including the wood piles). In general, the elevated sediment concentrations and presence of moderate to heavy sheen coincides with the surficial debris.

Cove Area PAA: The extent of nearshore surface sediment (up to 1 foot bml), which are largely soft and fine-grained, impacted by creosote NAPL in the Cove Area covers an area of approximately 1.2 acres (52,275 square feet) and is estimated to be approximately 1,950 cubic yards. Moderate to heavy sheen has been identified along approximately 300 linear feet of the shoreline, with steep slopes across approximately 500 linear feet of the riverbank. The sediment concentrations decrease with depth into the subsurface, with depths of contamination identified up to 12 feet bml, with an average depth of 5 feet bml resulting in an overall volume of impacted sediment of 17,200 cubic yards of sediment.

Upper Milton Creek PAA: The area of Upper Milton Creek where moderate to heavy sheen has been identified in the near surface (up to 1 foot bml) sediment and adjacent riverbank, extends approximately 200 linear feet and within an area of less than 0.05 acres (2,200 square feet) The estimated volume of soil and sediment that would be removed to regrade the bank along the creek from approximately 2H:1V to 4H:1V is approximately 1,020 cubic yards.

5.2.3 Common Elements and Assumptions

Area 1 Upland and In-Water Common Elements and Assumptions

The technologies assembled into alternatives represent a spectrum of potential remedial strategies, ranging from capping and natural recovery to complete removal options. Common elements and assumptions to the Area 1 Upland and in-water RAAs are included below and may not be specifically included in descriptions of RAAs.

- Institutional controls. ICs include administrative and legal mechanisms, such as EES, CMMPs, land use restrictions, and water use restrictions to reduce risk to human health, ensure long-term protectiveness of cleanup actions. The purpose of institutional controls is to provide notification regarding the presence of COCs, regulate the disturbance and management of contaminated materials, and aid in the long-term care of cleanup action, including long-term monitoring. If RAOs and PRGs are not completely achieved following remedial action, interim ICs may be necessary, such as a fish advisory.

- Engineering controls. Engineering controls include physical measures to prevent or minimize exposure to hazardous substances in contaminated materials that remain on Site. Examples of engineering controls include measures to prevent access, including fencing, paving pervious surfaces, directing stormwater away from contaminated media, and installing vapor barriers beneath future buildings constructed in upland contaminated areas.

- Remedial design investigations. Additional data collection and evaluations inform remedial design, including but not limited to additional chemical contamination characterization, debris and capping evaluations, measurements of groundwater seepage and river currents, hydraulic and erosion modeling, geotechnical investigations, and seismic design considerations. Preparation and implementation of a comprehensive pre-design investigation (PDI) inform Remedial Design/ Remedial Action (RD/RA) as well as support post-performance monitoring activities and post-construction residual risk assessment.

- Recontamination potential. RD/RA addresses recontamination potential of a constructed sediment remedy. Potential source control pathways are further examined during the PDI.

- Post-construction, long-term monitoring. Long-term monitoring is conducted following implementation of remediation actions to ensure remedial actions continue to be protective of human health and the environment and perform as designed and constructed in accordance with RAOs. Long-term monitoring is conducted in perpetuity for isolation walls and caps placed on upland soil and riverbanks and in-water areas. Performance monitoring includes but is not limited to visual inspections for petroleum sheens, cap integrity testing, sediment porewater/surface water sampling, and MNR assessment within and outside the PAAs where applicable to demonstrate sufficient rate of degradation is occurring. Long-term monitoring for natural recovery is conducted until all COC concentrations in sediment/riverbank soil, groundwater/porewater, and surface water are less than established CULs. Updates to appropriate management strategies are based on results of long-term monitoring.

- Permitting. Permitting requirements include endangered species act consultation, biological opinion, 404 USACE/Division of State Lands (DSL) permit, National Pollutant Discharge Elimination System (NPDES) permit, DSL lease negotiations, and applicable floodplain development permits.

- Construction considerations. Remedy construction considerations include evaluated vegetation removal, riverbank stabilization, cap construction, construction management and oversight, and water quality monitoring.

- Achievement of RAOs and PRGs. RAOs and PRGs should be achieved at construction completion, or the shortest reasonable period of time.

- In-water work window. In-water work is performed in the allowable Oregon Department of Fish and Wildlife work window of July 1 to October 31 and December 1 to January 31. The Multnomah Channel is tidally influenced.

- Debris removal. Debris is removed, to the extent necessary or practicable, in areas where applicable, and transported and disposed of at an off-site facility. Similarly, remnant wood pilings are typically cut at the mudline where active remedial technologies are applied. Removed or cut pilings are disposed of at an off-site facility.

In-Water Common Elements and Assumptions

In-water PAAs require active remedy consideration. Multiple objectives were considered during the Feasibility Study for development of in-water alternatives, including integrating chemical isolation and physical protection goals during cap design; habitat enhancements; and slope angle effects on remedy implementation and monitoring, stope stability, wave and wake impacts on the shoreline, and habitat creation.

The following are common elements of all RAAs for the in-water PAAs (except the No Action alternatives) and may not be specifically included in the RAA descriptions.

- Land lease and easement for nearshore contaminated sediment capping.
- Site use restrictions (e.g., limit access to riverbank areas, post signage informing presence of contamination, communication outreach).
- Sediment Management Plan.

In addition to elements listed above, the following are elements of all in-water RAAs that include caps and may not be specifically included in the RAA descriptions:

- The design of all caps need to consider the effectiveness of containing contamination from underlying materials and the potential for recontamination from upland sources.
- Various evaluations are needed to support remedial design, including but not limited to chemical transport modeling, sensitivity analyses, chemical isolation evaluations, erosion protection evaluations, habitat enhancement evaluations, debris and capping evaluations, measurements of groundwater seepage and river currents, hydraulic and erosion modeling, flood impacts, sea level rise resilience, geotechnical investigations, and seismic design considerations.
- The remedial design determines the specific materials, blends, thicknesses, extent, armoring stone sizing, and grading needed to achieve RAOs. Remedial design would result in the preparation of cap design plans and specifications.

5.2.4 RAA-1: No Action

All Upland and In-Water PAAs include RAA-1 (No Action). A “no action alternative” is included for comparative purposes only as stipulated in OAR 340-122-0085(2) and DEQ guidance. Under this RAA, no actions to treat, remove, or monitor COCs would be performed. There would be no reduction in site risk, and thus this RAA is not considered protective by DEQ.

5.2.5 Area 1 Upland Priority Action Area Remedial Action Alternatives

The following summarizes the RAAs considered for the Area 1 Upland PAA, with detailed descriptions of the remedial technologies included in Table 7. Creosote NAPL observed in Area 1 Upland riverbanks adjacent to Milton Creek and Scappoose Bay indicates that some lateral movement of NAPL occurs beneath the Site. As a result, much of the RAAs include source control measures.

RAA-2 fulfills RAOs 5 through 8 by protecting Site workers. Though RAA-2 reduces contaminant mass flux, it does not prevent recontamination of the in-water remedy from adjacent contaminated riverbank soils (RAO 3) or riverbank NAPL seeps (RAO 4). RAA-3 through RAA-6 fulfill RAOs 3 through 8 by protecting Site workers and preventing recontamination of the in-water remedy by controlling contaminant mass flux towards Milton Creek and/or the Cove Area of Scappoose Bay.

- RAA-2: Impervious surface cap and MNA ($5,565,000).
- RAA-3: Impervious surface cap, hydraulic containment, enhanced bioremediation, and MNA ($15,097,000).
- RAA-4: Impervious surface cap, permeable reactive barrier, and MNA ($7,890,000).
- RAA-5: Impervious surface cap, impermeable isolation wall, and MNA ($8,494,000).
- RAA-6: Excavation and offsite disposal of NAPL area, impervious surface cap, and MNA ($60,386,000).

5.2.6 In-Water Priority Action Areas Remedial Action Alternatives

5.2.6.1 Area 1 Dock Priority Action Area

The following summarizes the RAAs considered for the Area 1 Dock PAA, with detailed descriptions of the remedial technologies included in Table 8.

The Area 1 Dock RAAs address RAOs 1 and 2 by preventing releases of creosote NAPL to the aquatic environment, preventing risk associated with direct contact by recreational users and aquatic receptors, and protecting aquatic receptors from exposure to contaminants in surface sediment and surface water.

- RAA-2: Armored reactive cap ($5,382,000).
- RAA-3: Nearshore removal action, upland consolidation, and armored reactive capping ($8,138,000).
- RAA-4: Nearshore removal action, offsite disposal, and armored reactive capping ($9,528,000).
- RAA-5: Complete removal and offsite disposal ($29,181,000).

5.2.6.2 Area 2 Dock Priority Action Area

The following summarizes the RAAs considered for the Area 2 Dock PAA, with detailed descriptions of the remedial technologies included in Table 9.

The following Area 2 Dock RAAs address RAOs 1 and 2 by preventing releases of creosote NAPL to the aquatic environment, preventing risk associated with direct contact by recreational users and aquatic receptors, and protecting aquatic receptors from exposure to contaminants in surface sediment and surface water.

- RAA-2: Armored reactive cap ($1,309,000).
- RAA-3: Nearshore removal action, upland consolidation, and an ENR sand cap ($1,596,000).
- RAA-4: Nearshore removal action, offsite disposal, and an ENR sand cap ($1,604,000).

5.2.6.3 Cove Area Priority Action Area

The following summarizes the RAAs considered for the Cove Area PAA, with detailed descriptions of the remedial technologies included in Table 10.

The following Cove Area RAAs address RAOs 1 through 4 by preventing releases of creosote NAPL to the aquatic environment; preventing risk associated with direct contact by recreational users and aquatic receptors; protecting aquatic receptors from exposure to contaminants in surface sediment and surface water; and preventing recontamination of the in-water remedy from adjacent riverbank contaminated soils, NAPL riverbank seeps, and contaminated groundwater discharge.

- RAA-2: Armored reactive cap ($3,551,000).
- RAA-3: Riverbank restoration, nearshore removal action, upland consolidation, and armored reactive capping ($4,836,000).
- RAA-4: Riverbank restoration, nearshore removal action, offsite disposal, and armored reactive capping ($5,984,000).
- RAA-5: Complete removal and offsite disposal ($17,606,000).

5.2.6.4 Upper Milton Creek Priority Action Area

The following summarizes the RAAs considered for the Upper Milton Creek PAA, with detailed descriptions of the remedial technologies included in Table 11.

The Upper Milton Creek RAAs address RAOs 1 through 4 by preventing releases of creosote NAPL to the aquatic environment; preventing risk associated with direct contact by recreational users and aquatic receptors; protecting aquatic receptors from exposure to contaminants in surface sediment and surface water; and preventing recontamination of the in-water remedy from adjacent riverbank contaminated soils, NAPL riverbank seeps, and contaminated groundwater discharge.

- RAA-2: Armored reactive cap ($898,000).
- RAA-3: Regrade streambank, limited removal action, upland consolidation, and armored reactive capping ($1,146,000).

- RAA-4: Regrade streambank, limited removal action, offsite disposal, and armored reactive capping ($1,216,000).

5.2.7 Monitoring, Review, and Contingency Plan

There are numerous sources of uncertainty at the Site that make it difficult to predict the long-term effectiveness of any of the RAAs described above, including:

- Heterogeneity in the subsurface.
- Potential changes in future groundwater or surface water use patterns (i.e., beneficial uses).
- Potential changes in future land use and zoning.
- Changes in community concerns regarding remedial actions at the Site.
- Long-term performance of active treatment and/or cap areas.
- The long-term potential for deposition, erosion, or net-neutral conditions in the Sediment Area.
- Factors related to climate change (i.e., rainfall and sea-level rise).

Because of these uncertainties, a Performance Monitoring, Review, and Contingency Plan will be developed that will evaluate the performance of the remedy, and any changes that may affect the ability of the remedy to meet the RAOs. The objective of the Monitoring, Review, and Contingency Plan will be to maintain the overall protectiveness of the selected remedy by establishing a series of decision criteria and related response actions for each potential area of uncertainty identified above, and the RAOs identified in Section 5.1.2 of this document. Section 10.1.8 provides a description of potential contingency measures that could be implemented in the event the RAOs are not achieved following remedy implementation.

6. EVALUATION OF REMEDIAL ACTION ALTERNATIVES

6.1 EVALUATION CRITERIA

The criteria used to evaluate the RAAs described below are defined in OAR 340-122-0090 and establish a two-step approach to evaluate and select an RAA. The first step evaluates whether an RAA is protective; if not, the RAA is unacceptable and the second step of evaluation is not required. The RAAs considered protective are evaluated and compared with each other using five balancing factors. The five balancing factors are 1) effectiveness in achieving protection, 2) long-term reliability, 3) implementability, 4) implementation risk, and 5) reasonableness of cost.

An evaluation of how each alternative achieves the preference for treatment or removal of hot spots is also included. Lastly, consideration is given to how each alternative achieves green remediation, as described in DEQ's Green Remediation Policy. The alternative that compares most favorably against the balancing factors and complies with the hot spot criteria is selected for implementation. A residual risk assessment is then conducted for the selected alternative to document that it is protective of human health and the environment.

6.2 PROTECTIVENESS

The protectiveness of a given remedial action is evaluated by assessing whether an alternative would eliminate, reduce, or control risks to human health and the environment and achieve applicable RAOs and PRGs.

OAR 340-122-0090 states that protectiveness may be achieved by any of the following methods:

- Treatment.
- Excavation and offsite disposal.
- Engineering controls.
- ICs.
- Any other method of protection.
- A combination of the above.

Except for hot spots, there is no preference for any one of the above methods for achieving protectiveness. Where a hot spot has been identified, OAR 340-122-0090(4) establishes a preference for treatment or removal to the extent feasible, including a higher threshold for evaluating the reasonableness of costs for treatment.

Each RAA was screened for whether it is or is not protective. Alternatives that were deemed not to be protective were not evaluated further. Alternatives deemed to be protective were evaluated for the remaining criteria.

6.3 BALANCING FACTORS

The RAAs determined to be protective are evaluated against the following balancing factors defined in OAR 340-122-0090(3) unless otherwise noted:

Effectiveness. Effectiveness is the ability of an alternative to achieve protectiveness. Criteria for evaluating effectiveness include:

- Magnitude of the residual risk from untreated waste or treatment residuals (residual risks), without considering risk reduction achieved through on-site management of exposure pathways (i.e., engineering controls and ICs); the characteristics of the residuals are considered to the degree that they remain hazardous, considering their volume, toxicity, mobility, propensity to bioaccumulate, and propensity to degrade.

- Adequacy of any engineering controls and ICs necessary to manage residual risks.

- The extent to which the remedial action restores or protects existing or reasonably likely future beneficial uses of water.

- Adequacy of treatment technologies in meeting treatment objectives.

- The time until RAOs are achieved.

Each RAA was evaluated and assigned a ranking between 0 and 5 for effectiveness in protecting human health and ecological receptors from contamination risk. A ranking of 0 indicates that an alternative is not effective and a ranking of 5 indicates an alternative provides a high degree of effectiveness.

Long-term reliability. This factor includes evaluation of the ability of an alternative to achieve RAOs over the long-term following remedy implementation. Criteria for evaluating effectiveness include:

- The reliability of treatment technologies in meeting treatment objectives.

- The reliability of engineering controls and ICs needed to manage residual risks, taking into consideration the characteristics of the hazardous substances being managed, the ability to prevent migration and manage risk, and the effectiveness and enforceability over time of the controls.

- The nature and degree of uncertainties associated with any necessary long-term management (e.g., operations, maintenance, monitoring).

Each RAA was evaluated and assigned a ranking between 0 and 5 for long-term reliability in protecting human health and ecological receptors from contamination risk. A ranking of 0 indicates that an alternative has little to no long-term reliability and a ranking of 5 indicates an alternative has a high degree of long-term reliability.

Implementability. This factor includes evaluation of the ease or difficulty in implementing an alternative. Criteria for evaluating implementability include:

- Practical, technical, and legal difficulties and unknowns associated with the construction and implementation of the technologies, engineering controls, and/or ICs, including the potential for scheduling delays.

- The ability to monitor the effectiveness of the remedy.

- Consistency with regulatory requirements, activities needed to coordinate with and obtain necessary approvals and permits from other governmental bodies.

- Availability of necessary services, materials, equipment, and specialists, including the availability of adequate treatment and disposal services.

Each RAA was evaluated and assigned a ranking between 0 and 5 for implementability. A ranking of 0 indicates that an alternative has a significant degree of difficulty in implementing the alternative and a ranking of 5 indicates an alternative has little to no difficulty in implementing the alternative.

Implementation Risk. This factor includes evaluation of the potential risk to human health and the environment associated with remedial action implementation. Criteria for evaluating implementation risk include:

- Potential impacts to the community, workers involved in implementing the remedial action, and the environment and the effectiveness and reliability of protective measures to mitigate these impacts.

- Time until the remedial action is complete.

Each RAA was evaluated and assigned a ranking between 0 and 5 for implementation risk. A ranking of 0 indicates that an alternative has significant implementation risk and a ranking of 5 indicates an alternative has little to no implementation risk.

Reasonableness of Cost. This factor evaluates the reasonableness of the costs associated with the remedial action. Each alternative is assessed for reasonableness of cost by considering:

- Capital, operations and maintenance (O&M), and periodic review costs.

- The net present value of the above.

- The degree to which costs associated with the remedial action are proportionate to the benefits to human health and the environment through risk reduction or management.

- For any hot spots identified, the degree to which costs associated with the remedial action are proportionate to the benefits created through restoration or protection of beneficial uses of water.

- The degree of sensitivity and uncertainty of the costs.

In general, the least expensive remedial action is preferred unless the additional cost of a more expensive corrective action is justified by proportionately greater benefits to one or more of the other balancing factors. A higher threshold is used for evaluating the reasonableness of costs for treatment of hot spots than for remediation of non-hot spot areas.

Each RAA was evaluated and assigned a ranking between 0 and 5 for reasonableness of cost. A ranking of 0 indicates that an alternative has the highest cost and a ranking of 5 indicates an alternative has the lowest estimated cost.

Preference to Treat or Remove Hot Spots. As defined by OAR 340-122-0115(b), non-groundwater or surface water hot spots exist if hazardous substances present an unacceptable risk to human health or the environment and if the contamination is sufficiently concentrated, likely to migrate, or are not reliably containable. Under OAR 340-122-0090(4), a preference is given to alternatives that include treatment or excavation of hot spots to the extent feasible. In addition, a higher cost threshold is applied to sites where hot spots are present.

Each RAA was evaluated and assigned a ranking between 0 and 5 for hot spot treatment or removal. A ranking of 0 indicates that an alternative has no preference to treat or removal hot spots and a ranking of 5 indicates a meaningful reduction in hot spot contamination.

Green Remediation. Green remediation includes practices that lessen the overall environmental impact of remedial actions, such as limiting resources required for implementing the remedy, reducing generation of waste, and reducing greenhouse gas emissions. Alternatives were ranked and evaluated for their inclusion of green remediation technologies or methods.

Each RAA was evaluated and assigned a ranking between 0 and 5 for green remediation. A ranking of 0 indicates that an alternative has no preference for green remediation and a ranking of 5 indicates an alternative has meaningful reduction of resources and greenhouse gas emissions.

6.4 EVALUATION OF ALTERNATIVES AGAINST CRITERIA

Each RAA for each PAA was evaluated for protectiveness and balancing criteria. First, alternatives were screened for whether they achieve or do not achieve protectiveness. Alternatives that do not achieve protectiveness were not further evaluated while those that do achieve protectiveness were evaluated for the remaining criteria. Second, scores and discussion are provided for each balancing factor. Third, initial scores are calculated as the sum of the rankings for effectiveness, long-term reliability, implementability, implementation risk, and cost. Lastly, final scores are calculated as the initial score plus the scores for hot spot treatment and green remediation.

The following sections summarize the outcomes of the scoring and RAA selection for each PAA. Please reference Tables 12 through 16 for a more detailed explanation regarding how each alternative was evaluated against each criterion and Table 17 for a scoring summary for all RAAs considered for each PAA. All alternatives except RAA-1 (No Action) are considered to provide some level of protectiveness and were evaluated for all criteria.

7. COMPARATIVE ANALYSIS OF REMEDIAL ACTION ALTERNATIVES

In this section, each of the RAAs determined to be protective are compared with each other for the remedy evaluation criteria identified in Section 6.1. Because RAA-1 (No Action) is not considered protective and is only used as a baseline for evaluating the other RAAs, RAA-1 is not included in the comparative analysis. Sections 7.1 through 7.5 provide discussion summarizing the major conclusions of the comparative analysis and justification for differentiating issues specific to each of the upland and in-water PAAs. Additional details for each of the PAAs is presented in Tables 12 through 16. Table 17 provides an overall summary of the rankings for each of the PAAs.

7.1 AREA 1 UPLAND PRIORITY ACTION AREA

RAA-4 consisting of an impervious surface cap and permeable reactive barrier had the highest overall score (23) for any of the upland RAAs considered. RAA-6 ranked higher than RAA-4 for effectiveness and long-term reliability because RAA-6 includes removal of the hot spot volume of soil and transporting the material off-site to a permitted facility for disposal. However, during implementation, RAA-6 would have more short-term risks, including limitations related to critical resources, such as dump-trucks that may be limited to meet the demand necessary for completing the project on schedule; higher production of greenhouse gasses; and overall risk to the neighbors as a result of the large increase in traffic. RAA-2 would be easy to implement and therefore scored higher than the other RAAs for implementability and implementation risk. RAA-2 would result in the lowest short-term implementation risks. However, the effectiveness is ranked lower for RAA-2 because it would not meet several of the upland RAOs, including RAO 3 and RAO 4 (prevent recontamination of the in-water remedy). All RAAs would require institutional and engineering controls (e.g., Site use restrictions, CMMP, impervious surface cap, stormwater management, inspections, and maintenance) to achieve RAO 5 through RAO 8.

The cost to complete RAA-2 is the lowest of the RAAs. However, the alternative does not reduce the overall contaminant mass. The cost to complete RAA-4 is slightly less than the cost to complete RAA-5 and both would result in similar removal of upland contaminated soil and be effective in meeting all the upland RAOs (RAO 3 through RAO 8). Although RAA-3 would limit residual mass flux from the upland in groundwater, the cost to implement RAA-3 is higher than RAA-4 and RAA-5 due to the on-going monitoring and maintenance that would be required for the hydraulic containment system. The cost of RAA-6 is an order of magnitude higher than the other RAAs considered for the upland PAA and is considered unreasonable, especially when considering the associated short-term implementation risks.

Additional details and explanation are included in Table 12.

7.2 AREA 1 DOCK PRIORITY ACTION AREA

For the Area 1 Dock PAA, RAA-2 consisting of the installation of an armored reactive isolation cap had the highest initial score (16) considering the five primary evaluation criteria scores and the highest final score (21) when the additional criteria of hot spot treatment and green remedial considerations were also evaluated. RAA-2, RAA-3, and RAA-4 include an armored reactive isolation cap, which will reduce contaminant mass flux to the river and provide a barrier to direct contact with underlying impacted residual or source sediment. RAA-2 scored lower for effectiveness and long-term reliability than RAA-3 and RAA-4, which included removal of shallow hot spot sediment and creosote-impacted timber piles and surficial woody debris. However, RAA-2 scored highest for implementability compared to RAA-3 and RAA-4 because the significant volume of old, highly weathered wood debris present in the Area 1 Dock PAA is unlikely to be successfully removed, would likely make surface and subsurface sediment removal very difficult, and also likely result in an overall increase in the short-term risks to receptors related to the management of the impacted sediment and debris. RAA-2 has less short-term implementation risks to receptors and the environment based on a more focused scope of work, compared to RAA-3 and RAA-4.

Data gaps exist regarding contamination depth profiles in this PAA, and preliminary data suggest that removal of surface material may expose deeper, more highly contaminated material, which was tied into the implementability scores. Additional characterization and evaluation during remedial design would be needed to determine whether removing surface material is feasible and protective.

RAA-2 (amended isolation cap only), is the easiest to implement, has the lowest short-term risks to receptors, and has the lowest cost compared to other alternatives evaluated. However, RAA-2 removes the lowest volume of creosote-contaminated media compared to the other RAAs. RAA-5 would remove the largest volume of hot spot material, has the highest cost, and has the lowest overall score of all the RAAs evaluated, due to challenges associated with implementation and increased implementation risk.

If woody debris can be successfully removed, and subsurface sediment and debris could be accessed, up to approximately 80% of hot spot material could be removed through implementation of RAA-3 and RAA-4, while nearly all hot spot material could be removed with RAA-5. This would result in improved effectiveness and long-term reliability, but the increased scale and complexity of the required construction would make implementation challenging, implementation risks high, and have notably greater costs, particularly for RAA-5. Additional characterization during remedial design will provide additional information to consider if some areas of shallow sediment can be removed without decreasing the effectiveness and implementability in the Area 1 Dock PAA.

Additional details and explanation are included in Table 13.

7.3 AREA 2 DOCK PRIORITY ACTION AREA

RAA-4 scored highest overall for the Area 2 Dock PAA and consists of nearshore removal, offsite disposal, and placing a sand cap for ENR and to cover remaining residuals. RAA-4 and RAA-2 (armored reactive isolation cap only) both had the highest initial score (16). However, RAA-4 had the highest final score (22) because RAA-4 scored higher for effectiveness and long-term reliability through removal of the majority of the contaminated, near-shore surface hot spot material (up to approximately 84%). Each of the alternatives is easy to implement, with local resources available. Additional resources would be required to complete RAA-4 because of the additional scope of work required to dewater the sediment and transport the material to a permitted disposal facility, which resulted in a lower score for implementability and an increase in the short-term risks to receptors related to off-site transport (pollution, truck traffic through residential areas, etc.). RAA-4 effectively meets DEQ's preference to remove hot spot material from the PAA and removes more hot spot material from the PAA compared to RAA-2. RAA-3 would result in the same volume of hot spot media removed. However, the material would remain on-site, which increases the level of uncertainty for the long-term reliability of an on-site landfill.

The cost to complete the preferred alternative, RAA-4 is slightly higher than the cost to implement RAA-2 and RAA-3. However, the RAA-4 includes the removal of hot spot material compared to RAA-2 and the offsite disposal component included for RAA-4 resulted in a higher score and advantage over RAA-3 because RAA-4 would reduce permitting and stakeholder negotiations and eliminate the engineering controls, ICs, and monitoring and maintenance that would be required for on-site consolidations.

Additional details and explanation are included in Table 14.

7.4 COVE AREA PRIORITY ACTION AREA

RAA-4 consists of riverbank restoration, nearshore removal action, offsite disposal, and an armored reactive cap. RAA-2, RAA-3, and RAA-4 scored the same with an overall score of 21 points for the Cove Area PAA. RAA-3 and RAA-4 scored lower than RAA-2 (armored reactive cap only) for implementability and implementation risks due to their increased scopes. However, RAA-3 and RAA-4 include regrading the riverbank to reduce erosional forces imposed on the cap and remove near-shore shallow sediment, where hot spot concentrations are present, resulting in increased effectiveness and long-term reliability compared to RAA-2. RAA-5 would completely remove all surface NAPL source material and provide improved effectiveness and long-term reliability, but the increased scale and complexity of the required construction would make implementation challenging and result in an overall increase in the implementation risks. RAA-3 scored slightly lower than RAA-4 for the long-term reliability because RAA-3 would require long-term monitoring and maintenance and there is additional uncertainty related to maintaining an on-site landfill.

The cost for RAA-2 was the lowest of all the alternatives evaluated. However, RAA-2 also removes the smallest volume of hot spot material than the other RAAs evaluated. Alternatives RAA-3 and RAA-4 were similar in cost. RAA-5 had a notably greater costs than the other alternatives. Although the final score of RAA-4 was tied with RAA-3, RAA-4 would reduce permitting and stakeholder negotiations and eliminate the engineering controls, ICs, and monitoring and maintenance that would be required for on-site consolidation.

Additional details and explanation are included in Table 15.

7.5 UPPER MILTON CREEK PRIORITY ACTION AREA

RAA-4, consisting of streambank regrading, limited removal action, offsite disposal, and an armored reactive cap had the highest initial score (17) considering the five primary evaluation criteria and tied with RAA-3 for the highest final score (21) when the additional criteria of hot spot treatment and green remedial considerations were also evaluated for the Upper Milton Creek PAA. RAA-3 and RAA-4 both include streambank regrading, which provides many advantages over RAA-2, which does not include regrading. The regrading will remove some hot spot material, facilitate placement of the cap material, improve worker safety, and reduce erosional forces imposed on the cap, thereby resulting in increased effectiveness and long-term reliability compared to RAA-2. The long-term reliability was slightly lower for RAA-3 compared to RAA-4 because there are more future unknowns related to placing material within the 100-year flood plain for RAA-3. The implementation risks for RAA-2 and RAA-3 are less than the short-term risks to complete RAA-4 because RAA-4 would require truck traffic outside of the Site to transport wastes to the landfill. Each of the RAAs are feasible and easy to implement with readily available resources.

The cost to complete each of the RAAs in the Upper Milton Creek PAA are similar, with the cost to complete RAA-2 (armored cap only) slightly less. However, RAA-2 does not meet DEQ's preference for hot spot removal. The cost to complete RAA-4 is the highest of all the alternatives. RAA-4 would reduce permitting and stakeholder negotiations and eliminate the engineering controls, ICs, and monitoring and maintenance that would be required for on-site consolidation.

Additional details and explanation are included in Table 16.

8. RECOMMENDED REMEDIAL ACTION ALTERNATIVES IN STAFF REPORT

After a detailed evaluation of the remedial alternatives for each PAA (see Section 6 and 7), the most feasible, protective alternative was identified and presented to the public for review and comment in the form of a Staff Report. The recommended remedial alternatives are:

- **Area 1 Upland PAA (RAA-4):** This alternative includes placement of an impervious surface cap over the entire Area 1 Upland PAA and a permeable reactive barrier at the top of the riverbank, adjacent to the Cove PAA.

- **Area 1 Dock PAA (RAA-2):** This alternative includes removal of piles and creosote-impacted surficial woody debris and placement of an armored reactive cap.

- **Area 2 Dock PAA (RAA-4):** This alternative includes removal of surficial woody debris and 235 piles; removal of nearshore contaminated sediment to a depth of 1-foot below the sediment surface, where creosote sheen has been observed; and the placement of a thin, 1-foot-thick sand cap for ENR and to cover remaining sediment that may have residual impacts.

- **Cove Area PAA (RAA-4):** This alternative includes excavation and regrading for hot spot sediment and soil removal and armored reactive capping along the riverbank.

- **Upper Milton Creek PAA (RAA-4):** This alternative includes removal of hot spot soil and sediment, regrading the adjacent bank, installing an armored reactive cap across the Upper Milton Creek PAA, and conducting long-term MNR.

The remedial alternatives for each PAA form an integrated, cost-effective approach that removes and contains contaminated media, including hot spots, through a combination of upland groundwater in-situ treatment using sequestration agents (e.g., organoclays and granular activated carbon amendments); physical isolation of the in-water contamination through a combination of contaminated sediment and debris removal, capping, and contaminant burial (where natural recovery is already occurring); and reduction of risks to receptors through immobilization of bio-available contaminants in the in-water areas.

9. PUBLIC NOTICE, PUBLIC COMMENT, AND AGENCY RESPONSE

Pursuant to ORS 465.320 and OAR 340-122-0100, notice of DEQ's recommended remedial action for the Site was published in the Oregon Secretary of State's *The Oregon Bulletin* June and July issues and bi-weekly in *The Oregonian* and *Columbia County Spotlight* newspapers during June and July. The public notice was also posted on DEQ's public notifications web page. The 60-day comment period commenced on June 1, 2023, and ended on July 31, 2023. Public comments received and DEQ's response are included on Table 18.

DEQ also held several virtual informational sessions with various partners, community members, and stakeholders. Information about the Site, contamination, and recommended remedial action was presented followed by time for questions and answers. One of the informational sessions, minus the questions and answers portion, was recorded and is available to the public.

The Staff Report published May 31, 2023, presented DEQ's recommendation in greater detail based on previous work conducted at the Site, including remedial investigations, risk assessments, and feasibility study activities. These supporting documents are available online through DEQ's ECSI database for the Site (ECSI 0959).

10. SELECTED REMEDIAL ACTION

DEQ's selected remedial action is consistent with the recommended remedial action presented in the Staff Report. The selected remedial action for contaminated media in the Area 1 Upland and contaminated sediments located in Upper Milton Creek and Scappoose Bay adjacent to the former Pope and Talbot wood-treating is protective, and reflects the best balance of effectiveness, long-term reliability, implementability, implementation risks, reasonableness of costs, preference to treat or remove hot spots, and green remediation. Long-term monitoring and maintenance will be required to ensure the remedy remains protective over time. The selected action therefore satisfies the requirements of ORS 465.314 and OAR 340-122-0090.

10.1 DESCRIPTION OF THE SELECTED REMEDIAL ACTION

The following paragraphs describe the selected remedial action for each of the PAAs at the Site. There are no significant changes from the remedial action recommended in the Staff Report and the selected remedial action presented in this ROD. In addition to the specific remedial action described for each PAA below, Site-wide ICs will ensure long-term effectiveness of the selected remedial action for the Area 1 Upland PAA, and in-water ICs and MNR will help ensure effectiveness of the selected remedial action for all of the in-water PAAs. The total estimated cost for the selected remedial action is 22.1 million dollars.

10.1.1 Area 1 Upland Priority Action Area

The selected remedial action for Area 1 Upland PAA is RAA-4, which includes placement of an impervious surface cap over the entire Area 1 Upland PAA and a permeable reactive barrier at the top of the riverbank, adjacent to the Cove area, as conceptually shown in Figure 43. When combined with the Site-wide ICs, the selected remedial action protects on-site workers from direct exposure to the impacted media in the upland and achieves RAOs 5 through 8. The selected remedial action provides source control for the upland groundwater and in combination with the Upper Milton Creek and Cove Area RAAs, also achieves prevention of recontamination of in-water remedies, which will achieve RAOs 3 and 4.

The surface cap would be graded to direct stormwater away from the cap and into a stormwater collection and conveyance system that discharges outside of the Area 1 Upland PAA. Routing stormwater away from the Area 1 Upland PAA reduces infiltration into the underlying subsurface soil, where creosote NAPL is present, and associated groundwater flux towards in-water locations. The impermeable cap also provides protection against direct contact risks to receptors due to PCBs in the roadway soil and provides a vapor barrier to mitigate inhalation risks associated with volatilization of contaminants into ambient air. The PRB will be approximately 2 to 4 feet wide, consist of adsorptive and reactive materials (e.g., organoclay or granular activated carbon), and be placed at the top of the riverbank, upland of the Cove Area, where creosote NAPL seeps have been observed. PRBs have been shown to be effective in treating similar contaminants at other wood-treating cleanup sites. The PRB treatment wall will intercept and sequester creosote NAPL and dissolved phase COCs in groundwater before discharging into the Cove Area of Scappoose Bay, thereby providing source control for the groundwater and potentially mobile NAPL present in the

Area 1 Upland PAA. Although hot spots will remain within the Area 1 Upland PAA, the PRB combined with the engineered impervious surface cap and stormwater management system is expected to significantly reduce hot spots mobilizing downgradient of the PRB and stimulate biodegradation of dissolved phase PAHs and TPH in groundwater that migrate towards the Cove Area PAA. The actual footprint of the PRB, type of amendment, and material thickness and depth will be determined during remedial design.

The materials removed during PRB installation will be transported off-site for disposal. The selected remedial action will result in removal of approximately 3,000 tons of hot spot material that will be transported to a subtitle C landfill, and additional approximate 520 tons of impacted material that will be transported for disposal at a subtitle D landfill.

10.1.2 Area 1 Dock Priority Action Area

The selected remedial action for Area 1 Dock PAA is RAA-2, which includes removal of piles and creosote-impacted surficial woody debris and placement of an armored reactive cap. The armored reactive cap will remove direct contact risks to receptors, as identified in RAOs 1a, 1b, and 1c and immobilize bioavailable contaminants in porewater and surface water, which protects aquatic receptors from future exposures of any contaminants remaining below the cap (RAO 2). The Area 1 Dock PAA is shown on Figure 44 and the cross-sections for the selected remedial action are shown on Figures 45A and 45B.

An estimated total of 435 piles will be removed or attempted to be removed from the Area 1 Dock PAA. The piles and surficial debris (approx. 200 tons) will be removed and transported off-site for disposal as non-hazardous waste at a subtitle D landfill. The impacted sediment and debris removed will be transported off-site for disposal. The selected remedial action will result in removal of approximately 160 tons of impacted material that will be transported for disposal at a subtitle D landfill.

Additional sampling will be conducted during RD to inform the actual extent of the cap. Additional sampling will be completed following removal of the debris to verify the leave surface is consistent with the assumptions used for the final amended cap design. DEQ anticipates sampling will also determine if some removal of highly concentrated sediment proximal to and underlying creosote-impacted debris material and in shallow surface sediments is warranted. If found to be necessary, some hot spot surface sediment will be removed for off-site disposal at a permitted landfill, prior to installing the armored reactive cap.

Following removal of the piles and surficial debris, an estimated 1-foot-thick amended isolation cap will be placed across 80,600 square feet (approximately 56% of PAA) of the Area 1 Dock PAA where heavy to moderate sheen is present. The final amendments used in the amended isolation cap will be determined during remedial design. Areas around any remaining piles or dock structures that cannot be removed may require a different formulation of the amendment (e.g., proprietary product), dosage of amendment, or application method to achieve the performance goals of the amended isolation cap. The amended isolation cap will be armored with an estimated 2-foot-thick layer of protective rock with a habitat rock cover.

Surface and subsurface sediment exceeding the hot spot, highly concentrated criteria, will remain in-place, extending in some areas to depths greater than 14 feet bml, unless during remedial design it is determined that removal of this material is feasible and protective. However, this sediment would be isolated from direct contact through installation of the amended isolation cap, and the protective armor cover. Removal of the surficial debris, creosote-impacted timber piles, and installation of the amended isolation cap satisfies the preference for treatment of hot spots to the extent practicable. MNR will be implemented for the Area 1 Dock PAA outside of the limits of the protective isolation cap, with an overall timeline of 10 years to reach the remedial goals for the PAA. If the remedial goals are not met in this time, additional action may be needed.

10.1.3 Area 2 Dock Priority Action Area

The selected remedial action for Area 2 Dock PAA is RAA-4. RAA-4 addresses the in-water RAOs (RAO 1a, 1b, 1c, and 2) and is protective of human health and ecological receptors through a combination of removing surficial woody debris and 235 piles; removing nearshore contaminated sediment to a depth of 1-foot below the sediment surface, where creosote sheen has been observed; and the placement of a thin, 1-foot-thick sand cap over the entire PAA for ENR and to cover remaining sediment that may have residual impacts. The specific cap material, thickness, extent, and sufficiency or insufficiency of using sand only will be determined during remedial design. The Area 2 Dock PAA is shown on Figure 44 and the cross-section for the selected remedial action is shown on Figure 46.

Robust best management practices (BMPs) will be used during the removal of woody debris, piling, and sediment, including the use of a cofferdam and dewatering the area to allow for land-based access to the debris and impacted surface sediment. This management approach during implementation will reduce the short-term risks to in-water receptors and allow for a thorough removal of the sheen-impacted sediment in the Area 2 Dock PAA. The impacted sediment and debris will be transported off-site for disposal. The selected remedial action will result in removal of approximately 500 tons of hot spot material that will be transported to a subtitle C landfill, and additional approximate 200 tons of impacted material that will be transported for disposal at a subtitle D landfill.

10.1.4 Cove Area Priority Action Area

The selected remedial action for the Cove Area PAA is RAA-4, which is a combination excavation and regrading for hot spot sediment and soil removal and armored reactive capping along the riverbank. The amended isolation cap will immobilize bioavailable contaminants in porewater and surface water, which protects aquatic receptors from future exposures of any contaminants remaining below the cap (RAO 2). A depiction of the Cove Area PAA is shown on Figure 44 and the cross-sections for the selected remedial action are shown on Figures 47A, 47B, and 47C.

An estimated total of 139 piles and the hot spot areas of sediment, where heavy sheen has been observed in the Cove Area, will be removed. Removal of the heavy sheens in this area satisfies DEQs hot spot rule and RAOs 1a, 1b, and 1c. Approximately 540 linear feet along the adjacent bank will be regraded to achieve a stable slope of approximately 5H:1V. Removal of the adjacent bank soil will remove additional hot spots and prevent recontamination of in-water remedy from the adjacent bank area, which satisfies Upland RAO 3. The impacted sediment, bank soil, and debris removed will be transported off-site for disposal. The selected remedial action will result in removal of approximately 3,800 tons of hot spot material that will be transported to a subtitle C landfill, and additional approximate 1,600 tons of impacted material that will be transported for disposal at a subtitle D landfill.

Following removal of the soil and sediment, an estimated 1-foot-thick amended isolation cap will be placed across the Cove Area PAA, estimated to be an area of 50,000 square feet (approximately 33% of PAA) to address the residual soil and sediment concentrations in the areas where the highest concentrations were detected. The final amendments will be determined as part of the remedial design. The amended isolation cap will also be protected by the addition of an estimated 2-foot-thick layer of armor stone with a habitat rock cover. MNR will be implemented for the Cove Area PAA outside of the limits of the cap.

10.1.5 Upper Milton Creek Priority Action Area

The selected remedial action for Upper Milton Creek PAA is RAA-4. RAA-4 includes removal of hot spot soil and sediment, regrading the adjacent bank, installing an amended isolation cap across the Upper Milton Creek PAA, and conducting long-term MNR. The amended isolation cap will immobilize bioavailable contaminants in porewater and surface water, which protects aquatic receptors from future exposures of any contaminants remaining below the cap (RAO 2). Removal of the adjacent bank soil will prevent recontamination of in-water remedy from the adjacent bank area, which satisfies Upland RAO 3. The selected remedial action in Upper Milton Creek PAA also achieves prevention of direct contact with sheen (RAOs 1, 2, and 3). A depiction of the Upper Milton Creek PAA is shown on Figure 44 and the cross-section for the selected remedial action is shown on Figure 48.

Hot spot sediment, including locations where heavy sheen has been observed in the creek, will be removed using land-based equipment. Removal of the heavy sheens in this area satisfies DEQs hot spot rule and RAOs 1a, 1b, and 1c. The streambank adjacent to the creek will be regraded to reduce the current slope (up to 2H:1V) to a more stabilize slope (i.e., 4H:1V). The impacted sediment and impacted bank soil will be analyzed to determine the final disposition of the material. However, it is assumed that up to 1,550 tons of hot spot material will be transported off-site for disposal at a subtitle C landfill and an additional 82 cubic yards of impacted material will be transported for disposal at a subtitle D landfill.

Following removal of the impacted bank soil and creek sediment, an estimated 1-foot-thick isolation cap amended with organoclay will be placed across an approximate 2,000-square-foot area to cover residual soil and sediment. The amended isolation cap will also be protected by the addition of an estimated 2-foot-thick layer of armor stone with a habitat rock cover.

10.1.6 Engineering and Institutional Controls

Until such time that RAOs are achieved, limiting the potential for humans to ingest fish contaminated with primary COCs under recreational angling and subsistence angling scenarios, to the extent practicable, will be necessary. An advisory regarding consumption of fish, shellfish, and crayfish in Multnomah Channel and Scappoose Bay was issued by OHA in December 2020.

Signage communicating the OHA advisory will be installed to dissuade trespassers, recreational anglers, and subsistence anglers from fishing at or near the Site.

Additional ICs will be implemented as needed to manage human health and ecological risks. Other expected ICs that will be considered and more fully addressed during remedial design for the Area 1 Upland PAA include a prohibition on groundwater pumping/use in the upland and a restriction on upland property excavation, new construction, or redevelopment without DEQ approval/authorization. ICs will also be needed for the in-water PAAs, such as restrictions related to dredging within the project limits, vessel anchoring, and limits on navigation over in-water capped areas, etc.

10.1.7 Performance Monitoring

The remedial design work will also be used to inform the requirements for the performance monitoring for the Site, including a determination of points of compliance and timelines for performance monitoring, and an identification of contingency measures that may be implemented in the event that remedial measures prove to be ineffective or do not meet RAOs within specified time frames.

Short-term performance monitoring for the remedial action is anticipated to be completed directly after remedy implementation during Years 0 to 4, and long-term performance monitoring would be performed as determined to be necessary at routine intervals (e.g., Year 5, 10, and 15, etc.) thereafter.

Short- and long-term monitoring activities anticipated for the Site include upland groundwater sampling, in-water multi-beam bathymetric surveys, collection and analysis of surface sediment and porewater sampling, and potentially bioassays and benthic surveys to confirm RAOs are being achieved. Typical performance monitoring programs include a combination of the following monitoring activities:

- Periodic groundwater monitoring to evaluate the concentrations in the vicinity of the Upland PRB are consistent with anticipated design concentrations and the wall is performing as intended (i.e., no excessive biofouling, no excessive movement of the creosote NAPL body is occurring in the vicinity of the PRB, no evidence of active seeps along bank).

- Periodic cap inspections in the upland, along with in-water bathymetric surveys to ensure that the physical integrity of all caps is maintained and not compromised by scour, erosion, or other physical disturbances (e.g., prop-wash, wave-wake effect, etc.).

- Visual observations along Upper Milton Creek and Cove Area PAA banks to ensure the riverbanks remain stable and are not posing a recontamination issue due to excessive erosion and/or chemical breakthrough.

- Sediment, porewater, and/or surface water samples to monitor the overall effectiveness of the in-water remedy and performance of the amended isolation caps over time to ensure that cleanup goals are being achieved within the cleanup time frame (10 years) and maintained in sediment and porewater at the Site (and if they are not, evaluate whether the Site is being recontaminated by on-site and/or off-site sources).

- Monitor the effectiveness of natural recovery in MNR and ENR areas to ensure that recovery is progressing in areas outside of the in-water PAAs (prioritizing areas where heavy to moderate sheen have been observed) and recovery is progressing in the time frame (10 years) as included in the designed remedial action and identified in the overall PRGs for the Site. This effort should also include further evaluation of areas outside of the in-water PAAs exhibiting light petroleum sheen, especially areas where elevated contaminant levels have been previously observed (e.g., Lower Milton Creek near the location of the 2017 PWS-090617-2 sediment porewater sample).

- Collect data in remedial areas to evaluate contaminant concentration trends in each of the media (groundwater, sediment, and porewater) relative to the final RAOs and PRGs established for the Site during the remedial design effort.

10.1.8 Contingency Measures

In the event that the selected remedial action for each individual PAA is implemented and determined not to meet RAOs, either in the form of upland groundwater sequestration, debris and/or sediment removal, amended isolation capping, or natural recovery, contingency measures may be necessary. If contingency measures are necessary, they are expected to rely on the augmentation of selected remedial action.

Potential contingency measures could include: a) upgrading MNR areas to ENR (i.e., applying sand cover material to MNR and/or ENR areas); b) upgrading ENR areas to in situ treatment (i.e., applying more robust ENR effort in areas by extending the footprint of the ENR area or adding an amendment to the cover); c) upgrading ENR areas to engineered cap; d) increasing cap thickness and/or amendment concentrations; and e) localized hot spot removal with or without capping. Contingency measures will be formally addressed in a Performance Monitoring, Review, and Contingency Plan that will be prepared as part of the forthcoming remedial design document for the property following issuance of this ROD.

10.2 RESIDUAL RISK ASSESSMENT

OAR 340-122-0084(4)(c) requires a residual risk evaluation of the selected remedy to demonstrate that the standards specified in OAR 340-122-0040 will be met, namely:

- Assure protection of present and future public health, safety, and welfare, and the environment.

- Achieve CULs (i.e., the highest of acceptable RBCs or background concentrations).

- For designated hot spots of contamination, evaluate whether treatment or removal is reasonably likely to restore or protect a beneficial use within a reasonable time.

- Prevent or minimize future releases and migration of hazardous substances in the environment.

In the upland, the selected remedy achieves acceptable risk levels through an impervious cap that will limit direct contact with soil. The impervious cap will also limit stormwater infiltration into the upland soil and groundwater source area where hot spot levels of contamination are present, including creosote NAPL. The selected upland remedy also includes a PRB that will limit contaminant migration from the upland source area to the in-water area. The upland remedy does not directly treat source material in upland groundwater or subsurface soil; risks to potential industrial workers, excavation workers, and construction workers in the upland will therefore need to be addressed through ICs (EES and CMMP).

The long-term effectiveness of the selected remedy for Area 1 Upland is dependent on ICs and engineering controls to mitigate risks to potential industrial workers, construction workers, and excavation workers in the upland. The selected remedy for the upland assumes that an EES would be made between the Port of Columbia County and DEQ. ICs and engineering controls, including a CMMP, land use restrictions, water use restrictions, identification of engineered barriers, and long-term monitoring requirements will all need to be incorporated into the EES. To be protective of potential future industrial workers, this EES will need to mitigate or prevent inhalation exposure to contaminants volatilizing to both outdoor and indoor air from groundwater contamination in the source area of the upland. To be protective of potential future excavation workers, this EES will need to mitigate or prevent direct contact with and inhalation of contaminated groundwater in the upland. To be protective of potential future construction and excavation workers, this EES would also need to mitigate or prevent direct contact, ingestion, and inhalation of contaminated subsurface soil in the upland.

In the in-water areas, the selected remedy achieves acceptable risk levels through a combination of removal and capping of contaminated sediment. Concentrations of COCs in surface sediment will be immediately reduced at construction completion. In addition, cleaner sediments from upstream will continue to be deposited, further reducing COC concentrations at the sediment surface. The selected remedy does not, however, result in the immediate removal or destruction of all Site-related NAPL, petroleum sheen, or contaminated woody debris in the in-water areas. Monitoring after remedial implementation will be needed to evaluate any residual risk to subsistence fishers, sport fishers, or ecological receptors associated with residual contamination in sediment, porewater, or surface water in the in-water areas. As described in Section 10.1.8, contingency measures to address any residual risks that are identified will be addressed in a Performance Monitoring, Review and Contingency Plan that will be prepared as part of the forthcoming remedial design document for the Site.

The selected in-water remedy also achieves cleanup risk levels through preventing ongoing releases and direct contact with the NAPL and petroleum sheen at the seep locations and through immobilization of bioavailable contaminants in pore water and surface water in the in-water areas. Although the selected remedy does not result in the actual removal or destruction of all Site-related contaminants, the addition of reactive material to capping material in in-water PAAs is intended to make bioavailable COCs in sediment less bioavailable to humans and ecological receptors. Specifics of cap composition will be identified during remedial design with the intention of reducing bioavailability and mobility of contamination beneath the in-water caps. DEQ anticipates that porewater data collected post-construction will be used as a LOE to evaluate the efficacy of the remedy in reducing the bioavailability of COCs in impacted in-water areas.

Some potential residual Site risks, primarily associated with light petroleum sheen, are expected for a relatively short period of time over a limited area at the completion of the remedial action. However, the limited residual Site risks are expected to be mitigated through natural recovery processes, and by Year 10, Site-related risks are expected to be within acceptable levels throughout the in-water area. Performance monitoring will track the progress of the preferred remedy in achieving the RAOs following remedy construction in the PAAs. Additional investigation may be needed to evaluate and mitigate any potential residual risks (e.g., associated with light petroleum sheen) in in-water areas outside of the PAAs (e.g., Lower Milton Creek). As discussed in Sections 5.2.7, 10.1.7, and 10.1.8, the performance, monitoring, review, and contingency plans will be developed during remedial design.

11. STATUTORY DETERMINATIONS

The selected remedial action for contaminated media in the Area 1 Upland and contaminated sediments located in Upper Milton Creek and Scappoose Bay adjacent to the former Pope and Talbot wood-treating is protective, and reflects the best balance of tradeoffs considering effectiveness, long-term reliability, implementability, implementation risks, and reasonableness of costs. Long-term monitoring and maintenance will be performed to ensure the remedy remains protective over time. The selected remedial action therefore satisfies the requirements of ORS 465.314 and OAR 340-122-0090.

12. SIGNATURE

Kevin Parrett, Manager
Northwest Region Cleanup Program
Department of Environmental Quality

September 1, 2023
Date

13. ADMINISTRATIVE RECORD

ADMINISTRATIVE RECORD INDEX

Former Pope & Talbot Wood-Treating Site
St. Helens, Oregon

The Administrative Record consists of the documents on which the selected remedial action for the Site is based. The primary documents used in developing and evaluating RAAs for the former Pope & Talbot Wood-Treating Site are listed below. Additional background and supporting information can be found in the former Pope & Talbot Wood-Treating Site (ECSI No. 0959) project file located at DEQ Northwest Region Office, 700 NE Multnomah Street, Suite 600, Portland, Oregon and online.

SITE-SPECIFIC DOCUMENTS

Amec Environmental & Infrastructure, Inc. 2014. Draft Supplemental Remedial Investigation Report. May 22, 2014.

Bridgewater Group and Hart Crowser. 2003. Level II Ecological Risk Assessment. October 17, 2003.

Bridgewater Group and Kennedy/Jenks Consultants. 2006a. Human Health Risk Assessment, Pope & Talbot, Port St. Helens Site. November 28, 2006.

Bridgewater Group and Kennedy/Jenks Consultants. 2006b. Ecological Risk Assessment Summary Report. November 27, 2006.

Cascadia Associates. 2017. Phase 1 and 2 Offshore Data Gap Investigation Map Groundwater Discharge Areas and Sheen Occurrence. August 15, 2017.

Cascadia Associates. 2018. Progress Report. Results of the Offshore Data Gap Investigation. April 20, 2018.

Cascadia Associates. 2019. Map Creosote Sheen Occurrence Along Area 2 Shoreline. January 17, 2019.

Cascadia Associates. 2019. Feasibility Study Work Plan. November 4, 2019.

Cascadia Associates. 2020a. Updated Supplemental HHRA. January 2020.

Cascadia Associates. 2020b. Updated Supplemental Ecological Risk Assessment. January 2020.

Cascadia Associates. 2020c. Updated Supplemental Remediation Investigation Report. January 17, 2020.

DEQ. 1988. Preliminary Assessment. December 14, 1988.

DEQ. 1995. Order of Consent No. WMCSR-NWR-95-05, between Port of St. Helens (now Port of Columbia County) and DEQ. Effective April 13, 1995.

DEQ, 2014a. DEQ Comments on Supplemental Remediation Investigation Report, Proposed Draft Annotated Outline, November 22, 2013, Port of St. Helens/Former Pope & Talbot Wood Treating Site, 1550 Railroad Avenue, St. Helens, Oregon, ECSI #959, January 30, 2014.

DEQ, 2014b. E-mail from Deborah Bailey to Michelle Peterson re: PSH – Evaluation of Porewater and Dermal Risks from Water Contact in the Supplemental HHRA, March 6, 2014.

DEQ, 2020. Letter to Mr. Craig Allison with the Port, re: Conditional Approval, Updated Supplemental Remedial Investigation Report, Former Pope & Talbot Wood-Treating Site, ECSI No. 959. September 14.

DEQ, 2023. Staff Report, Recommended Remedial Action, May 31, 2023.

Ecology And Environment, Inc., 1990. Site Inspection. July 1990.

Evarts, Russel C, 2004, Geologic Map of the Ariel Quadrangle, Clark and Cowlitz Counties, Washington.

GeoEngineers. 2000. Remediation Investigation. April 7, 2000.

GeoEngineers. 2022. Revised Feasibility Study. September 22, 2022.

Harding Lawson Associates. 1994. Vadose Zone Contamination Investigation. January 28, 1994

STATE OF OREGON

Oregon's Environmental Cleanup Laws, Oregon Revised Statutes 465.200-.900, as amended by the Oregon Legislature in 1995.

Oregon's Groundwater Protection Act, Oregon Revised Statutes, Chapter 468B.

Oregon's Hazardous Substance Remedial Action Rules, Oregon Administrative Rules, Chapter 340, Division 122, adopted by the Environmental Quality Commission in 1997.

Oregon's Hazardous Waste Rules, Chapter 340, Divisions 100 - 120.

Oregon's Water Quality Criteria, Chapter 340, Division 41, Columbia Basin.

GUIDANCE AND TECHNICAL INFORMATION

DEQ. 2001a. Cleanup Program Quality Assurance Policy. September 1990, updated April 2001.

DEQ. Consideration of Land Use in Environmental Remedial Actions. July 1998.

DEQ. Green Remediation Policy. November 2, 2011.

DEQ. Guidance for Conducting Beneficial Water Use Determinations at Environmental Cleanup Sites. July 1998.

DEQ. Guidance for Conduct of Deterministic Human Health Risk Assessment. May 1998; updated May 2000.

DEQ. Guidance for Conducting Feasibility Studies. July 1998, updated 2006 and 2017.

DEQ. 2001b. Guidance for Ecological Risk Assessment: Levels I, II, III, IV. April 1998; updated December 2001.

DEQ. Guidance for Identification of Hot Spots. April 1998.

DEQ. Guidance for Use of Institutional Controls. April 1998.

DEQ. Human Health Risk Assessment Guidance, Environmental Cleanup Program, October 18, 2010.

MacDonald, D., Ingersoll, C. & Berger, T. Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. Archives of Environmental Contamination and Toxicology. 39, 20–31 (2000).

San Francisco Bay Regional Water Quality Control Board (SFBRWQCB), 2019. Environmental Screening Levels, Tier 1 ESLs, 2019 (Rev. 2). San Francisco Bay Regional Water Quality Control Board. Rev. 2.

Windward. 2013. Portland Harbor RI/FS, Remedial Investigation Report Appendix G, Baseline Ecological Risk Assessment, Final. Prepared for the Lower Willamette Group. Seattle, WA.

Table 1
Summary of RI Data Collection
Updated Supplemental RI Report
Former Pope & Talbot Wood-Treating Site
St. Helens, Oregon

Sample Count

Matrix	1996	1997	1998	1999	2000	2001	2003	2004	2005	2006	2007	2010	2011	2012	2013	2017	Total
NAPL	1	1										1		1			4
Groundwater	57	136	36	29	26	26	22	13	11	13	1	12	20	61			463
Porewater													11	63		30	74
Sediment	24						26	30	20				120	92	2	15	329
Seep Water	1		3														4
Soil	165		102										12		23		302
Surface Water	4		10													9	14
Total	252	137	151	29	26	26	48	43	31	13	1	13	163	217	25		1,175

Analytical Test Count

Method Group	1996	1997	1998	1999	2000	2001	2003	2004	2005	2006	2007	2010	2011	2012	2013	2017	Total
Dioxins	6																6
Fuels	75	89	66	18			22	11	11	12	1	25	121	61	25		537
Herbicides	105	90	65	18	17	18											313
Metals	105	89	67	18	17	18	11	6	3	5		12	23	61			435
SVOCs	140	99	80	21	18	20	48	41	31	13	0	12	126	193	25	45	867
VOCs	106	89	71	18	17	18						12	7			15	338
Other													136	209	25	15	385
Total	537	456	349	93	69	74	81	58	45	30	1	61	413	524	75	75	2,866

Analytical Results Count

Matrix	1996	1997	1998	1999	2000	2001	2003	2004	2005	2006	2007	2010	2011	2012	2013	2017	Total
NAPL	69	6										3		35			113
Groundwater	2,156	4,468	1,337	951	762	843	477	238	223	262	4	355	462	1,551			14,089
Porewater														2,226		80	2,226
Sediment	432						468	540	360				2,571	2,548	36	80	7,035
Seep Water	21		93														114
Soil	2,962		1,983										221		421		5,587
Surface Water	176		450													80	626
Total	5,816	4,474	3,863	951	762	843	945	778	583	262	4	358	3,254	6,360	457	240	29,950

Please refer to notes at end of table.

Cascadia Associates, LLC

Table 1
Summary of RI Data Collection
Updated Supplemental RI Report
Former Pope & Talbot Wood-Treating Site
St. Helens, Oregon

Analytical Tests by Matrix Count

Analyte Class	1996	1997	1998	1999	2000	2001	2003	2004	2005	2006	2007	2010	2011	2012	2013	2017	Total
NAPL																	
Dioxins	1																1
Fuels	1	1										1					3
Herbicides	1																1
Metals	2																2
SVOCs	1													1			2
VOCs	1																1
Groundwater																	
Fuels	43	88	22	18			22	11	11	12	1	24	18	55			325
Herbicides	43	90	22	18	17	18											208
Metals	42	89	22	18	17	18	11	6	3	5		12	20	61			324
SVOCs	47	99	27	21	18	20	22	11	11	13	0	12	20	64	0		385
VOCs	44	89	22	18	17	18						12					220
Porewater																	
PAHs														61		90	151
Other														56		120	176
Sediment																	
Fuels													89	6	2	32	129
Metals													3				3
SVOCs	24						26	30	20				94	67	2	64	327
VOCs													7			64	71
Other													124	153	2		279
Seep Water																	
SVOCs	1		3														4
VOCs			3														3
Soil																	
Dioxins	5																5
Fuels	27		34										14		23		98
Herbicides	57		33														90
Metals	57		35														92
SVOCs	63		40										12		23		138
VOCs	57		36														93
Other													12		23		35
Surface Water																	
Fuels	4		10													18	14
Herbicides	4		10														14
Metals	4		10														14
SVOCs	4		10													36	14
VOCs	4		10													9	14
Total	537	456	349	93	69	74	81	58	45	30	1	61	413	524	75	433	3,299

Acronyms/Abbreviations
PAHs = polycyclic aromatic hydrocarbons
SVOCs = semivolatile organic compounds
VOCs = volatile organic compounds
NAPL = nonaqueous-phase liquid
RI = Remedial Investigation
Other = Total Organic Carbon, Dissolved Organic Carbon, grain size, and/or percent solids

Notes
Sample Count = number of samples collected from each medium
Analytical Test Count = number of tests run for each chemical class
Analytical Results Count = number of individual analyte results for each medium
Analytical Tests by Matrix Count = number of tests run for each chemical class and each medium
SVOCs include PAHs by various methods; refer to the 2000 RI Report (GeoEngineers 2000) for a full list of SVOC analytes reported in the RI.

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Table 2
Summary of Risks
Former Pope & Talbot Wood Treating Site
St. Helens, Oregon

Source / Pathway	Excess Lifetime Cancer Risk		Hazard Index			Source	
	RME/Max Detected	CTE	RME/Max Detected	RME*	CTE		
Industrial Worker							
Outdoor Air / Inhalation	1E-06	3E-08	3.9E+02	NA	2.7E+01	Table F-8	2019 Updated HHRA
Indoor Air / Inhalation	2E-06	5E-08	3.9E+02	NA	2.7E+01	Table F-8	2019 Updated HHRA
Surface soil / direct contact	NA	NA	2.1E+00	NA	4.6E-01	Table F-13G	2019 Updated HHRA
Total	**4E-06**	**8E-08**	**7.7E+02**	NA	**5.4E+01**		
Excavation Worker							
Surface soil / direct contact	NA	NA	2.1E+00	NA	4.6E-01	Table F-13G	2019 Updated HHRA
Subsurface soil / direct contact-ingestion-inhalation	2E-09	1E-10	1.4E+00	6.4E-01	1.0E-01	Table F-13G	2019 Updated HHRA
Groundwater / direct contact-inhalation	NA	NA	3.9E+02	NA	2.7E+01	Table F-8	2019 Updated HHRA
Total	**2E-09**	**1E-10**	**3.9E+02**	**6.4E-01**	**2.8E+01**		
Construction Worker							
Surface soil / direct contact	NA	NA	2.9E-01	NA	2.4E-02	Table F-13G	2019 Updated HHRA
Subsurface soil / direct contact-ingestion-inhalation	6E-08	2E-08	1.4E+00	6.4E-01	5.8E-01	Table F-13G	2019 Updated HHRA
Total	**6E-08**	**2E-08**	**1.7E+00**	**6.4E-01**	**6.0E-01**		
Recreational Trespasser in Scappoose Bay							
Sediment / direct contact-ingestion-inhalation	2E-06	4E-07	3.7E-01	NA	5.4E-01	Table F-11	2019 Updated HHRA
Recreational Trespasser in Milton Creek							
Sediment / direct contact-ingestion-inhalation	9E-07	2E-07	9.7E-05	NA	2.5E-05	Table F-11	2019 Updated HHRA
Sport Fisher in Scappoose Bay							
Fish tissue / consumption (general)	2E-06	3E-06	NA	NA	7.9E-03	Table F-11	2019 Updated HHRA
Fish tissue / consumption (subsistence)	6E-05	3E-05	NA	NA	8.0E-02	Table F-11	2019 Updated HHRA
Sport Fisher in Milton Creek							
Fish tissue / consumption (general)	NA	NA	2.3E-03	NA	1.1E-03	Table F-11	2019 Updated HHRA
Fish tissue / consumption (subsistence)	NA	NA	1.9E-02	NA	1.1E-02	Table F-11	2019 Updated HHRA
DEQ Acceptable Risk Level	***1E-05***	***1E-05***	***1.0E+00***	***1.0E+00***	***1.0E+00***		

Notes:
NA explanations include:
- Surface soil / direct contact (industrial worker / excavation worker - Noncarcinogenic hazards were not evaluated in the 2006 HHRA.
- Groundwater / direct contact-inhalation (excavation worker) - Cancer risks and noncancer hazards from dermal exposures in water to semi-volatile compounds are not quantitatively evaluated; refer to the uncertainty discussion of dermal exposure for the excavation worker.
- Fish tissue / consumption (sport fisher) - The bioaccumulative PAHs are not carcinogenic.

RME - reasonable maximum exposure
CTE - central tendency exposure
HHRA - human health risk assessment
[A] The cancer risk and hazard index for surface water include all samples from Scappoose Bay and Milton Creek; the data were not segregated into exposure units.
Shading indicated total acceptable risk level exceeded.
*Two RMEs were calculated for the construction worker and excavation worker scenarios: 1) with all data and 2) without the statistical outlier (Dixon's Test, $p<0.05$), per EPA guidance (EPA, 2000; EPA, 2013a)

Cascadia Associates, LLC

Table 3

Upland and Riverbank Surface Soil Technology Screening

Port of Columbia County - Former Pope & Talbot Wood Treating Site

St. Helens, Oregon

General Response Action	Remedial Technology	Description	Screening Criteria			Screening Comments
			Effectiveness	**Implementability**	**Cost**	
NO ACTION	No Action	No Action	Not effective in achieving remedial action objectives (RAOs).	Easy to Implement	No capital or operation and maintenance (O&M) costs incurred.	Does not meet threshold criteria, but required to be retained for comparison purposes.
INSTITUTIONAL CONTROLS	Legal Restrictions, Regulations, and Covenants	May include restrictions such as: deed restrictions, easements, and covenants, attached to property-related documents; legal bans or controls of activities.	Can be effective at controlling human exposures, but less effective (or not effective) at controlling ecological exposures. Is not effective at controlling or reducing contamination migration. Most suitable for use in conjunction with other active technologies.	Likely to require acceptance and cooperation of multiple parties to implement.	Low	Potentially applicable to address human exposure in conjunction with other technologies and/or to address upland creosote contamination beneath existing fill cap.
	Contaminated Media Management Plan	Development and publication of protocols for handling and managing contaminated soil/riverbank during future work to protect workers, public health, ecological exposures, and the environment.	Effective for management of contaminated soils during future work. Effective at preventing human exposures. Not effective at preventing ecological exposures without other active technologies. Most suitable for use in conjunction with other active technologies. Is not effective at controlling or reducing contamination migration.	Easy to Implement	Low	Applicable in conjunction with other technologies and/or to protect excavation/construction workers from upland creosote contamination.
	Signage / Notifications / Advisories	Posting of signs and/or distribution of notifications regarding health concerns in area of contamination.	Can be effective at reducing human exposures via public education, but not effective at controlling ecological exposures. Is not effective at controlling or reducing contaminant migration. Most suitable for use in conjunction with other active remedial action technologies.	Easy to Implement	Low	Retain as potential technology to limit human health exposure.
	Monitoring	Development of sampling and analysis plan (SAP), quality assurance project plan (QAPP), and laboratory analysis of samples collected from soil.	Effective for documenting site conditions and exposure risks, evaluating migration and naturally occurring processes, and effectiveness of remediation actions. Does not address contaminant reduction or receptor exposures.	Currently implemented to the maximum extent feasible.	Low	Retain to monitor the effectiveness of selected remedial action alternative.
ENGINEERING CONTROLS	Physical Barriers (e.g., Fencing, Floating Booms)	The upland portions of the Site are currently fenced and access gates locked. Linked floating barriers (log booms) currently limited motorized boat access to a portion of the Site's riverbank (Cove Area).	Effective at controlling trespasser access to upland areas and riverbank in the Cove Area. Not effective in controlling trespassing along the entire length of the Site's shoreline. Not effective at reducing contaminant migration. Does not address or limit ecological exposure.	Upland is currently fenced. Relatively easy to extend log booms where existing offshore piling is present. May be difficult to obtain approval and install piling and barriers along the entire Site shoreline.	Low to Moderate	Existing chain-link fence will continue to mitigate upland trespassing and other barriers could be expanded to reduce boater and transient trespasser access to the Site's shorelines. These engineering controls have been retained and could be used in conjunction with other technologies to achieve RAOs.
	Stormwater Management	Regrading shoreline topography to promote infiltration outside inferred extent of NAPL and mitigate overland runoff towards adjacent surface water bodies and erosion of riverbank materials. In addition to regrading Site topography, could include the installation of stormwater collection, conveyance, and retention features.	Effective in mitigating overland flow and riverbank erosion. Except for localized areas of polychlorinated biphenyl's (PCBs), upland surface soil lack contaminants of concern (COC). Does not address contaminant reduction and subsurface mobility.	Easy to implement. Post-construction monitoring required.	Moderate	May be necessary to meet RAOs if used in conjunction with other technologies to prevent runoff from the site or riverbank erosion.

General Response Action	Remedial Technology	Description	Screening Criteria: Effectiveness	Screening Criteria: Implementability	Screening Criteria: Cost	Screening Comments
CONTAINMENT	Physical Barrier / Cap	Involves covering contaminated surface soil and riverbank material with clean material to prevent exposure. Upland surface soil consists of fill (dredged sand and gravel) imported to the Site after the wood treatment operations ceased. Except for localized gravel roadbeds, upland surface soil is expected to be clean. Installation of an engineered cap over impacted riverbank sediments is applicable. Armoring and/or vegetation can be used as a method of preventing riverbank erosion.	Effective at preventing direct contact with contaminated riverbank. Does not address contaminant reduction, but engineered cap could be designed to reduce contaminant mass flux and/or erosion of contaminated riverbank material. Cap design must be compatible with permit requirement and expected future Site use.	Site is largely vacant/undeveloped and the installation of a riverbank cap is feasible using common earth materials and land-based construction equipment. Permitting will be required (grading, stormwater, etc.) and work must be completed within the in-water work window. Cap would need to be compatible with current beneficial uses (e.g., ecological habitat) and its integrity maintained in perpetuity. Would require regrading of the shoreline and balanced cut/fill in flood plain. Would generate waste spoils for off-site disposal or on-site treatment.	Moderate to high planning, permitting and implementation costs associated with riverbank cap. Low to moderate long-term maintenance and performance monitoring costs.	Upland NAPL area is already sufficiently capped. Physical barrier / capping of riverbank in NAPL and contaminated groundwater seep areas is retained as a potential technology alone or in conjunction with other technologies to achieve RAOs.
	Adsorptive Cap	Installation of an engineered cap containing amendments (e.g., adsorptive materials such as activated carbon, biochar, oleophilic biobarrier, or organoclay) to promote the immobilization and biodegradation of NAPL and dissolved-phase COCs along the riverbank. These adsorptive amendments are usually emplaced directly on (or mixed into) contaminated media, as components in engineered caps, or within engineered mats that are placed on the contaminated area. The use of amendments in a shoreline cap does not preclude the need for a physical barrier to prevent erosion and direct contact by human and ecological receptors. The use an adsorptive cap is not applicable nor considered for addressing upland surface soil containing PCBs.	If implemented properly, an engineered riverbank cap with adsorptive amendments can be highly effective in mitigating the discharge of creosote NAPL and dissolved-phase COCs at concentration above PRGs. An adsorptive riverbank cap does not address upland contaminant source areas, but rather is designed to sequester and enhance the biodegradation of creosote COCs in groundwater before it discharges into the aquatic environment. Pilot testing of often required to assess effectiveness.	Extensive permitting required and work must be completed within the in water work window below ordinary high water. Cap would need to be compatible with current beneficial uses (e.g., ecological habitat) and its integrity maintained in perpetuity. Would require regrading of the shoreline and balanced cut/fill in flood plain. Would generate waste spoils for off site disposal or on site treatment.	Moderate to high planning, permitting, and implementation costs associated with riverbank cap. Low to moderate long-term maintenance and performance monitoring costs.	Reactive capping technologies have been retained to address the shoreline NAPL seeps and contaminated groundwater discharge.
REMOVAL AND DISPOSAL	Excavation	Mechanical removal of contaminated surface soil and riverbank. Excavation of some or all of the soil and riverbank containing COCs (e.g., PCBs, creosote-related constituents) for subsequent treatment and/or disposal. Focused excavation may include only higher concentrations or "hot spot" soil. Site restoration could include backfill with imported soil and regrading disturbed areas to prevent runoff or erosion.	Effective in removing hot spot soil and riverbank materials. Addresses direct exposure pathways (where applicable). Does not address or control ongoing contaminant migration unless combined with containment (e.g., adsorptive cap) or subsurface removal.	Implementation involves conventional land-based construction equipment and methods. Depending on extent of excavation and surface water conditions, may have short-term adverse impact on current land use and existing riparian / aquatic habitat.	High	Applicable for removal of surface hot spot riverbank material. Upland excavation of all upland soil containing COCs (e.g., PCBs, creosote-related constituents) does not appear to be required or feasible, but should be retained for detailed evaluation in the Feasibility Study (FS).
	Off-Site Disposal	Soil impacted by historical wood treating operations are considered a listed hazardous waste (F032, F034, and F035). Therefore, off-site disposal would likely have be at Chemical Waste Management in Arlington, Oregon, as a Corrective Action Management Unit (CAMU)-eligible waste.	Landfills are controlled, managed facilities that are effective in preventing future exposures. Removes listed contamination and generated hazardous waste from the flood plain.	Implementation involves CAMU eligibility process, transportation of contaminated media for potentially long distances, and potential macro-encapsulation at the landfill. Off-site transportation requires the elimination of free liquids from saturated excavation spoils.	High	Not a stand alone technology. Applicable for handling of excavated upland and riverbank soils.
	On-site Upland Landfill	Construction of a permitted upland landfill facility at the Site for the disposal of the excavated soil and riverbank material. Would require suitable area and acceptance by local, state and federal permitting agencies.	Effective at removing source material from cleanup area and placement in a self-managed waste facility. Addresses direct exposure pathways and migration by removing contaminant mass from cleanup area. Would require placement below clean cap and ongoing maintenance/monitoring of landfilled material.	On-site landfilling of hot spot soil (listed hazardous waste) below a clean cap is not compatible with site conditions (shallow groundwater, within the flood plain) or current/future site use (industrial).	High	Not retained because contaminated soil and sediment is a listed hazardous waste, shallow water table, and the Site is situated within the 100-year flood plain.

General Response Action	Remedial Technology	Description	Screening Criteria			Screening Comments
			Effectiveness	Implementability	Cost	
IN-PLACE PHYSICAL/ CHEMICAL TREATMENT	Chemical Oxidation	Chemically converts hazardous contaminants to less toxic compounds. Effective in destroying organic contaminants and oxidizing inorganic contaminants to less toxic/less mobile forms. Can include oxidant chemicals such as peroxides, permanganates, or ozone.	Can be highly effective at destruction of organic contaminants or oxidation of inorganics.	Equipment and vendors are readily available. Generally not appropriate for surface applications. Would be destructive to existing beneficial organics in soil.	High	Not retained because technology generally not appropriate for surface soil and riverbank applications without high implementation risks. Lower cost options exist.
	Soil Flushing	Circulation of water, steam, or an amended aqueous solution through the contaminated soil and riverbank to detach and collect particle-bound contaminants. The circulated water or steam is then recovered and treated.	Not appropriate or effective for NAPL recovery in the riverbank.	Difficult to maintain control of NAPL migration, amended water, and steam. Inefficient removal within fine-grained soil.	Moderate to High	Technology not retained as implementation risks are high and other more suitable technologies are available.
	Solidification / Stabilization	Contaminants are physically bound or enclosed in a stabilized mass (solidification) or chemical reactions are induced between the stabilizing agent and contaminants to reduce the contaminant mobility (stabilization). Methods may include the addition of Portland cement, lime, kiln dust, pozzolan, sorbent clay (i.e., bentonite), and proprietary reagents.	Potentially suitable at reducing mobility of and accessibility to site contaminants. Difficult to ensure complete enclosure of upland soil and riverbank with *in-situ* implementation. Reduction of bioavailability of organic contaminants could be effective with use of carbon (or similar) addition to upland soil and riverbank.	Solidifying and/or stabilizing upland areas (e.g., paving) could be compatible for industrial land use. However, solidification of contaminated riverbank is not compatible with efforts to enhance riparian and shallow water habitat. Stabilization of the contaminated riverbank would likely require regrading and the use of adsorptive amendments.	High implementation cost, except that incorporation of additives into cap, which can be relatively inexpensive.	Stabilization (immobilization) of creosote-impacted riverbank material retained as potentially useful technology when combined with containment and/or capping. Other process options (e.g., vitrification, soil freezing) not retained because less suitable to Site conditions and high cost.
IN-PLACE BIOLOGICAL TREATMENT	Enhanced Bioremediation	Add amendments (e.g., nutrients, electron acceptors) to stimulate the natural degradation or use engineered capping materials to facilitate/enhance the bioremediation of creosote constituents in riverbank material.	Not effective or considered for upland PCB-impacted soil. Creosote NAPL is expected to severely limit microorganism activity / performance. Can be difficult to achieve full coverage and have meaningful contaminant mass reduction within a reasonable amount of time. Only effective if coupled with containment technologies.	Would require regrading of the riverbank and must be able to withstand seasonal flooding and hydrodynamics of the river system. Would need to be coupled with either an upland containment wall or passive adsorptive barrier.	Moderate	Not retained as standalone technology in treating creosote NAPL without soil flushing (which was not retained) and high implementation risks. Could be effective on dissolved PAHs, with low implementation risks, if used in conjunction with NAPL containment technologies (e.g., barrier wall and/or reactive permeable barrier).
	Phytoremediation	The process of using plants to remove, transfer, stabilize, and/or destroy contaminants in upland soil or riverbank.	Can be effective at removing a variety of shallow dissolved-phase organic compounds from soil / riverbank through plant uptake in the plant rhizosphere. Upland contamination is buried beneath 5 to 8 feet of clean fill. Not effective in removing creosote NAPL.	Would require planting of suitable plants for site conditions, or changing of site conditions to accommodate more trees along the Site's shoreline. May not be compatible with current and future industrial site use.	Low	Not as standalone technology for addressing NAPL. However, is retained for addressing dissolved-phase mass flux.
NATURAL PROCESSES	Monitored Natural Recovery	Naturally occurring physical processes (advection, desorption, dispersion, diffusion, dilution, resuspension, and volatilization), and biological processes (biodegradation) reduce contaminant concentrations. Process is monitored to verify exposures.	Not effective in reducing NAPL mass/mobility or achieving RAOs within a reasonable amount of time within the priority action areas (PAAs).	Easy to implement. Must be combined with long-term monitoring of COC in sediment porewater and surface water. Must be used in conjunction with NAPL removal and/or containment.	Low	Natural recovery has been ongoing since the wood treating operations ceased in 1960. Within the PAAs, natural recovery alone (i.e., in the absence of other technologies) is not effective and will not achieve RAOs within an reasonable amount of time.

General Response Action	Remedial Technology	Description	Screening Criteria: Effectiveness	Screening Criteria: Implementability	Screening Criteria: Cost	Screening Comments
EX-SITU PHYSICAL/ CHEMICAL TREATMENT	Separation	Use of physical means to separate coarse-grained material (which would have less contamination) from Native Soil for beneficial reuse or separation of debris prior to further treatment or disposal.	Generally not effective for upland soil and riverbank material encountered at the Site.	Commercial equipment is available for separation (i.e., sieves). Separated sand may be available for potential beneficial use (would require verification testing and identification of potential use). Bench scale testing may be needed to define specific operating parameters.	Low to Moderate	Sediments previously identified to have high organic content. Not retained because the impacted material removed would primarily consist of fine-grained material.
	Soil Washing	Contaminants are separated from the excavated soil with wash water augmented with additives to help remove creosote.	Most suitable for highly refined petroleum products (e.g., gasoline, diesel) in coarse-grained material. Less effective on viscous contamination like creosote in fine-grained material.	Elutriate would require treatment and disposal, which could significantly increase the overall cost of treatment. Bench-scale testing would be required during design. Requires staging area for treatment or transport to approved off-site facility. Air quality standards may be affected by open-air treatment methods.	High	Not retained because not compatible with creosote-impacted fine-grained soil and more cost-effective options are available.
	Chemical Oxidation	Includes the application of chemical oxidants for the purpose of remediating excavated soils. Generally involves reduction / oxidation (redox) reactions that chemically convert hazardous contaminants to less toxic or less mobile forms.	Can be effective in reducing particle-bound PAHs in well mixed media slurry. May not be cost effective on organic-rich media with creosote NAPL due to the large amounts of oxidizing agent required.	Risks associated with handling of oxidant in above-ground application. Bench-scale testing would be required during design. Requires staging area for treatment or transport to off-site facility. Air quality standards for site workers may be affected by open-air treatment methods.	High	Not retained because technology has relatively high implementation risks to workers and less costly options are equally protective and available.
	Chemical Extraction	Excavated upland surface and riverbank soil is mixed with an extractant (e.g., acid or solvent), which dissolves the contaminants. The solution is then placed in a separator to remove the contaminant/extractant mixture for treatment.	Most suitable to semi-volatile or inorganic contamination. Less effective in fine-grained soil/sediment.	Difficult to remove all contaminant/extractant from organic-rich sediment and would likely require finish treatment. Elutriate would require treatment and disposal, which could significantly increase the overall cost of treatment. Bench-scale testing would be required during design. Requires staging area for treatment or transport to off-site facility. Air quality standards may be affected by open-air treatment methods.	High	Not retained because not compatible with sediment grain size and more cost-effective options available.
	Solidification / Stabilization	Contaminants are physically bound or enclosed in a stabilized mass (solidification) or chemical reactions are induced between the stabilizing agent and contaminants to reduce the contaminant mobility (stabilization). Methods may include the addition of Portland cement, lime, kiln dust, pozzolan, sorbent clay (i.e., bentonite), and proprietary reagents. PCB impacted gravel could potentially be used for asphalt aggregate for onsite paving.	Can be effective at reducing mobility of contaminants or solidifying for disposal.	Requires staging area for treatment or transport to off-site facility. Dewatering of riverbank soil may be necessary. Air quality standards for site/occupational workers may be affected by open-air dewatering and stabilizing mixing methods.	Moderate	Retained as a potential component off-site disposal or onsite treatment.

Table 3

General Response Action	Remedial Technology	Description	Screening Criteria			Screening Comments
			Effectiveness	Implementability	Cost	
EX-SITU PHYSICAL/ CHEMICAL TREATMENT (CONTINUED)	Solar Detoxification	Contaminants are destroyed by photochemical and thermal reactions using ultraviolet energy in sunlight or artificial UV light. Usually involves application of catalyst agent.	Can be effective at treating a variety of organic compounds. Most effective when used with a catalyst agent (i.e., titanium dioxide). Does not address inorganic contaminants such as metals.	Implementation with sunlight limited by availability (not effective during nighttime and limited effectiveness during cloudy/wet seasons). Requires staging area for treatment or transport to off-site facility. Air quality standards for site/occupational workers may be affected by open-air treatment methods.	Moderate	Not retained because adequate space is not available at the site and limited usefulness for creosote.
EX-SITU BIOLOGICAL TREATMENT	Land Treatment/ Landfarming	Land treatment reduces contaminant concentrations through biological processes. Excavated soil is placed in lined and bermed treatment cells and manipulated as necessary to improve biological conditions (such as tilling material to aerate and mix in nutrient amendments).	Can be effective at removing PAHs in soil. Most effective with control of moisture, heat, nutrients, oxygen, and pH to enhance biodegradation. Effectiveness is reduced by the presence of NAPL and low ambient temperatures during 8 months of the year.	Requires large upland area for soil treatment. Requires the dewatering and removal of debris from soil. Erosion and stormwater controls need to address ponding and/or contaminated runoff. Bench-scale testing would be required to define operating parameters, particularly during wet weather. Long anticipated implementation period with extensive performance and confirmation monitoring. Air quality standards may be affected by open-air treatment methods.	Moderate	Not retained because adequate space is not available at the site and limited usefulness for creosote.
	Biopiles	Soil is mixed with amendments, placed in aboveground enclosures, and aerated with blowers or vacuum pumps. Microorganisms present degrade the contaminants present.	Effective at removing volatile organic contamination from soil. Most effective with control of moisture, heat, nutrients, oxygen, and pH to enhance biodegradation. Effectiveness is reduced by the presence of NAPL.	Requires area for soil treatment or transport to an off-site facility. Requires initial dewatering of saturated soil and ongoing moisture control. Requires stormwater and leachate management and control. Bench-scale testing would be required to define operating parameters. Air quality standards may be affected by aeration treatment methods.	Moderate to High	Not retained because adequate space is not available at the site and limited usefulness for creosote.
	Slurry-phase Biological Treatment	A slurry of soil with water and other additives is mixed to keep solids suspended and microorganisms present in the slurry in contact with the soil contaminants. When complete, the slurry is dewatered and the treated soil/sediment is disposed on or offsite.	Can be effective at treating a variety of organic compounds and diluting NAPL into manageable concentrations.	Requires staging area for treatment cell or transport to an off-site facility. Slurry dewatering generates liquid waste stream that will require treatment or disposal. Bench-scale testing would be required to define operating parameters. Air quality standards may be affected by open-air treatment methods.	High	Not retained because other more cost-effective options available.
EX-SITU THERMAL TREATMENT	Off-site Incineration	High temperatures are used to combust (in the presence of oxygen) organic constituents in hazardous wastes.	High temperatures result in generally complete decomposition of organic chemicals. Effective across wide range of soil characteristics.	Requires air pollution control device. Listed hazardous waste designation will likely rule out acceptance into most treatment facilities. Involves high energy consumption.	High	Unlikely that a permitted facility will accept this listed hazardous waste stream for treatment. If found, anticipate significant cost for transportation and treatment. Other less expensive technologies available.
	On-Site Thermal Desorption / Pyrolysis / Hot Gas Decontamination	Waste soils are heated to either volatilize (desorption and hot gas) or to anaerobically decompose (pyrolysis) organic contaminants. Off-gas is collected and treated.	Effective at removing organic materials from excavated sediment/soil (particularly volatile organics). Pyrolysis generally used for semi-volatiles. Efficiency of PAH thermal desorption will be approximately 90%.	Requires the on-site mobilization of thermal desorption units and permitting with local land use and air quality agencies. Requires dewatering of excavated media, off-gas treatment, and extensive confirmation sampling.	High	Not retained because other more cost-effective options available.

Note:

Shading indicates technologies that have been eliminated from consideration.

Table 4

Upland Subsurface NAPL, Soil, and Groundwater Technology Screening

Port of Columbia County - Former Pope & Talbot Wood Treating Site

St. Helens, Oregon

General Response Action	Remedial Technology	Description	Screening Criteria			Screening Comments
			Effectiveness	Implementability	Cost	
NO ACTION	No Action	No Action	Not effective in achieving remedial action objectives (RAOs)	Easy to Implement	No capital or operations and maintenance (O&M) costs incurred	Does not meet threshold criteria, but required to be retained for comparison purposes.
INSTITUTIONAL CONTROLS	Legal Restrictions, Regulations, and Covenants	May include restrictions such as: deed restrictions, easements, and covenants, attached to property-related documents; legal bans or controls of activities.	Can be effective at controlling human exposures, but less effective (or not effective) at controlling ecological exposures. Is not effective at controlling or reducing contamination migration. Most suitable for use in conjunction with other active technologies.	Likely to require acceptance and cooperation of multiple parties to implement.	Low	Potentially applicable to address human exposure in conjunction with other technologies and/or to address upland creosote contamination beneath existing fill cap.
	Groundwater Use Restrictions	Restrict use of groundwater within the locality of facility (LOF).	Effective at preventing direct contact, but use restrictions are not effective at controlling or reducing contaminant migration. Most suitable for use in conjunction with other active technologies.	As there is no planned future use of on-site groundwater, or off-site property owners to coordinate with, this can be easily implemented.	Low costs associated with implementing the use restrictions	Applicable for precluding the future use of groundwater for industrial, irrigation, or domestic use. Not applicable at addressing migration to Milton Creek or Scappoose Bay.
	Monitoring	Laboratory analysis of groundwater samples for assessing the effectiveness of other remedial technologies.	Effective for documenting site conditions and exposure risks, evaluating migration and naturally occurring processes, and effectiveness of remediation actions. Does not address contaminant reduction or receptor exposures.	Easy to Implement	Low	Applicable to confirm effectiveness of other technologies.
ENGINEERING CONTROLS	Control of Building heating ventilation and air conditioning (HVAC) System	Use HVAC system to maintain positive pressure in buildings overlying creosote nonaqueous phase liquid (NAPL).	Effective in mitigating potential risk of vapor intrusion in buildings overlying highly concentrated hot spots. Does not address contaminant reduction. Generally used in conjunction with other engineering controls.	Easy to implement. Post-construction monitoring required.	Low	May be necessary to meet remedial action objectives (RAOs) if used in conjunction with NAPL containment technologies.
	Vapor Barriers	Installation of low-permeable barriers beneath buildings overlying groundwater containing creosote NAPL to prevent vapor intrusion.	Effective in mitigating potential risk of vapor intrusion in buildings overlying highly concentrated hot spots. Does not address contaminant reduction.	Difficult to implement on existing structures. Easy to implement during future construction. Post-construction monitoring required.	Moderate	May be necessary to meet RAOs if used in conjunction with NAPL containment technologies.
	Alternative Water Supply	Site is currently serviced by municipal water supply. An easement and equitable servitudes (EES) precluding the use of groundwater and surface water within the LOF will likely be a part of the Site remedy.	Effective in preventing the use of contaminated groundwater. No current or likely future use of contaminated groundwater. Does not address NAPL migration to surface water.	Easy to expand municipal water service. Use restrictions requires local and State of Oregon Water Resources Department (OWRD) approvals.	High capital costs, low to moderate O&M costs.	Not retained as the Site is currently serviced by municipal supply and the beneficial use of shallow groundwater limited to discharge to surface water.
	Wellhead Construction or Treatment	Site-specific construction techniques to avoid pumping from contaminated zones or treatment at individual impacted water supply wells with the use of *Ex-Situ* Physical/Chemical/Thermal treatment.	Effective in reducing contaminant concentrations in groundwater prior to use either through use of a well design that does not pump impacted groundwater or wellhead treatment.	Easy to implement. Treatment units are readily available. Requires ongoing testing and system maintenance to remain effective.	Low to high capital costs and O&M costs, depending on treatment technology.	Not retained as the Site is currently serviced by municipal supply and the beneficial use of groundwater is limited to discharge to surface water.

General Response Action	Remedial Technology	Description	Screening Criteria			Screening Comments
			Effectiveness	Implementability	Cost	
CONTAINMENT	Physical Barrier - Cutoff Wall	Installation of vertical barriers (e.g., sheet piling, soil-bentonite slurry wall, grout, etc.) to prevent migration of groundwater containing creosote NAPL.	Effective at preventing lateral migration. Requires keying into underlying Basalt Bedrock. Surface cap and/or hydraulic control often necessary as supplemental measures to achieve containment.	Moderately easy to implement using conventional construction equipment. Requires pre-construction bench-scale testing and post-construction monitoring. May be difficult to achieve seal in Basalt Bedrock.	High implementation costs. Low to moderate O&M and long-term monitoring costs.	Potentially applicable technology for Site conditions.
	Riverbank - Engineered Cap	Installation of an engineered cap over impacted riverbank soil is applicable. Riverbank caps may include placement of clean soil, gravel, armoring, and/or vegetation as a method of preventing riverbank erosion.	Effective at preventing direct contact with contaminated riverbank soil. Does not address contaminant reduction, but engineered cap could be designed to reduce contaminant mass flux and/or erosion of contaminated riverbank material. Cap design can also be compatible with expected future site use.	Site is largely vacant/undeveloped and the installation of a riverbank is cap feasible using standard construction equipment. Extensive permitting required and work must be completed within the in-water work window below ordinary high water. Cap would need to be compatible with current beneficial uses (e.g., ecological habitat) and its integrity maintained in perpetuity. Would require regrading of the shoreline and balanced cut/fill in flood plain. Generate waste spoils for off-site disposal or on-site treatment.	Moderate to high planning, permitting and implementation costs associated with riverbank cap. Low to moderate long-term maintenance and performance monitoring costs.	Upland NAPL area is already sufficiently capped. Physical barrier / capping of riverbank in NAPL seep areas is retained as a potential technology alone or in conjunction with other technologies to achieve RAOs.
	Riverbank Permeable Reactive Barrier	Installation permeable reactive cap to prevent migration of NAPL from upland areas to Scappoose Bay. A number of reactive materials are available for consideration including activated carbon, biochar, organoclay, and oleophilic biobarriers.	Effective at prevent lateral migration of erodible soil along the riverbank or NAPL/groundwater at seeps. A permeable reactive cap is designed to reduce contaminant mass flux and/or erosion of contaminated riverbank material.	Moderately easy to implement using conventional construction equipment. Requires pre-construction bench-scale testing and post-construction monitoring. Extensive permitting required and work must be completed within the in-water work window. Cap would need to be compatible with current beneficial uses (e.g., ecological habitat) and its integrity maintained in perpetuity. Would require regrading of the shoreline and balanced cut/fill in flood plain. Would generate waste spoils for off-site disposal or on-site treatment.	High implementation costs, low to moderate O&M and long-term monitoring costs.	Potentially applicable technology for Site conditions.
	Pumping / Hydraulic Containment	Extraction well(s) with submersible pumps to lower the water table and create hydraulic gradients that direct contaminant migration into the extraction wells situated along the Site's shoreline. Extracted groundwater would require treatment before discharge (see *Ex-Situ* Physical/Chemical/ Thermal Treatment).	Effective in porous soils for preventing further contaminant migration. May also be used in conjunction with other technologies. Not efficient for complete removal of contaminant mass.	Existing monitoring wells could be utilized, although new and/or larger wells will likely be needed to capture full length of area of concern. Extraction of large volumes of water may be required to contain the discharge of groundwater to the river. Discharge of treated water would need to be permitted.	Moderate to high capital costs due to anticipated high pumping rates and anticipated treatment required prior to disposal. New extraction wells would likely be required. Moderate to high O&M costs.	Potentially applicable technology for Site conditions.
	Pump and Treat Using Vertical Extraction Wells	Extraction wells with submersible pumps and/or belt skimmers within the upland NAPL areas to reduce the volume and mobility of groundwater containing NAPL. Oil-water separation and treatment of extracted groundwater would be required before discharge (see *Ex-Situ* Physical / Chemical / Thermal Treatment).	Effective in porous soils for reducing the mobility of NAPL. Less effective on NAPL in fine-grained soil. Generally not effective in significantly reducing contaminant mass unless combined with other technologies.	Existing monitoring wells could be utilized, although new and/or larger wells likely needed to capture full length of area of concern. Extraction of large quantities of water may be required to contain discharge near shoreline with limited NAPL recovery / mass reduction. Discharge of treated water to surface water would likely be difficult to permit and routinely meet permit conditions.	Moderate to high capital costs due to installation of extraction wells and treatment system, disposal. New extraction wells likely required. Moderate to high O&M costs.	Not retained as a standalone technology. Potentially applicable if used sparingly in conjunction with containment technologies.

General Response Action	Remedial Technology	Description	Screening Criteria			Screening Comments
			Effectiveness	Implementability	Cost	
REMOVAL AND DISCHARGE (NAPL AND GROUNDWATER)	Pump and Treat Using Horizontal Cut-off Trench(es)	Trench filled with porous media along the top of riverbank immediately upgradient of NAPL seeps. Trench contains gravity drains to sump/pump. Oil-water separation and treatment of extracted groundwater would be required before discharge (see *Ex-Situ* Physical / Chemical / Thermal Treatment).	Effective in reducing NAPL migration to riverbank and surface water. May also be used in conjunction with other technologies.	Would likely require trenching down to Basalt Bedrock using long-reach trackhoe and management of contaminated soils. Treatment, management, and discharge of recovered water and creosote would likely require extensive long-term oversight. Discharge of treated water to surface water would likely be difficult to permit and routinely meet permit conditions.	Moderate to High	Potentially applicable technology for Site conditions.
	Discharge to Surface Water	Discharge of recovered and treated water into surface water. Municipal sanitary sewer supply is not available.	Effective for disposal of extracted groundwater. Oil-water separation and treatment of water would be necessary prior to disposal.	A discharge permit would be required and would likely be difficult to obtain. Extensive treatment of water would be needed to meet permit criteria and offshore RAOs. Noncompliant discharge has the potential to confound or interfere with in-water RAOs (no sheen and ΣSWTU < 1)	Moderate to high disposal costs depending upon treatment required, permit fees, and monthly usage fees.	Not applicable as there is no suitable location for surface discharge and high implementation risks.
	Discharge to Reinjection Wells	Upland discharge of extracted and treated water into the granular Fill Zone outside the inferred NAPL areas.	Moderate effectiveness, depending upon whether injection wells can be adequately located to prevent increasing groundwater gradient.	Underground injection control permit required for reinjection.	Moderate to high capital and O&M costs for reinjection wells.	Potentially applicable discharge option if used in conjunction with limited groundwater extraction.
	Reuse	Reuse of treated water for non-potable use such as industrial and irrigation.	Effective for treated, extracted groundwater.	A suitable on-site use would need to be identified that could accommodate a steady flow rate in all seasons. Treatment would be required prior to reuse.	Moderate to high costs depending upon storage, treatment, pumping and conveyance requirements.	No identified potential use suitable for flow rate expected from extraction system.
REMOVAL AND DISPOSAL (SOIL)	Excavation	Mechanical removal of contaminated soil and riverbank. Excavation of some or all of the soil and riverbank containing creosote NAPL for subsequent treatment and/or disposal. Focused excavation may include only higher concentrations or "hot spot" soil. Site restoration could include backfill with imported soil and regrading disturbed areas to prevent runoff or erosion.	Effective in removing hot spot soil and riverbank. Addresses direct exposure pathways (where applicable) and migration by reducing or controlling NAPL migration.	Implementation involves conventional construction equipment and methods. Depending on extent of excavation, may have short-term adverse impact on current land use and existing riparian / aquatic habitat.	High	Applicable for removal of hot spot riverbank material. Upland excavation of all upland soil containing creosote NAPL does not appear to be required or feasible, but should be retained for detailed evaluation in the FS.
	Off-Site Disposal	Soil impacted by wood treating operations is considered a listed hazardous waste. Therefore, off-site disposal would likely be at Chemical Waste Management in Arlington, Oregon as a Corrective Action Management Unit (CAMU)-eligible waste.	Landfills are controlled, managed facilities that are effective in preventing future exposures. Removes listed contamination and generated hazardous waste from the flood plain.	Implementation involves CAMU eligibility process and transportation of contaminated media on public roads for potentially long distances. Transportation by truck requires elimination of free liquids from saturated excavation spoils.	High	Not a stand alone technology. Applicable for handling of excavated sediment and riverbank.
REMOVAL AND DISPOSAL (SOIL)	Onsite Upland Landfill	Construction of a permitted upland landfill facility at the Site for the disposal of the excavated soil. Would require suitable area and acceptance by permitting agencies.	Effective at removing source material from cleanup area and placement in a self-managed waste facility. Addresses direct exposure pathways and migration by removing contaminant mass from cleanup area. Would require placement below clean cap and ongoing maintenance/monitoring of landfilled material.	On-site landfilling of hot spot soil (listed hazardous waste) below a clean cap is not compatible with current and future site use (industrial) and permitting is unlikely within the 100-year flood plain.	High	Not retained because contaminated soil and sediment is a listed hazardous waste and the Site is situated within the 100-year flood plain.
	Chemical Oxidation	Includes the application of chemical oxidants such as peroxides, permanganates, or ozone for the purpose of remediating contaminated groundwater. Generally involves reduction/oxidation (redox) reactions that chemically convert hazardous contaminants to less toxic or less mobile forms.	Can be effective at destruction of organic contaminants in homogeneous porous soil. Significantly less effective and difficult to achieve uniform treatment in heterogenetic fine-grained soil matrix. Would need to be coupled with groundwater recirculation, which could mobilize residual NAPL. Generally not effective when soil matrix contains significant amounts of wood debris (e.g., buried piling in former operational surface).	Would be difficult to get uniform contact of oxidant with NAPL in thin sand layers and would require multiple injections and/or mixing points. Could be implemented as slurry but would require significant containment effort (such as installation of sheet piling). Care would be needed to prevent secondary impacts (such as from mobilized NAPL or metals) during oxidation.	Moderate to High	Not retained because it would be difficult to ensure adequate coverage and has high implementation risks.

General Response Action	Remedial Technology	Description	Screening Criteria			Screening Comments
			Effectiveness	Implementability	Cost	
IN-SITU PHYSICAL / CHEMICAL / THERMAL TREATMENT	Air Sparging / Soil Vapor Extraction (SVE)	Injecting air below the water table to treat organics in groundwater, combined with soil vapor extraction in vadose soil. Increasing the contact between water and air to enhance volatilization.	Effective for volatile contamination. Not effective on semi-volatile polycyclic aromatic hydrocarbons (PAHs) and residual NAPL. Would require shallow vapor extraction to prevent uncontrolled vapor migration. Sparging will turn plume aerobic which will interfere with monitored natural attenuation (MNA) processes already in effect.	Radius of influence in fine-grained matrix would require multiple injection and recovery points. Equipment and technology for air sparging and SVE is readily available. Sparging would cause groundwater mounding that could increase NAPL mobility.	Moderate	Not retained because Site conditions would severely limit effectiveness. High implementation risks.
	Steam Flushing/Steam Stripping	Steam is injected into the contaminated aquifer to vaporize less volatile organics.	May increase temperature of water discharging into river. Used in conjunction with vapor recovery. May be effective for increasing usability of SVE for low-volatility compounds.	Equipment and technology are readily available. Treatment of recovered vapors would likely be required. Could mobilize residual NAPL and would likely require significant containment effort.	High	Not retained due to high implementation risks.
	Passive / Reactive Riverbank Cap	Barriers placed across groundwater movement that allows passage of water while facilitating degradation or removal of contaminants. Reactive materials can be incorporated in riverbank cap to treat groundwater prior to emergence into river (reactive cap).	Can be effective in controlling NAPL migration and doesn't require groundwater extraction and treatment.	Could be implemented using conventional excavation, shoring, and backfill equipment. Extensive long-term monitoring required. Relatively easy to add reactive materials to riverbank caps.	High costs for installation. Low to moderate costs for performance and compliance monitoring, and periodic maintenance. Relatively low incremental cost to add to riverbank cap.	Potentially applicable technology for Site conditions if used in conjunction with containment technologies.
	Smoldering	Self-sustaining treatment for active remediation to thermally oxidize NAPL contaminants in the subsurface. After initial ignition, the process is maintained by using adjacent contaminants as the fuel source for continued combustion.	Can be implemented below the water table, although operation below the water table may impact the efficiency of the heating units. Control of the combustion is maintained by adjusting the supply of oxygen. Will require the use of SVE system to capture vapors from smoldering process. Radius of influence (ROI) on the order of 7 feet has been documented in field studies. May result in an increase in the temperature discharging to the River.	Would require remediation equipment and infrastructure similar to air sparge/soil vapor extraction to control air flow and vapor recovery. Limited full-scale examples.	Limited full-scale examples available for estimating purposes. Expect the implementation costs to be high due to drilling and equipment costs.	Potentially applicable technology for further consideration; however it is a relatively new technology and may have significant risk related to effectiveness and Implementability compared to other technologies.
IN-SITU PHYSICAL / CHEMICAL / THERMAL TREATMENT (CONTINUED)	Solidification / Stabilization	Contaminants are physically bound or enclosed within a stabilized mass (solidification and vitrification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization), or additives are used to reduce mobility or bioavailability of contaminants (immobilization). Could be directly applied/mixed with soil or applied as part of an active capping approach.	Potentially suitable at reducing mobility of and accessibility to site contaminants. Difficult to ensure complete enclosure of upland soil and riverbank with *in-situ* process. Reduction of bioavailability of organic contaminants could be effective with use of (for example) carbon addition to soil and riverbank.	Difficult to obtain full stabilization *in-situ* in heterogeneous subsurface. Technologies such as vitrification to solidify mass would require significant power supply. Incorporation of additives into cap in order to stabilize mass is relatively simple.	High implementation cost, except that incorporation of additives into cap material relatively inexpensive.	Potentially applicable technology for Site conditions.
	EcoSPEARS®	EcoSPEARS® are an emerging proprietary remediation product designed primarily for removal of PCBs (although they may be suitable for other persistent pollutants as well) from sediments via sorption onto the polymer material that is pushed into the surface sediment.	EcoSPEARS® are not suitable for upland or subsurface media (groundwater).	It is not expected that the EcoSPEARS® could be installed in the upland or bank areas.	Limited full-scale examples available for estimating purposes. Expect implementation costs to be moderate to High due to the expected treatment area.	Not retained because the technology is not suitable for upland or subsurface implementation.
	Multi-Phase Extraction (MPE)	MPE provides simultaneous extraction of soil vapor, contaminated groundwater, and separate phase liquid using single vacuum pump, multiple in-well pumps, or bioslurping.	Generally effective for NAPL removal in low to moderate soil permeability. May require vapor effluent treatment.	Equipment and technology for MPE are readily available. Treatment of recovered soil vapors and groundwater would be required prior to discharge.	Moderate to high capital and O&M costs. Higher costs if vapor treatment needed.	Not retained because effective less costly passive containment technologies exist.

General Response Action	Remedial Technology	Description	Screening Criteria			Screening Comments
			Effectiveness	Implementability	Cost	
IN-SITU BIOLOGICAL TREATMENT	Enhanced Bioremediation	Addition of nutrients, electron acceptors, or other amendments to groundwater to enhance bioremediation.	Not likely to be effective in reducing NAPL mass and mobility without groundwater recirculation. Could be effective in cut off trench downgradient of primary NAPL zones.	Injecting amendments below the water table could mobilize NAPL. Uniform treatment performance would require extensive monitoring and oversight.	Moderate to high implementation and O&M costs. Hight cost if NAPL containment is needed.	Not retained as standalone technology. Potentially applicable if used in conjunction with containment or NAPL cut off technology.
	Phytoremediation	The process of using plants to remove, transfer, stabilize, and/or destroy contaminants in groundwater.	Can be effective at removing a variety of organic compounds in shallow groundwater through plant uptake in the plant rhizosphere. Not effective in limiting NAPL mobility, particularly in deeper sand layers.	Would require planting of suitable plants for Site conditions or changing of Site conditions to accommodate plants (such as regrading the riverbanks).	Moderate	Not retained because incompatible with Site conditions. Not effective as depth to NAPL is expected to be deeper than plant rhizosphere.
IN-SITU NATURAL PROCESSES	Monitored Natural Recovery	Naturally occurring physical processes (advection, desorption, dispersion, diffusion, dilution, resuspension, and volatilization), and biological processes (biodegradation) reduce contaminant concentrations. Process is monitored to verify exposures.	Not effective in reducing NAPL mass and mobility within a reasonable time frame. Anerobic degradation of PAHs is slow and NAPL will continue to be long-term source of toxicity to aquatic receptors if not combined with containment technology.	Easy to implement. Requires long-term monitoring of NAPL and COCs in groundwater.	Low	Natural recovery alone is not effective in achieving RAOs. Must be used in conjunction with NAPL containment.
EX-SITU PHYSICAL / CHEMICAL / THERMAL TREATMENT (SOIL)	Solidification / Stabilization	Contaminants are physically bound or enclosed in a stabilized mass (solidification) or chemical reactions are induced between the stabilizing agent and contaminants to reduce the contaminant mobility (stabilization). Methods may include the addition of Portland cement, lime, kiln dust, pozzolan, sorbent clay (i.e., bentonite), and proprietary reagents.	Potentially suitable at reducing mobility of and accessibility to contaminants in excavated material prior to disposal.	Easy to implement. Amendments would be mixed into excavated material using common construction equipment.	High to very high implementation cost.	Solidification and stabilization are potentially applicable if used in conjunction with excavation/ removal and either on-site or off-site disposal.
EX-SITU PHYSICAL / CHEMICAL / THERMAL TREATMENT (GROUNDWATER)	Dewatering	Management and treatment of water as part of a saturated soil removal action. Methods may include passive dewatering in lined/bermed stockpiles, on barges, in geotextile tubes (filters), filter presses or other mechanical dewatering methods, or dewatering by adding chemical reagents or adsorptive materials.	Various methods can be effectively used (selected based on site conditions and degree of dewatering needed) to remove water from removed saturated media. Debris may need to be removed from soil prior to dewatering. Resultant water may need to be treated prior to disposal.	Fine-grained nature of soil may require long drying times and significant operational effort to meet landfill free liquid standards. Water removed from the contaminated media would require either treatment, evaporation, or absorptive onto a solid material (e.g., perlite).	Low to Moderate	Not a stand-alone technology. Retained as potentially applicable for use in conjunction with other technologies such as preparation of excavated saturated media for off-site disposal.
	Air Stripping	Air is pumped through a water column of extracted groundwater designed to increase exposed surface area (such as a packed column, shallow tray), allowing transfer of contaminant mass from the aqueous phase to the vapor phase.	Very effective at removing many volatile organic compounds from extracted water stream. It may be necessary to treat treatment of vapor effluent with carbon or other technology.	Applicable for treatment of site contaminants in extracted water. Treatment equipment is readily available. Requires air emission testing and modeling to determine if off gas treatment is required. Disposal of water would be required.	Moderate to High	Not practical due to anticipated high pumping rates required to achieve cleanup in a reasonable timeframe.
	Sprinkler Irrigation	Extracted groundwater is pumped through a sprinkler irrigation system to increase the surface area of the water that is exposed to air, allowing transfer from the aqueous phase to the vapor phase. Typically done over a porous media.	Effective at removing many organic contaminants from the extracted water stream. Simpler system than more aggressive treatment technologies (such as air stripping).	Applicable for treatment of site contaminants in extracted water, but requires significant treatment system area.	Low to Moderate	Not retained since land use not compatible with Site conditions.
	Precipitation / Coagulation / Flocculation	Use of chemical additives to aqueous solution containing dissolved contaminants to transform the dissolved contaminants into an insoluble solid, allowing removal of the contaminant from the liquid phase by sedimentation or filtration. The use of coagulant compounds can increase particle size and aid sedimentation.	Generally only effective for treating inorganic contaminants.	Treatment equipment is readily available. Disposal of water would be required.	Moderate to High	Not compatible with Site contaminants.

General Response Action	Remedial Technology	Description	Screening Criteria			Screening Comments
			Effectiveness	Implementability	Cost	
	Constructed wetlands	Utilizes natural geochemical and biological processes inherent in an artificial wetland ecosystem to remove contaminants from extracted groundwater.	Effective at removing organic and inorganic contaminants from the extracted groundwater.	Requires large land area to implement. May introduce attractive nuisance hazard for local wildlife. Low expected O&M costs.	Moderate to High	The site is within a flood plain area. Not retained because the required space may not be suitable with Site usage.
	Trickling Filter	Contaminants in extracted groundwater are put into contact with microorganisms in attached or suspended growth biological reactors.	Effective at removing organic contaminants from the extracted groundwater. Efficiency may be impacted by temperature and variations. May not be efficient enough to reach treatment goals	Difficult to maintain effectiveness with variable groundwater concentrations. Reactors would require significant area. Routine maintenance may be required.	Moderate to High	Not retained because the required space may not be suitable with Site usage.
	Adsorption	Collecting/concentrating constituents on surface of a sorbent material such as activated carbon to remove the constituent from the bulk liquid.	Effective at removing organic compounds from extracted groundwater.	Disposal of water would be required. Treatment equipment is readily available. O&M costs would be expected to be high.	Moderate to High	Retained for use in support of treating groundwater removed as part of excavation dewatering or hydraulic containment.
	Ion Exchange	Ion exchange removes ions from the liquid phase by exchange with a counter ion on the exchange media.	Effective at removing inorganic contaminants from groundwater.	Easy to implement and treatment technology is readily available. O&M costs would be expected to be high.	Moderate to High	No compatible with site contaminants.

Note:

Shading indicates technologies that have been eliminated from consideration.

Table 5

In-Water Sediment and Porewater Technology Screening
Port of Columbia County - Former Pope & Talbot Wood Treating Site
St. Helens, Oregon

General Response Action	Remedial Technology	Description	Screening Criteria			Screening Comments
			Effectiveness	Implementability	Cost	
NO ACTION	No Action	No Action	Not effective in achieving remedial action objectives (RAOs).	Easy to Implement	No capital or operation and maintenance (O&M) costs incurred.	Does not meet threshold criteria, but required to be retained for comparison purposes.
INSTITUTIONAL CONTROLS	Legal Restrictions, Regulations, and Covenants	May include restrictions such as: deed restrictions, easements, and covenants, attached to property-related documents; legal bans or controls of activities.	Can be effective at controlling human exposures, but less effective (or not effective) at controlling ecological exposures. Is not effective at controlling or reducing migration. Most suitable for use in conjunction with other active technologies.	Likely to require acceptance and cooperation of multiple parties to implement.	Low	Potentially applicable to address human exposure in conjunction with other technologies and/or to address residual contamination.
	Sediment / Soil Management Plan	Development and publication of protocols for handling and managing contaminated sediments/soil during future work to protect workers, public health, ecological exposures, and the environment.	Effective for management of contaminated sediments / soils. Not effective at preventing human or ecological exposures without other active technologies.	Easy to implement	Low	Potentially applicable in conjunction with other technologies and/or to address residual contamination.
	Signage / Notifications / Advisories	Posting of signs and/or distribution of notifications regarding health concerns, trespassing, or no-wake zones in areas of contamination.	Can be effective at reducing human exposures via public education, but not effective at controlling ecological exposures. A no-wake zone may be effective at reducing migration of erodible riverbank soils, but will not control migration. Most suitable for use in conjunction with other active technologies.	Easy to implement	Low	Potentially applicable to address human exposure in conjunction with other technologies.
	Monitoring	Laboratory analysis of samples collected from sediment, porewater and surface water.	Effective for documenting site conditions and exposure risks, evaluating migration and naturally occurring processes, and effectiveness of remediation actions. Does not address contaminant reduction or receptor exposures.	Easy to implement	Low	Potentially applicable to confirm effectiveness of other technologies.
ENGINEERING CONTROLS	Physical Barriers (e.g., Floating Booms)	Linked floating barriers (log booms) currently limited motorized boat access to a portion of the Site's riverbank (Cove Area).	Effective at controlling trespasser access to riverbank in the Cove Area. Not effective in controlling trespassing along the entire length of the Site's shoreline. Not effective at reducing contaminant migration. Does not address or limit ecological exposure.	Relatively easy to extend log booms where existing offshore piling is present. May be difficult to obtain approval and install piling and barriers along the entire Site shoreline.	Low to Moderate	Existing barriers could be expanded to reduce boater and transient trespasser access to the Site's shorelines. These engineering controls have been retained and could be used in conjunction with other technologies to achieve RAOs.
	Physical Barriers (Log Boom)	Log boom placed off the shoreline of Areas 1 and 2. Maintenance of the log boom in place to prevent access to the Cove Area.	Effective at preventing beach access to recreational boat users and can be effective at dissipating wakes from passing boats. Does not address or limit ecological exposure.	Likely to require acceptance and permitting from multiple parties to implement. Relatively simple technology to implement.	Moderate	Potentially applicable to address human exposure in conjunction with other technologies and/or to address residual contamination / recontamination of in-water sediment.

General Response Action	Remedial Technology	Description	Screening Criteria: Effectiveness	Screening Criteria: Implementability	Screening Criteria: Cost	Screening Comments
CONTAINMENT	Cap	Installation of an engineered cap over impacted sediment. Armoring of riverbank below the ordinary high water mark (OHWM) and sediment within the intertidal zone may be necessary along the Area 1 and 2 shorelines.	Should be very effective for Site contaminants that have low-solubility and high sorption (i.e., chemicals likely to remain bound to sediment).	Generally uses proven technologies. Partial dredging followed by capping could be implemented.	Moderate to High	Retained as applicable technology.
	Adsorptive Cap	Installation of an engineered cap containing adsorptive additives (e.g., activated carbon or organoclay) over impacted sediment. Adsorptive layers would be placed in the lower portion of the cap to treat groundwater passing through the cap. The upper portion would consist of habitat material or armoring, as appropriate.	May be effective in reducing recontamination due to nonaqueous phase liquid (NAPL) migration and seeps. It is not clear at this time if an adsorptive amended cap would be more effective than an passive isolation cap (e.g., traditional sand capping).	It is difficult to estimate the useful life of amendments used to sequester and degrade contaminants without pilot testing.	Moderate to High	Retained as applicable technology.
REMOVAL AND DISPOSAL	Dredging/Excavation	Mechanical removal of contaminated sediment. Could include: mechanical dredging, hydraulic dredging, or land-based excavation of exposed near-shore material during seasonal low water and low tide.	Effective in removing impacted sediment and debris.	Dredging/excavation equipment is readily available.	High	Applicable for removal of impacted sediment/debris.
	Off-Site Disposal	Sediment impacted by wood treating operations are considered a listed hazardous waste. Therefore, off-site disposal would likely be at Chemical Waste Management in Arlington, Oregon, as a Corrective Action Management Unit (CAMU)-eligible waste.	Landfills are controlled, managed facilities that are effective in preventing future exposures. Addresses direct exposure pathways and migration by removing contaminant mass from Site.	Implementation involves transportation of contaminated sediment on barge or trucks. Transportation by truck requires elimination of free liquids from sediment.	High	Not a stand alone technology. Potentially applicable for handling of dredged/excavated sediment.
	Onsite Upland Landfill	Construction of a permitted upland landfill facility at the Site for the disposal of the dredged/excavated sediments. Would require suitable area and acceptance by permitting agencies.	Effective at removing source material from cleanup area and placement in a self-managed waste facility. Addresses direct exposure pathways and migration by removing contaminant mass from cleanup area. Would require ongoing maintenance of landfill.	On-site landfilling of hot spot sediment (listed hazardous waste) below a clean cap is not compatible with current and future Site use (industrial) and permitting is unlikely within the 100-year flood plain.	High	On-site landfilling of the hot spot sediment (listed hazardous waste) below a clean cap is not compatible with the current and future Site use (industrial) and permitting is unlikely within the 100-year floodplain.
	Upland Re-Use	Re-use of dredged/excavated sediment as fill at an upland site. Would require material characterization. Sediment to be re-used would need to be below applicable risk-based screening levels and/or appropriate exposure protection measures would required at the re-use site.	Effective at removing source material from cleanup area and placement at an upland site for re-use. Not effective if material exceeds applicable screening levels. May require additional measures (e.g., capping) to reduce exposure.	Easy to difficult depending on location of re-use site and any additional measures that might be required. Typically would require beneficial re-use approval from DEQ. Suitable re-use site needed.	Moderate	Not retained as no beneficial re-use site has been identified.
REMOVAL AND DISPOSAL	Confined Aquatic Disposal (CAD)	Disposal area is excavated in open water or utilizes existing low spots in the water body The disposal cell is then filled with the dredged / excavated sediment and covered with clean material (i.e., capped).	Effective at removing source material from cleanup area and placement in a self-managed waste facility. Addresses direct exposure pathways and migration by removing contaminant mass from cleanup area. Placement and design of CAD facility must account for potential soluble contamination migration. Would require ongoing maintenance of disposal facility.	Potential for increased releases during disposal. Mitigation would be required. Unlikely to find location suitable for disposal cell. Significant permitting effort would be required and acceptance by regional stakeholders. Would require long-term monitoring and maintenance.	High	Not retained because, among other issues, no suitable site is available.
	Confined Disposal Facility (CDF)	A disposal facility built on-site within land or reclaimed land. The sediment is deposited in the lower, saturated portion of the cell. Sediment in the CDF is physically separated from waterway by clean soil.	Effective at removing source material from cleanup area and placement in a self-managed waste facility. Addresses direct exposure pathways and migration by removing contaminant mass from cleanup area. Placement and design of CDF facility must account for potential soluble contamination migration. Would require ongoing maintenance of disposal facility.	Potential for increased releases during disposal. Mitigation would be required. Significant permitting effort would be required and acceptance by regional stakeholders. Would require long-term monitoring and maintenance.	High	Not a stand alone technology. Potentially applicable for handling of dredged/excavated sediment.

General Response Action	Remedial Technology	Description	Screening Criteria			Screening Comments
			Effectiveness	Implementability	Cost	
IN-PLACE PHYSICAL / CHEMICAL TREATMENT	Chemical Oxidation	Involves application of oxidizing agents that result in reduction / oxidation (redox) reactions that chemically convert hazardous contaminants to less toxic or less mobile forms.	Can be highly effective at destruction of organic contaminants. However, would be difficult to achieve full coverage (contact between oxidant and COC). Is not effective in sediment matrix containing significant amounts of creosote-treated wood debris.	Would be difficult to get obtain full coverage of oxidant in sediment. Could be implemented as slurry but would require removal of wood debris and significant containment effort (such as installation of sheet piling). Less suitable for shallow sediments as application difficult to separate from free water zone and multiple injection/mixing points would be needed. Care would be needed to prevent secondary impacts (such as from mobilized NAPL) during oxidation.	Moderate to High	Not retained because technology is incompatible with Site conditions.
	Sediment Flushing	Water or some other aqueous solution is circulated through the contaminated sediment to desorb contaminants. The circulated water is then recovered and treated.	Bench scale tests at other sites have shown to be effective. Less effective for organic contaminants bound on organic matter (wood debris) and would require an upland treatment operation.	Would be difficult to get full coverage of solution through sediment. Less suitable for shallow sediments as application difficult to separate from free water zone and multiple injection/mixing points would be needed.	Moderate to High	Not retained as implementation risks are high and other more suitable technologies are available.
	Solidification / Stabilization	Contaminants are physically bound or enclosed in a stabilized mass (solidification) or chemical reactions are induced between the reagent and contaminants to reduce their mobility (stabilization).	Most suitable to inorganic contaminants. Resultant sediments may not provide suitable ecological habitat.	High-energy solidification would be inefficient (or impractical) with saturated sediments.	Moderate to High	Not retained because technologies incompatible with Site conditions.
	Electrokinetic Separation	Application of a low-intensity direct current through the sediment between electrodes (cathode array and anode array). This mobilizes charged ion species causing movement toward the electrodes.	Effective at removing inorganic ions and some polar organics from saturated soil. No demonstrated application to sediment treatment.	Requires significant electrical power and would have high implementation risks in standing water. Would be difficult to control in shallow sediments.	Moderate to High	Not retained because technology incompatible with Site contaminants and has high implementation risks.
IN-PLACE PHYSICAL / CHEMICAL TREATMENT	Electrochemical Oxidation	Technology for degrading organic contaminants *in situ* by applying an electrical current across electrodes placed in the subsurface to ionize oxidizing species (i.e., metal ions) and cause oxidation of the COC.	Laboratory bench scale tests suggest technology could be effective for organics. Application in sediments is untested and would be experimental.	Requires significant electrical power and would have high implementation risks in standing water. Would be difficult to control in shallow sediments.	Moderate to High	Not retained because it is an unproven technology and has high implementation risks.
	Organoclay Sediment Cap	A semi-permeable layer of organoclay is placed over impacted sediment to adsorb contaminants as impacted groundwater or porewater moves through the material.	May be effective in reducing recontamination due to NAPL migration and seeps. It is not clear at this time if a reactive cap would be more effective than a traditional cap. Would require long-term monitoring to verify effectiveness of the cap.	There are full-scale examples of organoclay sediment caps. It may be difficult to estimate the useful life of a reactive cap. Required construction equipment is expected to be relatively easy to obtain for implementation.	Low to Moderate	Retained as applicable technology.
	Activated Carbon Amendment	Activated carbon is blended into sediments to increase sorptive capacity of sediment and reduce bioavailability of organic contaminants.	Could effectively control residual concentrations after dredging or to enhance natural recovery.	Several pilot projects have demonstrated effectiveness for organic constituents. Relatively simple technologies required for implementation.	Low to Moderate	Potentially applicable for management of residual concentrations of PAHs.
	Biochar Amendment	Biochar is a sorbing agent made by pyrolysis of biomass that is similar to activated carbon. The biochar is spread or blended into sediments to increase sorptive capacity of sediment and reduce bioavailability of organic contaminants.	Could effectively control residual concentrations after dredging or to enhance natural recovery. Available information suggests that biochar is generally less effective as a adsorptive agent than activated carbon. Would require long-term monitoring to verify effectiveness of the cap.	There is limited experience in full-scale implementation of biochar amendment of sediment. Required construction equipment is expected to be relatively easy to obtain for implementation.	Low to Moderate	Potentially applicable for management of residual concentrations of PAHs.

General Response Action	Remedial Technology	Description	Screening Criteria			Screening Comments
			Effectiveness	Implementability	Cost	
IN-PLACE PHYSICAL / CHEMICAL TREATMENT (cont.)	Ecospears	A relatively new remediation product designed primarily for removal of PCBs from sediments via sorption onto the polymer material that is pushed into the surface sediment.	Laboratory bench scale tests suggest technology could be effective for some Site contaminants. Application in sediments is generally untested and would be experimental. Little to no application literature is available to assess effectiveness. Primarily developed for removal of PCBs, although it may be suitable for other persistent pollutants.	There is limited experience in full-scale implementation of biochar amendment of sediment. Required construction equipment is expected to be relatively easy to obtain for implementation.	Moderate to High	Not retained because it is an unproven technology and has high implementation risks.
	Oleophilic Biobarrier	A relatively new technology, oleophilic biobarriers utilize a oleophilic (strong affinity for oils) plastic geocomposite mat that is placed over the sediment surface. The mat is intended to intercept and adsorb NAPL before it can cause a sheen. The retained NAPL remains bioavailable for degradation in the aerobic zone.	Unlike other adsorptive barriers which are designed to reduce the bioavailability of NAPL, oleophilic biobarriers are designed to increase aerobic conditions within the mat to promote biodegradation by naturally occurring microorganisms.	There is limited experience in full-scale implementation of oleophilic biobarriers. Required construction equipment is expected to be relatively easy to obtain for implementation.	Moderate	Retained and potentially applicable for managing petroleum sheens within the waterway.
IN-PLACE BIOLOGICAL TREATMENT	Enhanced Bioremediation	Addition of nutrients, electron acceptors, or other amendments to sediment to enhance bioremediation.	Not likely to be effective for many of the contaminants of concern.	Blending of amendments into sediment would require disturbance of sediment and would potentially cause significant resuspension.	Moderate	Not retained because not effective on NAPL and many of the high molecular weight PAHs.
	Phytoremediation	The process of using plants to remove, transfer, stabilize, and/or destroy contaminants in soil or sediment.	Can be effective at removing a variety of organic and inorganic compounds from soil/sediment through plant uptake in the plant rhizosphere.	Would require planting of suitable plants for Site conditions, or changing of Site conditions to accommodate plants (such as the construction of engineered wetlands). May not be compatible with current industrial Site use.	Moderate	Not retained because incompatible with Site conditions.
NATURAL PROCESSES	Monitored Natural Recovery	Naturally occurring physical processes (advection, desorption, dispersion, diffusion, dilution, resuspension, sedimentation, and volatilization), and biological processes (biodegradation) reduce contaminant concentrations. Process is monitored to verify exposures. In areas of low natural sedimentation processes, natural recovery can be enhanced by placement of a thin-layer cap.	Effectiveness for sediments is primarily related to sedimentation. Would require long time-frame for degradation of residual organics. Natural sedimentation likely will not be effective in the Upper Milton Creek, Area 1 Dock, Area 2 Dock offshore areas due to the higher energy of the creek and channel.	Easy to implement. Monitoring of COC concentrations in sediment porewater and surface water would require long-term passive sampling and sheen monitoring. May require significant timeframe to reach cleanup goals. For enhanced recovery, thin-layer caps use conventional technologies.	Low	Natural recovery is applicable in areas of lower energy such as the Cove Area. Monitored natural recovery is not suitable in areas where COC concentrations exceed preliminary remediation goals (PRGs).
	Enhanced Monitored Natural Recovery	Enhancement of natural attenuation consisting of a thin-layer cap (i.e., 4 to 6 inches to 1 foot of sand) that provides a surface layer of cleaner sediment accelerating physical isolation that occurs from the natural sedimentation process.	Would be effective at providing a surface layer to provide separation and attenuation of dissolved-phase contaminant mass flux. Would require long timeframe for degradation of residual organics. Enhanced recovery through placement of a thin layer cap could be very effective, especially in areas with relatively low exceedance factors.	Easy to implement. Monitoring of PAHs in sediment porewater and surface water would require long-term monitoring. May require significant timeframe to reach cleanup goals. For enhanced recovery, thin-layer caps use conventional technologies.	Moderate	Enhanced recovery is potentially applicable, especially in areas with relatively lower exceedance ratios.

General Response Action	Remedial Technology	Description	Screening Criteria			Screening Comments
			Effectiveness	Implementability	Cost	
EX-SITU PHYSICAL/ CHEMICAL TREATMENT	Dewatering	Removal of water from dredged/excavated sediment (such as to facilitate disposal). Methods may include passive dewatering on barges, in an upland lined and bermed stockpile, geotextile tubes (filters), filter presses, other mechanical dewatering methods, or dewatering by adding chemical reagents or adsorptive materials.	Various methods can be effectively used (selected based on site conditions and degree of dewatering needed) to remove water from dredged/excavated sediment. Debris may need to be removed from sediment prior to dewatering. Resultant water may need to be treated prior to disposal.	Fine-grained nature of sediment may require long drying times and significant operational effort to meet landfill free liquid standards. Water removed from the contaminated media would require either treatment, evaporation, or absorptive onto a solid material (e.g., perlite).	Low to Moderate	Not a stand-alone technology. Retained as potentially applicable for use in conjunction with other technologies such as preparation of excavated saturated media for off-site disposal.
	Separation	Use of physical means to separate sandier sediments (which would have less contamination) for beneficial reuse or separation of debris prior to further treatment or disposal.	Generally not effective for site sediment conditions.	Commercial equipment is available for separation (i.e., sieves). Separated sand may be available for potential beneficial use (would require verification testing and identification of potential use). Bench scale testing may be needed to define specific operating parameters.	Low to Moderate	Sediments previously identified to have high organic content. Not retained because the impacted material removed would primarily consist of finer sediments.
	Sediment Washing	Contaminants are separated from the dredged sediment with wash water augmented with additives to help remove contamination.	Most suitable for highly refined petroleum products (e.g., gasoline, diesel) in coarse-grained material. Less effective on viscous contamination like creosote in fine-grained material.	Elutriate would require treatment and disposal, which could significantly increase the overall cost of treatment. Bench-scale testing would be required during design. Requires staging area for treatment or transport to approved off-site facility. Air quality standards may be affected by open-air treatment methods.	High	Not retained because not compatible with creosote-impacted fine-grained sediment and more cost-effective options are available.
	Chemical Oxidation	Includes the application of chemical oxidants for the purpose of remediating contaminated sediments/soils. Generally involves reduction/oxidation (redox) reactions that chemically convert hazardous contaminants to less toxic or less mobile forms.	Can be highly effective at destruction of organic contaminants. May not be cost effective for high contaminant concentrations or high organic sediments due to large amounts of oxidizing agent required. Less efficient for low concentrations compared to other technologies.	Risks associated with handling of oxidant in above-ground application. Bench-scale testing would be required during design. Requires staging area for treatment or transport to off-site facility. Air quality standards for site workers may be affected by open-air treatment methods.	High	Not retained because technology has relatively high implementation risk to workers and equally effective lower cost technologies are available.
	Chemical Extraction	Dredged / excavated sediment is mixed with an extractant (e.g., acid or solvent), which dissolves the contaminants. The resultant solution is placed in a separator to remove the contaminant / extractant mixture for treatment.	Most suitable to semi-volatile or inorganic contamination. Less effective in fine-grained sediment.	Difficult to remove all contaminant / extractant from sediment - would likely require finish treatment. Elutriate would require treatment and disposal, which could significantly increase the overall cost of treatment. Bench-scale testing would be required during design. Requires staging area for treatment or transport to off-site facility. Air quality standards may be affected by open-air treatment methods.	High	Not retained because not compatible with sediment grain size and more cost-effective options available.
	Solidification / Stabilization	Contaminants are physically bound or enclosed in a stabilized mass (solidification) or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization). Methods may include the addition of Portland cement, lime, kiln dust, pozzolan, sorbent clay (i.e., bentonite), and proprietary reagents.	Can be effective at reducing mobility of contaminants (most suitable to inorganics) or solidifying for disposal.	Would need to be significantly dewatered prior to solidification. Requires staging area for treatment or transport to off-site facility. Air quality standards for Site occupational workers may be affected by open-air dewatering methods.	Moderate	Would likely still require landfill disposal and dewatering technologies already retained above.

Table 5

General Response Action	Remedial Technology	Description	Screening Criteria			Screening Comments
			Effectiveness	Implementability	Cost	
EX-SITU PHYSICAL/ CHEMICAL TREATMENT (cont.)	Solar Detoxification	Contaminants are destroyed by photochemical and thermal reactions using ultraviolet energy in sunlight or artificial UV light. Usually involves application of catalyst agent.	Can be effective at treating a variety of organic compounds. Most effective when used with a catalyst agent (i.e., titanium dioxide).	Implementation with sunlight limited by availability (not effective during nighttime and limited effectiveness during cloudy/wet seasons). Requires staging area for treatment or transport to off-site facility. Air quality standards for Site/occupational workers may be affected by open-air treatment methods.	Moderate	Not retained because space requirement and has limited usefulness for Site contaminants.
EX-SITU BIOLOGICAL TREATMENT	Land Treatment/ Landfarming	Land treatment reduces contaminant concentrations through biological processes. Dredged / excavated sediment is placed in lined and bermed treatment cells and manipulated as necessary to improve biological conditions (such as tilling material to aerate and mix in nutrient amendments).	Can be effective at removing PAHs in sediment. Most effective with control of moisture, heat, nutrients, oxygen, and pH to enhance biodegradation. Effectiveness is reduced by the presence of NAPL, wood debris, and low ambient temperatures during 8 months of the year.	Requires large upland area for sediment treatment. Requires the dewatering and removal of debris from sediment. Erosion and stormwater controls need to address ponding and/or contaminated runoff. Bench-scale testing would be required to define operating parameters, particularly during wet weather. Long anticipated implementation period with extensive performance and confirmation monitoring. Air quality standards may be affected by open-air treatment methods.	Moderate	Not retained because space requirement and has limited usefulness for Site contaminants.
	Biopiles	Sediment is mixed with amendments, placed in aboveground enclosures, and aerated with blowers or vacuum pumps. Microorganisms present degrade the contaminants present.	Effective at removing volatile organic contamination from sediment. Most effective with control of moisture, heat, nutrients, oxygen, and pH to enhance biodegradation. Effectiveness is reduced by the presence of NAPL.	Requires area for sediment treatment or transport to an off-site facility. Requires dewatering of sediment, and controls likely to be needed for contaminant migration from runoff and leachate. Bench-scale testing would be required to define operating parameters. Air quality standards may be affected by open-air treatment methods.	Moderate	Not retained because effectiveness is severely limited by the presence of NAPL and wood debris.
	Slurry-phase Biological Treatment	An aqueous slurry of sediment with water and other additives is mixed to keep solids suspended and microorganisms in contact with the particle-bound contaminants. When complete, the slurry is dewatered and the treated sediment is disposed of.	Can be effective at treating a variety of organic compounds and diluting NAPL into manageable concentrations.	Requires area for treatment cell or transport to an off-site facility. Slurry dewatering generates liquid waste stream that will require treatment or disposal. Bench-scale testing would be required to define operating parameters. Air quality standards may be affected by open-air treatment methods.	High	Not retained because other more cost-effective options available.
EX-SITU THERMAL TREATMENT	Off-Site Incineration	High temperatures are used to combust (in the presence of oxygen) organic constituents in hazardous wastes.	High temperatures result in generally complete decomposition of organic chemicals. Effective across wide range of sediment characteristics.	Requires air pollution control device. Listed hazardous waste designation will likely rule out acceptance into most treatment facilities. Involves high energy consumption.	High	Unlikely that a permitted facility will accept this hazardous waste stream for treatment. If found, anticipate significant cost for transportation and treatment. Other less expensive technologies available.
	On-Site Thermal Desorption/ Pyrolysis/ Hot Gas Decontamination	Dredged spoils are heated to either volatilize (desorption and hot gas) or to anaerobically decompose (pyrolysis) organic contaminants. Off-gas is collected and treated.	Effective at removing organic materials from excavated sediment/soil (particularly volatile organics). Pyrolysis generally used for semi-volatiles. Efficiency of PAH thermal desorption will be approximately 90%.	Requires the on-site mobilization of thermal desorption units and permitting with local land use and air quality agencies. Requires dewatering of excavated media, off-gas treatment, and extensive confirmation sampling.	High	Not retained because other more cost-effective options available.

Note:

Shading indicates technologies that have been eliminated from consideration.

Table 6 - Estimated Quantities of Contaminated Media

Priority Action Area	Timber Piling	Area	Volume (approx. cubic yards)	Depth (feet)	Length (approx. LF)	Offsite-Disposal (Preferred RAA)[1]	
	Each	(approx. acre)				Haz (tons)[2]	Non-Haz (tons)[2]
Upland Area							
Soil hot-spot (Includes NAPL)	--	3.45	95,000	8 feet bgs to approx. 25 feet bgs. (upper 8-feet, clean cap overburden)	--	2,947	520
Area 1 Dock							
Wood Debris/ Surface Sediments (NAPL/moderate to heavy sheen)	435	1.85	3,000	mudline to 1 foot bml (biologically active zone)	--	--	163
Subsurface Sediments	--	1.85	29,800	Varies; >1 foot bml up to 11 feet bml	--	--	--
Area 2 Dock							
Wood Debris/ Surface Sediments (Creosote Impacted)	235	0.34	560	mudline to 1 foot bml (biologically active zone)	--	519	222
Cove Area							
Riverbank hotspots (NAPL seeps)/Riverbank Regrading from 2H:1V to 4H:1V	--	--	--	11 to 25 feet bgs in 1-foot-thick or less sand layers	300 LF seeps/540 LF regrading	3,787	1,623
Wood Debris/ Surface Sediments (NAPL/moderate to heavy sheen)	139	1.2	1,950	mudline to 1 foot bml (biologically active zone)	--		
Subsurface Sediments	--	0.85	15,250	Varies; >1 foot bml up to 12 feet bml, average 5 feet bml	--	--	--
Upper Milton Creek							
Riverbank hotspots (NAPL seeps)/Riverbank Regrading from 2H:1V to 4H:1V	--	0.05	1,020	19 feet bgs in 1-foot-thick or less sand layer	200 LF seeps/ regrading	1,550	82

Notes:

[1] See Section 8 of Staff Report for description of preferred RAAs.

[2] Estimates assume 1.6 tons/CY for impacted soil and sediment.

>	greater than	LF	linear feet
approx.	approximately	NAPL	non-aqueous phase liquid
bgs	below ground surface	RAA	Remedial Action Alternative
bml	below mud line	V	vertical
H	horizontal		

Table 7. Area 1 Upland PAA remedial technologies descriptions and assemblage of RAAs.

Remedial Action Alternative[1]	Impervious Surface Cap & Stormwater System		Hydraulic Containment & Enhanced Bioremediation	Permeable Reactive Barrier	Impermeable Isolation Wall	Complete Excavation and Offsite Disposal		Monitored Natural Attenuation
	Cap constructed across the entire PAA, consisting of low-permeability (1 x 10-6 cm/s or less) material (e.g., concrete or bituminous asphalt pavement). This PAA was previously covered with 7 to 8 feet of imported fill material and a low permeability surface cap would further isolate contamination from human and ecological receptors. However, the main purpose of the cap would be to reduce stormwater infiltration through contaminated soil and reduce groundwater flux towards in-water locations. The cap will be graded to collect and convey stormwater to a bioswale for infiltration outside the groundwater plume. Stormwater management reduces erosion caused by stormwater runoff.	Cap area: 3.45 acres (150,370 SF)	Groundwater pumping, treatment, and recirculation system. The groundwater extraction system will consist of wells or interceptor trenches constructed between the upland NAPL area and the Cove Area PAA. Extracted groundwater will include NAPL separation, treatment with adsorptive media, and amended with electron acceptors and nutrients to aid in enhanced natural biodegradation. Treated and amended groundwater will be infiltrated back to areas with residual contamination. A pilot study is needed to determine groundwater extraction and infiltration rates, influence of fine-grained native soil, radius of influence, infiltration gallery sizing, and groundwater treatment methodologies. Microbial profiling and bench-scale testing of total PAH degradation under different conditions is needed to determine the appropriate electron acceptors and nutrients for groundwater amendment. Regular upkeep and maintenance required over the long term.	PRB placed along top of riverbank, upland of the Cove Area NAPL seeps, to capture mobile creosote NAPL and dissolved phase COCs in groundwater prior to discharging to the Cove Area. The PRB will consist of adsorptive (e.g., organoclay) and reactive materials to (1) remove contaminants from groundwater and (2) stimulate treatment of contaminants (e.g., adding electron acceptors to enhance biodegradation). The PRB will be 2 to 4 feet wide and extend to the top of the Basalt Bedrock, approximately 25 feet bgs but deeper in some areas. A total of 3,467 tons of creosote-impacted soil would be removed and transported for off-site disposal. A pilot study and modeling are needed to select the PRB media, amendments, installation methods, thickness, depth, length, and placement. Media fouling and reduced permeability impact long-term maintenance needs.	Isolation wall surrounding the entire length of the inferred upland NAPL area and extending to the underlying bedrock to physically isolate the contamination in the upland NAPL area from groundwater flow and reduce contaminant transport. Wall would be constructed with low permeability (1 x 10-7 cm/s or less) material (e.g., bentonite slurry). Construction by excavating a 3-foot-wide trench, blending excavated soil with bentonite, and replacing the material to the trench. Wall keyed into bedrock, with bedrock locations greater than 25 feet bgs requiring specialized equipment. Significant excavation required. Assumption that excess material or material deemed unsuitable for backfill will be disposed offsite at a Subtitle C landfill. Additional investigation needed to delineate lateral and vertical upland NAPL extent. During remedial design the isolation wall type and blend of material and placement would be determined.	Remove all NAPL-impacted soil and sediment within the inferred upland NAPL area to an approximate depth of 25 feet bgs. Contaminated soil transported offsite for disposal at a Subtitle C landfill. Dewatering, treatment of extracted groundwater, and discharge to the Scappoose Bay under permit. Shoring will be required near the Scappoose Bay shoreline. Confirmation soil samples will be collected from the sidewalls and base of the excavated area to ensure complete removal. Clean fill will be used to backfill the entire excavated area followed by construction of an impervious surface cap. No long-term ICs required.	Volume removed: 95,000 CY (100% hot spot soil removed)	Creosote in subsurface soil and groundwater is expected to slowly reduce over time through natural processes, including diffusion, dispersion, hydrolysis, sorption, and biodegradation. However, MNA alone is not expected to reduce COC concentrations in source areas within a meaningful timeframe and is only considered in combination with other remedial actions.
RAA-1: No Action								
RAA-2: Impervious Surface Cap, MNA	X							X
RAA-3: Impervious Surface Cap, Hydraulic Containment, Enhanced Bioremediation	X		X					X
RAA-4: Impervious Surface Cap, MNA, Permeable Reactive Barrier	X			X				X
RAA-5: Impervious Surface Cap, MNA, Impermeable Isolation Wall (NAPL Area)	X				X			X
RAA-6: Excavation and Offsite Disposal, Impervious Surface Cap (over residuals), MNA	X					X		X

Notes:

1	See Staff Report Section 5
bgs	below ground surface
cm/s	centimeters per second
COCs	Constituents of Concern
CY	Cubic Yards
IC	Institutional Control
MNA	Monitored Natural Attenuation
NAPL	Non-Aqueous Phase Liquid
PAA	Priority Action Area
PAHs	Polycyclic Aromatic Hydrocarbons
PRB	Permeable Reactive Barrier
RAA	Remedial Action Alternative
SF	Square Feet
%	percent
(yellow)	Selected Remedial Action

Table 8. Area 1 Dock PAA remedial technologies descriptions and assemblage of RAAs.

Remedial Action Alternative[1]	Armored Reactive Cap		Nearshore Removal Action		Upland Consolidation	Offsite Disposal	Complete Excavation	
	An engineered reactive cap will be constructed over the entire Area 1 Dock PAA (1.85 acres). Debris, including timber piling and other remnants of dock structures, and vegetation will be removed prior to cap placement. The cap will include a reactive chemical isolation layer designed to contain and isolate contaminants. Cap armoring will be needed to ensure cap stability and protection from erosion and scouring, particularly given the stronger river currents in this area, and will include aquatic supporting material. During remedial design, the cap materials, amendments, rock armoring size, layer thicknesses, and extent will be determined. Evaluations of how remaining debris may impact long-term cap performance will be conducted.	Cap area: 1.85 acres (80,586 SF)	Upper nearshore sediment exhibiting moderate to heavy petroleum sheen (up to 80%) will be excavated using land-based equipment. Prior to excavation, debris, including timber piling and other remnants of dock structures, and vegetation will be removed. A temporary cofferdam system will be installed surrounding the PAA to extend the reach of the land-based removal equipment. The area behind the cofferdam will be dewatered by pumping, with pumped water treated prior to discharge. During remedial design the methods for removal, depth and extent of excavation, locations suitable for a cofferdam system, methods for dewatering the cofferdam area, methods and criteria for treating pumped water, and appropriate treated water discharge areas will be determined. A flood rise analysis will also be conducted and may impact regrading needs. Wood debris has been observed as deep as 11 feet bml and an estimated 435 creosote-treated piles will need to be removed. Geotechnical investigations will be conducted to address soft sediment and the feasibility of removing wood debris due to the significant volume and age of the debris. If removing full pilings is not feasible, pilings will be cut at the surface to facilitate cap placement.	Volume removed: 100 CY (1% hot spot treated) 435 Piles	Excavated material (7,744 tons) and 435 timber piles will be dewatered and stabilized as needed (e.g., drying agents) and placed in a lined upland containment area, covered with clean overburden material, and covered with a low-permeability cap as described for the Upland PAA. During remedial design the dewatering and stabilization methods, exact dimensions of the containment area, lining material, composition and depth of clean overburden material, and surface cap specifications will be determined.	Removed material will be dewatered and stabilized as needed (e.g., drying agents) and transported to an offsite disposal facility. The proper facility for disposal (i.e., Subtitle C or Subtitle D landfill) will be determined by material profiling. A total of 7,744 tons of creosote-impacted soil would be removed and transported for off-site disposal, along with 435 piles. Trucks, train, and/or barge may be used depending on the volume of removed material in conjunction with other PAAs. During remedial design the dewatering, stabilization, and transportation methods will be determined.	Remove all creosote-impacted sediment within the PAA to a depth of 12 feet. A steel interlocking sheet pile wall will be installed along the riverward perimeter of the PAA. Sediment and riverbank material will be removed using land-based and barge-based equipment. Clean replacement material will be placed within the excavation area following removal activities. The remedial design will determine methods for implementing the sheet pile wall, equipment and methods for material removal, dewatering and stabilization methods, profiling required for offsite disposal, and composition of clean replacement material.	Volume removed: 33,000 CY (100% hot spot treated) 435 Piles
RAA-1: No Action								
RAA-2: Armored Reactive Cap	X							
RAA-3: Nearshore Removal Action, Upland Consolidation, and Armored Reactive Capping of Residuals	X		X		X			
RAA-4: Nearshore Removal Action, Offsite Disposal, and Armored Reactive Capping of Residuals	X		X			X		
RAA-5: Complete Removal and Offsite Disposal							X	

Notes:

1	See Staff Report Section 5
bml	below mudline
CY	Cubic Yards
PAA	Priority Action Area
RAA	Remedial Action Alternative
SF	Square Feet
%	percent
(yellow)	Selected Remedial Action

Table 9. Area 2 Dock PAA remedial technologies descriptions and assemblage of RAAs.

Remedial Action Alternative[1]	Armored Reactive Cap		Sand Cap		Nearshore Removal Action		Upland Consolidation	Offsite Disposal
	An engineered reactive cap will be constructed over 600 feet of nearshore sediments exhibiting moderate to heavy petroleum sheen. Debris, including timber piling and other remnants of dock structures, and vegetation would be removed prior to cap placement. The cap will include a reactive chemical isolation layer designed to contain and isolate contaminants. Cap armoring will be needed to ensure cap stability and protection from erosion and scouring, particularly given the stronger river currents in this area, and will include aquatic supporting material. During remedial design, the cap materials, amendments, rock armoring size, layer thicknesses, and extent will be determined. Evaluations of how remaining debris may impact long-term cap performance will be conducted.	Cap area: 0.34 acres (15,182 SF) 235 Piles	A layer of sand will be placed throughout the PAA, including the 3,000 square foot area that is not accessible by land-based equipment. As most of the contamination is in the surface sediments, following removal action there will be limited contamination residuals within excavation areas. During remedial design, the cap material, thickness, extent, and sufficiency or insufficiency of sand only will be determined. Evaluations of how remaining debris may impact long-term cap performance will be conducted.	Cap area: 0.34 acres (15,182 SF) 235 Piles	The upper 12 inches of nearshore sediment exhibiting moderate to heavy petroleum sheen (up to 84%) will be excavated using land-based equipment. Prior to excavation, debris, including timber piling and other remnants of dock structures, and vegetation will be removed. A temporary cofferdam system will be installed surrounding the PAA to extend the reach of the land-based removal equipment. However, approximately 3,000 square feet of the PAA will not be accessible by land-based equipment. The area behind the cofferdam will be dewatered by pumping, with pumped water treated prior to discharge. During remedial design the methods for removal, depth and extent of excavation, locations suitable for a cofferdam system, methods for dewatering the cofferdam area, methods and criteria for treating pumped water, and appropriate treated water discharge areas will be determined. A flood rise analysis will also be conducted and may impact regrading needs. Petroleum sheen near creosote-impacted wood debris has been observed within the upper 12 inches of sediment. An estimated 235 creosote-treated piles will need to be removed. Geotechnical investigations will be conducted to address the feasibility of removing wood debris.	Volume removed: 560 CY (100% hot spot removed) 235 Piles	Excavated material will be dewatered and stabilized as needed (e.g., drying agents) and placed in a lined upland containment area, covered with clean overburden material, and covered with a low-permeability cap as described for the Upland PAA. During remedial design the dewatering and stabilization methods, exact dimensions of the containment area, lining material, composition and depth of clean overburden material, and surface cap specifications will be determined.	Removed material will be dewatered and stabilized as needed (e.g., drying agents) and transported to an offsite disposal facility. The proper facility for disposal (i.e., Subtitle C or Subtitle D landfill) will be determined by material profiling. Trucks, train, and/or barge may be used depending on the volume of removed material in conjunction with other PAAs. During remedial design the dewatering, stabilization, and transportation methods will be determined.
RAA-1: No Action								
RAA-2: Armored Reactive Cap	X							
RAA-3: Nearshore Removal Action, Upland Consolidation, and Capping of Residuals			X		X		X	
RAA-4: Nearshore Removal Action, Offsite Disposal, and Capping of Residuals			X		X			X

Notes:

1	See Staff Report Section 5
CY	Cubic Yards
PAA	Priority Action Area
PRB	Permeable Reactive Barrier
RAA	Remedial Action Alternative
SF	Square Feet
%	percent
(yellow highlight)	Selected Remedial Action

Table 10. Cove Area PAA remedial technologies descriptions and assemblage of RAAs.

	Armored Reactive Cap		Riverbank Restoration & Limited Removal Action		Upland Consolidation	Offsite Disposal	Complete Excavation	
Remedial Action Alternative[1]	An engineered reactive cap will be constructed over the 300-foot section of streambanks exhibiting moderate to heavy petroleum sheen. Debris, including timber piling and other remnants of dock structures, and vegetation will be removed prior to cap placement. The cap will include a reactive chemical isolation layer to contain and isolate contaminants. Cap armoring will be needed to ensure cap stability and protection from erosion and scouring, though the Cove's off-channel backwater setting provides some protection against wake- and wind-driven waves. The armored surface and slope must be compatible with shallow water habitat. According to preliminary CapSim modeling, the cap will effectively prevent contaminants from entering the river. Potential risks associated with differential settlement below the cap can be mitigated using capping materials that evenly distribute the weight of armoring (e.g., marine mattress). Mitigation will be needed to offset the loss of intertidal shallow water habitat. Sediment porewater and surface water quality outside the cap boundary is expected to continue naturally recovering as new, cleaner sediment is deposited in the Cove (0.2 to 1.4 in/yr). During remedial design, the cap materials, amendments, rock armoring size, layer thicknesses, and extent will be determined.	Cap area: 1.2 acres (52,275 SF) 139 Timber Piles	Approximately 500 feet of riverbank will be regraded as needed to a sufficiently shallow slope (e.g., 4H:1V) to reduce erosion potential and aid in land-based removal and long-term monitoring. This regraded area will include the 300-foot section of riverbank with intermittent NAPL seeps. Regrading facilitates improved access by land-based equipment, hot spot removal, more controlled placement of cap material, reduced erosional forces imposed on the cap, and long-term monitoring. The upper portion of the nearshore sediment exhibiting moderate to heavy sheen (up to 90%) will be excavated using land-based equipment. This approach will remove nearshore hot spot areas to the extent practicable. Prior to excavation, debris, including timber piling and other remnants of dock structures, and vegetation will be removed. A temporary cofferdam system will be installed surrounding the PAA to extend the reach of the land-based removal equipment. The area behind the cofferdam will be dewatered by pumping, with pumped water treated prior to discharge. During remedial design the exact slopes, methods for regrading and removal, depth and extent of excavation, locations suitable for a cofferdam system, methods for dewatering the cofferdam area, methods and criteria for treating pumped water, and appropriate treated water discharge areas will be determined. A flood rise analysis will also be conducted and may impact regrading needs.	Volume removed: 1,950 CY (25% hot spot treated) 139 Timber Piles	Excavated material will be dewatered and stabilized as needed (e.g., drying agents) and placed in a lined upland containment area, covered with clean overburden material, and covered with a low-permeability cap as described for the Upland PAA. During remedial design the dewatering and stabilization methods, exact dimensions of the containment area, lining material, composition and depth of clean overburden material, and surface cap specifications will be determined.	Removed material will be dewatered and stabilized as needed (e.g., drying agents) and transported to a Subtitle C landfill. Trucks, train, and/or barge may be used depending on the volume of removed material in conjunction with other PAAs. During remedial design the dewatering, stabilization, and transportation methods will be determined.	Remove all creosote-impacted sediment within the PAA to a depth of 12 feet. A steel interlocking sheet pile wall will be installed along the riverward perimeter of the PAA. Sediment and riverbank material will be removed using land-based and barge-based equipment. Clean replacement material will be placed within the excavation area following removal activities. The remedial design will determine methods for implementing the sheet pile wall, equipment and methods for material removal, dewatering and stabilization methods, profiling required for offsite disposal, and composition of clean replacement material.	Volume removed: 17,170 CY (100% hot spot removed) 139 Timber Piles
RAA-1: No Action								
RAA-2: Armored Reactive Cap	X							
RAA-3: Riverbank Restoration, Nearshore Removal Action, Upland Consolidation, and Reactive Capping of Residuals	X		X		X			
RAA-4: Riverbank Restoration, Nearshore Removal Action, Offsite Disposal, and Reactive Capping of Residuals	X		X			X		
RAA-5: Complete Removal and Offsite Disposal						X	X	

Notes:

1	See Staff Report Section 5
CY	Cubic Yards
H:V	horizontal distance to vertical rise
in/yr	inches per year
NAPL	Non-Aqueous Phase Liquid
PAA	Priority Action Area
RAA	Remedial Action Alternative
SF	Square Feet
%	percent
(yellow highlight)	Selected Remedial Action

Table 11. Upper Milton Creek PAA remedial technologies descriptions and assemblage of RAAs.

Remedial Action Alternative[1]	Armored Reactive Cap		Regrading & Removal Action		Upland Consolidation	Offsite Disposal
	An engineered reactive cap will be constructed over the 200-foot section of streambanks exhibiting moderate to heavy petroleum sheen. Debris and vegetation will be removed prior to cap placement. The cap will include a reactive chemical isolation layer to contain and isolate contaminants. Cap armoring and shoreline stabilization will be needed to ensure cap stability and protection from erosion and scouring. During remedial design, the cap materials, amendments, rock armoring size, layer thicknesses, and extent will be determined. The cap will be placed following any regrading and removal activities.	Cap area: 0.05 acres (2,200 SF)	Currently, the upper portion of Milton Creek has relatively steep 15-foot embankments and generally consists of 0 to 1 foot of soft sediment overlying compact clayey silt with gravel and cobbles. The streambank will be regraded as needed to a sufficiently shallow slope (e.g., 3H:1V) to facilitate hot spot removal, more controlled placement of cap material, reduced erosional forces imposed on the cap, and long-term monitoring. The lower portion of the streambank exhibiting moderate to heavy sheen will be excavated using land-based equipment. Contaminated sediments are primarily within the reach that the seeps occur and within the soft unconsolidated surface sediments. This approach would remove hot spot areas to the extent practicable. Prior to excavation, debris and vegetation will be removed. During remedial design the exact slopes, methods for regrading and removal, depth, and extent of excavation will be determined.	Volume removed: 1,020 CY	Removed material will be dewatered and stabilized as needed (e.g., drying agents) and transported to an offsite disposal facility. The proper facility for disposal (i.e., Subtitle C or Subtitle D landfill) will be determined by material profiling. Trucks, train, and/or barge may be used depending on the volume of removed material in conjunction with other PAAs. During remedial design the dewatering, stabilization, and transportation methods will be determined.	Removed material will be dewatered and stabilized as needed (e.g., drying agents) and transported to an offsite disposal facility. The proper facility for disposal (i.e., Subtitle C or Subtitle D landfill) will be determined by material profiling. Trucks, train, and/or barge may be used depending on the volume of removed material in conjunction with other PAAs.
RAA-1: No Action						
RAA-2: Armored Reactive Cap	X					
RAA-3: Regrade Streambank, Limited Removal Action, Upland Consolidation, and Armored Reactive Capping of Residuals	X		X		X	
RAA-4: Regrade Streambank, Limited Removal Action, Offsite Disposal, and Armored Reactive Capping of Residuals	X		X			X

Notes:

1	See Staff Report Section 5
CY	Cubic Yards
H:V	horizontal distance to vertical rise
PAA	Priority Action Area
RAA	Remedial Action Alternative
SF	Square Feet
(yellow highlight)	Selected Remedial Action

Table 12. Area 1 Upland PAA remedial action alternatives rankings and rationale for evaluation criteria.

RAO	Remedial Action Alternative	Protectiveness	Balancing Factors[1]											Additional Factors					Overall		
			Effectiveness 5 = high effectiveness		Long-Term Reliability 5 = high reliability		Implementability 5 = high implementability		Implementation Risk 5 = low risk		Cost 5 = low cost		Initial Total Score[2]	Hot Spot Treatment 5 = likely		Green Remediation 5 = highly sustainable		Total Score[3]	Unknowns	Advantages	Disadvantages
None	RAA-1: No Action	Alternative does not provide protection because no action is taken to remove, treat, or contain residual contamination at the Site.												As a result, Alternative 1 was not carried forward or evaluated for criteria as it does not achieve protectiveness.							
5, 6, 7, 8	RAA-2: Impervious Surface Cap, MNA	This alternative is considered protective. The upland PAA is already essentially capped with fill material to prevent direct exposure to COCs by human and ecological receptors. An impermeable cap and stormwater treatment would reduce groundwater recharge through contaminated soil and thereby reduce the migration of creosote NAPL and impacted groundwater towards the in-water PAAs. Managing stormwater would also reduce the impact of erosion caused by stormwater runoff.	2	Constructing the impervious surface cap and stormwater management system would limit infiltration through contaminated soil and reduce contaminant migration from the upland area to the in-water areas. However, the overall effectiveness is unclear as no impacted soil would be treated or removed and a cap alone would not address the connection with further upland infiltration and groundwater flow that may contribute to the migration of creosote NAPL and impacted water. Additionally, it is not evident that MNA would achieve RAOs in a reasonable time period. As evidenced by current plume extent, MNA is not effectively occurring under current conditions. All risks remain on-site, including impacts to beneficial water use. The RAA would rely on the ICs to remain effective.	2	Conditions should get no worse than current, and may improve with time. However, the long term reliability of an impervious cap alone to address advective mass flux has yet to be determined. This alternative is sensitive to subsurface hydrogeologic and geochemical conditions. Monitoring and surface cap maintenance will be required in perpetuity with annual inspections and periodic maintenance.	4	Stratigraphy may challenge technology though local experience is available. Equipment and materials are standard and readily available. Installation, inspections, and maintenance would be easy to implement.	4	Contaminated soil should not be encountered during construction of the impervious surface cap and/or stormwater management system. However, there is still a low potential for worker exposure to creosote (e.g., dust exposure) and an inhalation risk for vapors. Few toxic degradation products; however, long-term risks to receptors will not change rapidly, as overall process is slow. Longer-term risks to workers will be managed by ICs.	4	$5,565,000 Low capital cost, some long-term O&M.	16	2	No treatment or removal of hot spots, though hot spot mobility would be reduced by limiting infiltration through contaminated soils and reducing groundwater mass flux. However, it is difficult to estimate the reduction in groundwater flux with the impervious cap alone as groundwater upgradient from the site may be of influence.	4	This alternative relies on passive technologies and greenhouse gas emissions would only be associated with construction and maintenance. The long-term monitoring of groundwater for natural attenuation would generate a minimal volume of IDW.	22	Groundwater flow and COC migration dynamics in groundwater have not been well characterized. Hydraulic connection to upgradient groundwater and associated influence on contaminant migration has not been determined.	Passive and cost effective, allows for some property reuses.	Less likely to effectively reduce risks compared to other alternatives and does not address hot spots in critical source areas and may not reduce risk.
3, 4, 5, 6, 7, 8	RAA-3: Impervious Surface Cap, Hydraulic Containment, Enhanced Bioremediation, MNA	This alternative is considered protective. The cap limits infiltration, the hydraulic containment system limits contaminant migration to potential receptors, and enhanced bioremediation reduces contaminant concentrations. However, the ability of the hydraulic containment and enhanced bioremediation system to be successful has not been determined.	4	The actual effectiveness of the hydraulic containment and groundwater recirculation system, particularly within the fine-grained soils at the Site, would need to be determined through extensive field pilot-scale testing. Most COCs are aerobically biodegradable. However, it is not evident that enhanced bioremediation will achieve RAOs in a reasonable time period and it is unclear how effective the system would be at reducing concentrations.	3	This alternative uses proven technologies in highly conductive soil, which exists in the fill. Equipment and maintenance needs can easily be met. Fouling issues may impede the reliability of the hydraulic containment system. Provides treatment only while active. Progress is difficult to measure and the rate of remediation may be very slow. Treatment and system maintenance must continue indefinitely pending source mitigation.	2	This alternative ranked lower for implementability than RAA-2 due to the additional infrastructure necessary for the extraction and treatment system. Though specialized, the equipment for the system would be relatively easy to obtain. Local experience to guide treatment system testing and design are available. The treatment system would require significantly more O&M than passive alternatives, including a monitoring well network.	2	Requires long-term monitoring and maintenance of the active extraction and treatment system. Few toxic degradation products. Pumping may cause vertical or lateral creosote NAPL mobility. Treatment plant must operate efficiently to be successful.	2	$15,097,000 Installation cost is reasonable, long term O&M costly as the extraction and treatment system would have to operate indefinitely. Relies on functional water treatment plant.	13	4	This alternative would treat hot spots through enhanced bioremediation and reduce hot spot mobility through groundwater extraction.	2	This alternative ranks lower than RAA-2 due to the greenhouse gas emissions associated with long-term operation of the extraction and treatment system, which uses high amounts of energy over the long-term as well as treatment-associated wastes generated.	19	The ability of the extraction and treatment system to reduce contamination is unknown as the following have not been determined: desorption potential of COCs from soil/TOC, nutrient requirements to support aerobic degradation, and flow rate required to provide hydraulic containment.	Contains COC migration, removes some mass from subsurface, may reduce hot spot concentrations over a long-period of time.	High cost long term, and large energy consumption, may be ineffective at mass removal due to low hydrologic conductivity in deeper aquifer and to fact that dissolved mass can only be recovered in large volumes of water.
3, 4, 5, 6, 7, 8	RAA-4: Impervious Surface Cap, MNA, Permeable Reactive Barrier	This alternative is considered protective. The cap limits infiltration and the PRB would add a further barrier to prevent migration of upland sources towards in-water locations, though would not include source area treatment.	4	Similar to Alternative 3, a PRB would be designed to capture nearly all groundwater COC flux to the river, as supported by initial CapSim modeling. However, creosote NAPL may migrate into the basalt. Predominant risks remain on-site in upland, including impacts to beneficial water use	4	Captures, contains, and treats majority of groundwater leaving source area. Reliable method to deflect and guide groundwater flow, if flow is already mostly perpendicular to wall. Cap maintenance/monitoring will be required in perpetuity. Some downgradient monitoring will be needed to assess performance of barrier wall. Possible need to change-out media (not currently included/assumed to be necessary).	3	This alternative is relatively implementable given the length and depth of the PRB and the surface access. Some wastes would be produced in installing the reactive media. A small monitoring well network beyond the wall would be required. Meets ARARs.	3	Site geology may make installation difficult. PRB may have differing effects on groundwater and lead to additional fractured flow to the river, resulting in the need for additional understanding of Site hydraulics. Potential to mobilize creosote NAPL during installation. Large construction project implemented over a short time period. Some risks associated with long-term PRB performance and the need to replace adsorptive media due to media fouling and reduced permeability.	3	$7,890,000 Installation cost is high. Long term O&M cost low over time, but goes on indefinitely at least until sources removed. Disposal costs for carbon may also be high, if determined to be necessary in future (not included in costs).	17	3	No treatment or removal of hot spots but is expected to reduce hot spot mobility through reduced groundwater flux associated with the cap and groundwater treatment as the water migrates through the PRB.	3	Larger excavated volumes than RAA-3, but the PRB is a passive system with reduced greenhouse gas emissions associated with long term O&M.	23	Long term impact of COCs on media breakthrough, total extent to contain plume, propensity for groundwater to flow towards creek versus to the bay.	Protects cove area interaction with groundwater through absorption within the barrier wall. Short time-period for installation.	High capital cost. No hot spot treatment or removal.

Table 12. Area 1 Upland PAA remedial action alternatives rankings and rationale for evaluation criteria.

RAO	Remedial Action Alternative	Protectiveness	Balancing Factors											Additional Factors					Overall		
			Effectiveness 5 = high effectiveness		Long-Term Reliability 5 = high reliability		Implementability 5 = high implementability		Implementation Risk 5 = low risk		Cost 5 = low cost		Initial Total Score[2]	Hot Spot Treatment 5 = likely		Green Remedy 5 = highly sustainable		Total Score[3]	Unknowns	Advantages	Disadvantages
3, 4, 5, 6, 7, 8	RAA-5: Impervious Surface Cap, MNA, Impermeable Isolation Wall (NAPL Area)	This alternative is considered protective. The impermeable bentonite slurry wall would surround the inferred extent of upland creosote NAPL area and extend vertically through the contaminated zone into the upper surface of basalt bedrock. The combination of the impermeable cap and isolation wall would prevent the migration of creosote NAPL and dissolved phase constituents by sealing off the inferred extent of upland creosote NAPL from Milton Creek and Scappoose Bay.	4	If keyed into basalt, reduces most flux from source area. Creosote NAPL may migrate into the basalt. Possible for diffusive transport of COCs through wall. Does not remove source so some risk pathways remain on-site. however, the full upland lateral and vertical extent of creosote NAPL is not known.	4	Reliable method to isolate source. May cause groundwater mounding and reduce effectiveness. Strong acids, bases, salt solutions, and organic chemicals may degrade grout. Cap maintenance/monitoring will be required in perpetuity. Some long-term monitoring required for groundwater to ensure effectiveness/integrity of wall is maintained.	2	Assume floorless injected from surface. Good surface access. Produces additional waste due to the greater excavation required. In locations with deeper basalt bedrock, would require less common excavation equipment to key into the basalt bedrock.	2	Site geology may make installation difficult. Additional risk due to the larger extent of excavation required. Wall may cause groundwater mounding, resulting in the need for additional understanding of Site hydraulics.	3	$8,494,000 Installation cost is high, long term O&M costs low. Monitoring goes on indefinitely. May not address all risks due to underlying fractures as pathway through basalt.	15	3	No hot spot treatment of removal, but reduces hot spot mobility by containment.	2	This alternative would generate additional excavated material and take a longer amount of time to implement. However, emissions associated with long term O&M may be reduced as a result of increased reliability.	20	Long term impact of COCs on wall integrity, full upland lateral and vertical extent of creosote NAPL, propensity for source to move vertically into underlying fractured basalt.	Diversion of groundwater outside of source area is a straightforward way to protect bay from source of creosote NAPL. Short time-period for installation.	High capital cost. Hydrogeologic modeling has not been completed, so unknowns are high.
3, 4, 5, 6, 7, 8	RAA-6: Excavation and Offsite Disposal, Impervious Surface Cap (over residuals), MNA	This alternative is considered protective. The excavation and offsite disposal of all accessible upland soil containing creosote NAPL would directly remove contamination and eliminate long-term O&M.	5	This alternative is the most effective as it removes the majority of hot spots and associated risks, resulting in shorter time to meet upland RAOs.	5	Highly reliable. Established method with few uncertainties. Long-term O&M needs are reduced or eliminated.	1	Uses established technologies, though the large extent of excavation reduces the implementability. Generation of significant volumes of excavated material and increase in construction time period. Would require significant truck loads to remove material or barge and/or rail cars. Dewatering is expected to be needed, and associated treatment of water.	1	The large volume of excavated material corresponds to increased risk associated with soil handling and increased risk to the community and environment related to truck traffic emissions and the increased potential for spills during transport. The excavation depth may require shoring (e.g., soil freezing). Some uncertainty with long-term liability at landfill.	1	$60,386,000. Extremely high cost to implement (disposal). Mitigates risks so no long term O&M. Relies on permitted landfill.	13	5	Includes extensive hot spot removal.	1	The extent of excavation is considerably larger than the other alternatives, resulting in increased greenhouse gas emissions during construction and disposal and larger volumes of waste material.	19	Ability to remove all creosote NAPL and potential for displacement during excavation.	Quick to implement, satisfies RAOs quickly and effectively meets hot spot rules.	Disproportionately high capital cost due to transport and disposal costs. Increased community and environmental impacts due to truck traffic.

Notes:

1	Staff Report Sections 6.2 and 6.3 provide evaluation criteria considered for each of the balancing factors.
2	Initial score includes the combined scores from the 5 balancing factors described in OAR 340-122-0090(3)
3	The final score includes additional scores from additional preferred criteria, including hot spot treatment and green remediation.
ARARs	Applicable or Relevant and Appropriate Requirements
COCs	Constituents of Concern
IC	Institutional Control
IDW	Investigation Derived Waste
MNA	Monitored Natural Recovery
NAPL	Non-Aqueous Phase Liquid
O&M	Operations and Maintenance
PAA	Priority Action Area
PRB	Permeable Reactive Barrier
RAA	Remedial Action Alternative
RAO	Remedial Action Objective
TOC	Total Organic Carbon

Table 13. Area 1 Dock PAA remedial action alternatives rankings and rationale for evaluation criteria.

RAO	Remedial Action Alternative	Protectiveness	Balancing Factors[1]										Initial Total Score[2]
			Effectiveness 5 = high effectiveness		Long-Term Reliability 5 = high reliability		Implementability 5 = high implementability		Implementation Risk 5 = low risk		Cost 5 = low cost		
None	RAA-1: No Action	Alternative does not provide protection because no action is taken to remove, treat, or contain residual contamination at the Site.											
1a, 1b, 1c, 2	RAA-2: Armored Reactive Cap	This alternative is considered protective. Some removal of contaminated wood debris to aid in cap installation. The cap is expected to reduce contaminant mass flux and provide a barrier to direct contact. However, this portion of the Site's shoreline is subjected to stronger river current compared to the other in-water PAAs and additional armoring will likely be required.	2	The cap would effectively shield contaminants from entering the river, including from any remaining contaminated wood debris. Uncertainty posed by significant amount of remaining contaminated wood debris.	2	Long-term reliability impacted by ability to remove wood debris prior to cap installation. Long-term monitoring and maintenance required. Differential settlement of sediment may require and gas ebullition from decomposing wood debris may impact long-term reliability. Significant amounts of contaminated wood debris left in place below the mudline.	4	Proven technologies and placement methods. Any specialized materials or equipment expected to be readily available. Additional on-site grading may be needed pending results of the flood rise analysis.	4	Implementation risk is lower than RAA-3 and RAA-4 because the reduced scope of construction and removal. Some risk associated with the removal of timber pilings and wood debris.	4	$5,382,000 Installation cost is high, long term O&M costs low. Monitoring goes on indefinitely. May not address all risks due to no hot spot treatment or removal.	16
1a, 1b, 1c, 2	RAA-3: Nearshore Removal Action, Upland Consolidation, and Armored Reactive Capping of Residuals	This alternative is considered protective. The cap will reduce contaminant mass flux and some hot spot removal (nearshore contaminated sediment and wood debris) will take place, though some of the PAA (approximately 20%) is not accessible by land-based equipment. Uncertainty related to ability to remove wood debris due to the age and highly weathered nature of the material. Uncertainty related to contamination with depth, and is possible that removing surface material may expose greater contamination concentrations and increase risk. Material consolidated on site presents different risk.	3	Approximately 80% of nearshore surface hot spot material removed from PAA. However, the ability to remove wood debris source material is unclear due to the significant volume and age. It is likely that much of the wood debris would remain. Additionally, impact of removal on effectiveness is unclear due to data gaps related to contaminant concentration with depth. Removing surface material removes contamination but may expose deeper contamination of greater concentrations. Material consolidated on site requires additional institutional and engineering controls.	3	Long-term reliability may be improved as hot spot material is removed. However, uncertainties related to ability to remove wood debris and contamination depth profile. Additional institutional and engineering controls needed compared to off site disposal. Robust long-term monitoring and maintenance, including sediment and porewater sampling, needed as creosote NAPL-containing sediment would be left in place.	2	Increased construction and complexity associated with removal due to volume of buried waste. Removal of wood debris may be challenging due to non-heterogeneous subsurface. Construction issues may occur due to strong river currents. Additional permitting and stakeholder negotiations needed for on site consolidation, particularly as material would be placed within the 100-year flood plain.	3	Greater scope of construction, greater complexity associated with significant amount of wood debris. Potential risk associated with potentially exposing greater contamination with surface material removal. Disturbance of contaminated sediment during the removal action has a high potential for accidental release to the environment. Robust BMPs would be required for implementation. Managing material on site would reduce implementation risk to the community from truck traffic but would present longer-term risk based on the material remaining on site.	3	$8,138,000 Installation cost is high, long term O&M costs low. Monitoring goes on indefinitely. May not address all risks due to incomplete hot spot treatment or removal.	14
1a, 1b, 1c, 2	RAA-4: Nearshore Removal Action, Offsite Disposal, and Armored Reactive Capping of Residuals	This alternative is considered protective. Same considerations as RAA-3, but material removed from site reduces risk.	4	Same considerations as RAA-3 except material removed from site removes associated risk.	4	Same considerations as RAA-3 except removing contaminated material off site improves long-term reliability.	3	Same considerations as RAA-3 except reduced permitting and stakeholder negotiations as contaminated material would be disposed off site.	2	Same considerations as RAA-3 except disposing of material off site would increase implementation risk to the community and environment related to truck traffic emissions and the increased potential for spills during transport. However, off site disposal reduces long term risk by removing contamination from the site.	2	$9,528,000 Installation cost is high, long term O&M costs low. Monitoring goes on indefinitely. May not address all risks due to incomplete hot spot treatment or removal.	15
1a, 1b, 1c, 2	RAA-5: Complete Removal and Offsite Disposal	This alternative is considered protective. The excavation and offsite disposal of all creosote NAPL-impacted sediment would directly remove contamination and reduce or eliminate long-term O&M. However, depth of contamination has not been fully characterized.	5	This alternative is the most effective as it removes the majority of hot spots and associated risks, resulting in shorter time to meet upland RAOs. However, depth of contamination has not been fully characterized.	5	Highly reliable. Established method with few uncertainties. However, depth of contamination has not been fully characterized. Long-term O&M needs are reduced or eliminated.	1	Uses established technologies. Large construction scope and extent of excavation reduces the implementability. Ability to remove all wood debris is unlikely, significantly impacting ability to remove all sediment. Specialized equipment to shore the excavation area. Generation of significant volumes of excavated material and increase in construction time period. Would require significant truck loads to remove material or barge and/or rail cars. Dewatering is expected to be needed, and associated treatment of water.	1	Greater extent and complexity of construction. The large volume of excavated material corresponds to increased risk associated with material handling, increased potential for releases outside the work area, and increased risk to the community and environment related to truck traffic emissions and the increased potential for spills during transport. Some uncertainty with long-term liability at landfill. Risk associated with removal of significant amount of wood debris. Wood debris will impede removal.	1	$29,181,000. Extremely high cost to implement (disposal). Mitigates risks so reduced or eliminated long term O&M. Relies on permitted landfill.	13

Table 13. Area 1 Dock PAA remedial action alt

Table 13. Area 1 Dock PAA remedial action alternatives rankings and rationale for evaluation criteria.

RAO	Remedial Action Alternative	Additional Factors					Overall		
		Hot Spot Treatment 5 = likely		Green Remediation 5 = highly sustainable		Total Score[3]	Unknowns	Advantages	Disadvantages
None	RAA-1: No Action	As a result, Alternative 1 was not carried forward or evaluated for criteria as it does not achieve protectiveness.							
1a, 1b, 1c, 2	RAA-2: Armored Reactive Cap	1	Some contamination removal associated with removal of wood and pilings. However, generally no hot spot treatment or removal, but reduces hot spot mobility.	4	Low amount of construction and associated emissions and minimal generation of waste, resulting in low effect on environment.	21	Bench and/or pilot tests needed to determine the specific materials and thicknesses needed for the cap, particularly considering the stronger river currents in this PAA. Additional characterization and cap modeling needed for pre-design investigation. Additional geotechnical investigation needed for pre-design investigation to address soft sediment and contaminated wood waste. The extent of debris and timber piles.	Established technology and materials, less construction requirements.	No hot spot treatment or removal.
1a, 1b, 1c, 2	RAA-3: Nearshore Removal Action, Upland Consolidation, and Armored Reactive Capping of Residuals	3	Aim to remove timber piles and approximately 80% of creosote-impacted surface sediment hot spot material. Cap reduces hot spot mobility. However, some hot spot material would remain and potentially greater concentrations could be exposed from removal of surface material. Additionally, it is unclear how successful removal of wood debris is due to the significant volume and age.	3	Some construction, including personnel and equipment, is required for nearshore removal action and the on site consolidation system. Waste management would result in additional impact during dewatering. However, on site consolidation would require less truck traffic and associated emissions. Opportunities for green remediation efforts, such as low sulfur fuels, etc.	20	The extent of hot spot material remaining after removal. The ability to remove pilings and wood debris given significant volume and age. Data gaps related to contamination with depth. Additional characterization and cap modeling needed for pre-design investigation. Additional geotechnical investigation needed for pre-design investigation to address soft sediment and contaminated wood waste. Potential permitting or stakeholder negotiations complications related to on site consolidation.	Established technology and materials. Includes some hot spot removal. Less truck traffic associated with off site disposal.	Increased construction requirements compared to RAA-2. Potential exposure of deeper, buried, contamination with removal of surface sediment. On site consolidation of contaminated material presents risk. Robust long-term monitoring and maintenance, including sediment and porewater sampling, needed as creosote NAPL-containing sediment would be left in place.
1a, 1b, 1c, 2	RAA-4: Nearshore Removal Action, Offsite Disposal, and Armored Reactive Capping of Residuals	3	Same considerations as RAA-3.	2	Same considerations as RAA-3 except off site disposal would require additional truck traffic and associated emissions.	20	Same considerations as RAA-3 except those related to on site consolidation.	Established technology and materials. Includes some hot spot removal. Removal of contaminated material from site.	Increased construction requirements compared to RAA-2. Potential exposure of deeper contamination. Increased truck traffic required for off site disposal.
1a, 1b, 1c, 2	RAA-5: Complete Removal and Offsite Disposal	5	Includes extensive hot spot removal.	1	The extent of excavation is considerably larger than the other alternatives, resulting in increased greenhouse gas emissions during construction and disposal and larger volumes of waste material. Higher energy consumption related to longer time frame required for implementation.	19	The ability to remove pilings and wood debris given significant volume and age. Data gaps related to contamination with depth. Additional characterization needed for pre-design investigation. Additional geotechnical investigation needed for pre-design investigation to address soft sediment and contaminated wood waste.	Satisfies RAOs quickly and effectively meets hot spot rules.	Increased construction requirements compared to RAA-2, RAA-3, and RAA-4. Potential exposure of deeper contamination. Disproportionately high capital cost due to transport and disposal costs. Increased community and environmental impacts due to truck traffic.

Notes:

1	Staff Report Sections 6.2 and 6.3 provide evaluation criteria considered for each of the balancing factors.	O&M	Operations and Maintenance
2	Initial score includes the combined scores from the 5 balancing factors described in OAR 340-122-0090(3)	PAA	Priority Action Area
3	The final score includes additional scores from additional preferred criteria, including hot spot treatment and green remediation.	RAA	Remedial Action Alternative
BMP	Best Management Practice	RAO	Remedial Action Objective
NAPL	Non-aqueous Phase Liquid	%	Percent

Table 14. Area 2 Dock PAA remedial action alternatives rankings and rationale for evaluation criteria.

RAO	Remedial Action Alternative	Protectiveness	Balancing Factors[1]										
			Effectiveness 5 = high effectiveness		Long-Term Reliability 5 = high reliability		Implementability 5 = high implementability		Implementation Risk 5 = low risk		Cost 5 = low cost		Initial Total Score[2]
None	RAA-1: No Action	Alternative does not provide protection because no action is taken to remove, treat, or contain residual contamination at the Site.											
1a, 1b, 1c, 2	RAA-2: Armored Reactive Cap	This alternative is considered protective. Some removal of contaminated wood debris to aid in cap installation. The cap is expected to reduce contaminant mass flux and provide a barrier to direct contact. However, this portion of the Site's shoreline may be subjected to stronger river current compared to the other in-water PAAs and additional armoring may be required.	2	The cap would effectively shield contaminants from entering the river, including from any remaining contaminated wood debris. Uncertainty in the amount of remaining contaminated wood debris.	2	Long-term reliability impacted by ability to remove wood debris prior to cap installation. Long-term monitoring and maintenance required.	4	Proven technologies and placement methods. Any specialized materials or equipment expected to be readily available.	4	Implementation risk is lower than RAA-3 and RAA-4 because the reduced scope of construction and removal.	4	$1,309,000 Installation cost is high, long term O&M costs low. Monitoring goes on indefinitely. May not address all risks due to no hot spot treatment or removal.	16
1a, 1b, 1c, 2	RAA-3: Nearshore Removal Action, Upland Consolidation, and ENR Capping of Residuals	This alternative is considered protective. The cap will reduce contaminant mass flux and hot spot removal (approximately 84%) will take place. However, some of the PAA (approximately 16%) is not accessible by land based equipment. Material consolidated on site presents different risk.	3	Approximately 84% of hot spot material removed from PAA, which would greatly increase the effectiveness of the remedial action. Material consolidated on site requires additional institutional and engineering controls. Uncertainty related to the effectiveness of a sand-only cap in an area with stronger river currents.	3	Improved long-term reliability as large percentage of hot spot material is removed. Additional institutional and engineering controls needed compared to off site disposal. Long-term monitoring and maintenance needed. Uncertainty related to the long-term reliability of a sand-only cap in an area with stronger river currents.	2	Increased construction and complexity associated with streambank regrading and removal action. River current control, robust BMPs needed to construct in area of stronger river currents. Additional permitting and stakeholder negotiations needed for on site consolidation, particularly as material would be placed within the 100-year flood plain.	3	Disturbance of contaminated sediment during the removal action has a higher potential for accidental release to the environment. Managing material on site would reduce implementation risk to the community from truck traffic but would present longer-term risk based on the material remaining on site.	3	$1,596,000 Installation cost is high, long term O&M costs low. Monitoring goes on indefinitely. May not address all risks due to incomplete hot spot treatment or removal.	14
1a, 1b, 1c, 2	RAA-4: Nearshore Removal Action, Offsite Disposal, and Capping of Residuals	This alternative is considered protective. Same considerations as RAA-3, but material removed from site reduces risk.	4	Same considerations as RAA-3 except material removed from site removes associated risk.	4	Same considerations as RAA-3 except removing contaminated material off site improves long-term reliability.	3	Same considerations as RAA-3 except reduced permitting and stakeholder negotiations as contaminated material would be disposed off site.	2	Same considerations as RAA-3 except disposing of material off site would increase implementation risk to the community and environment related to truck traffic emissions and the increased potential for spills during transport. However, off site disposal reduces long term risk by removing contamination from the site.	3	$1,604,000 Installation cost is high, long term O&M costs low. Monitoring goes on indefinitely. May not address all risks due to incomplete hot spot treatment or removal.	16

Table 14. Area 2 Dock PAA remedial action alternatives ran

RAO	Remedial Action Alternative	Additional Factors					Overall		
		Hot Spot Treatment 5 = likely		Green Remediation 5 = highly sustainable		Total Score[3]	Unknowns	Advantages	Disadvantages
None	RAA-1: No Action	As a result, Alternative 1 was not carried forward or evaluated for criteria as it does not achieve protectiveness.							
1a, 1b, 1c, 2	RAA-2: Armored Reactive Cap	**1**	Some contamination removal associated with removal of wood and pilings. However, generally no hot spot treatment or removal, but reduces hot spot mobility.	**4**	Minimal construction and associated emissions and low volume of waste generated, resulting in lower overall impacts to the environment.	21	Bench and/or pilot tests needed to determine the specific materials and thicknesses needed for the cap, particularly considering the stronger river currents in this PAA. The extent of debris and timber piles.	Established technology and materials, less construction requirements.	No hot spot treatment or removal.
1a, 1b, 1c, 2	RAA-3: Nearshore Removal Action, Upland Consolidation, and ENR Capping of Residuals	**4**	Timber piles and approximately 84% of creosote-impacted surface sediment hot spot material will be removed. Cap reduces hot spot mobility. However, some hot spot material would remain.	**3**	Short distances for truck traffic for on-site consolidation, resulting in low emissions and overall low impacts to the environment	21	The extent of hot spot material remaining after removal. Potential permitting or stakeholder negotiations complications related to on site consolidation. Ability of sand-only cap to effectively remain in place in an area with stronger river currents.	Established technology and materials. Includes some hot spot removal. Less truck traffic associated with off site disposal.	Increased construction requirements compared to RAA-2. On site consolidation of contaminated material presents risk.
1a, 1b, 1c, 2	RAA-4: Nearshore Removal Action, Offsite Disposal, and Capping of Residuals	**4**	Same considerations as RAA-3.	**2**	Same considerations as RAA-3 except off site disposal would require additional truck traffic and associated emissions.	22	The extent of hot spot material remaining after removal.	Established technology and materials. Includes some hot spot removal. Removal of contaminated material from site.	Increased construction requirements compared to RAA-2. Increased truck traffic required for off site disposal.

Notes:

1	Staff Report Sections 6.2 and 6.3 provide evaluation criteria considered for each of the balancing factors.
2	Initial score includes the combined scores from the 5 balancing factors described in OAR 340-122-0090(3)
3	The final score includes additional scores from additional preferred criteria, including hot spot treatment and green remediation.
BMP	Best Management Practice
ENR	Enhanced Natural Recovery
O&M	Operations and Maintenance
PAA	Priority Action Area
RAA	Remedial Action Alternative
RAO	Remedial Action Objective
%	Percent

Table 15. Cove Area PAA remedial action alternatives rankings and rationale for evaluation criteria[1].

RAO	Remedial Action Alternative	Protectiveness	Balancing Factors[1]										
			Effectiveness 5 = high effectiveness		Long-Term Reliability 5 = high reliability		Implementability 5 = high implementability		Implementation Risk 5 = low risk		Cost 5 = low cost		Initial Total Score[2]
None	RAA-1: No Action	Alternative does not provide protection because no action is taken to remove, treat, or contain residual contamination at the Site.											
1-4	RAA-2: Armored Reactive Cap	This alternative is considered protective. An amended cap is expected to reduce contaminant mass flux from sediment to surface water and provide a barrier to direct contact. Sediment porewater and surface water quality outside the cap boundary is expected to continue naturally recovering as new, cleaner sediment is deposited in the Cove (0.2 to 1.4 in/yr.).	2	The cap would effectively shield contaminants from entering the river, supported by preliminary CapSim modeling. No impacted material would be removed, resulting in less certainty in the effectiveness.	2	Preliminary CapSim modeling indicates long-term cap effectiveness (500 years). The Cove's off-channel backwater setting provides protection against wake and wind driven waves. New sediment is expected to accumulate over the in-water portions of the cap. Long-term monitoring and maintenance required.	4	Proven technologies and placement methods. Potential for differential settlement below an armored reactive cap, can be addressed with specialized capping materials and placement techniques as developed at other sites with similar conditions. Materials and equipment are expected to be available in the Pacific Northwest. On-site grading needed to maintain the flood-carrying capacity of the waterway if the results of the flood rise analysis exceed the City of St. Helen's threshold. Mitigation needed to offset the loss of intertidal shallow water habitat.	4	Implementation risk is lower than RAA-2, RAA-3, and RAA-5 because there would be no in-water removal of sediment. Potential risks associated with differential settlement below the cap can be mitigated using capping materials that evenly distribute the weight of armoring (e.g., marine mattress).	4	$3,551,000 Installation cost is high, long term O&M costs low. Monitoring goes on indefinitely. May not address all risks due to no hot spot treatment or removal.	16
1-4	RAA-3: Riverbank Restoration, Nearshore Removal Action, Upland Consolidation, and Reactive Capping of Residuals	This alternative is considered protective. The cap will reduce contaminant mass flux and some hot spot removal will take place. Improved cap performance with streambank regrading. Uncertainty related to contamination with depth, and is possible that removing surface material may expose greater contamination concentrations and increase risk. Material left on site presents long-term risk.	3	Regrading facilitates improved access by land-based equipment, some hot spot removal (up to 90% contaminated surface sediment), more controlled placement of cap material, reduced erosional forces imposed on the cap. The temporary cofferdam allows an extended excavation area. Impact of removal on effectiveness is unclear due to data gaps related to contaminant concentration with depth. Removing surface material removes contamination but may expose deeper contamination of greater concentrations. Material consolidated on site requires additional institutional and engineering controls.	3	Constructing the cap on a flatter streambank is more reliable. Hot spot removal, though there are uncertainties related to the contamination depth profile and total volume that may remain in the stranded wedge. Additional institutional and engineering controls needed for on-site containment site disposal. Future water levels expected to rise, so long-term reliability may be affected. Long-term monitoring and maintenance needed.	2	Local resources available for streambank regrading and removal action. Additional permitting and stakeholder negotiations needed for on site consolidation, particularly as material would be placed within the 100-year flood plain.	3	Flattening the streambank would improve cap constructability and construction worker safety. Greater scope of construction. Potential risk associated with potentially exposing greater contamination with surface material removal. Disturbance of contaminated sediment during the removal action has a potential for accidental release to the environment. Managing material on site would reduce implementation risk to the community from truck traffic but would present longer-term risk based on the material remaining on site.	3	$4,836,000 Installation cost is high, long term O&M costs low. Monitoring goes on indefinitely. Most hot spot material removed, but may not address all risks due to incomplete hot spot treatment or removal.	14
1a, 1b, 1c, 2, 3, 4	RAA-4: Riverbank Restoration, Nearshore Removal Action, Offsite Disposal, and Reactive Capping of Residuals	This alternative is considered protective. Same considerations as RAA-3, but material removed from site reduces risk.	4	Same considerations as RAA-3 except material removed from site removes associated risk.	4	Constructing the cap on a flatter streambank is more reliable. Hot spot removal, though there are uncertainties related to the contamination depth profile and total volume that may remain in the stranded wedge. Additional institutional and engineering controls needed for cap. Long-term monitoring and maintenance needed.	3	Same considerations as RAA-3 except reduced permitting and stakeholder negotiations as contaminated material would be disposed off site.	2	Same considerations as RAA-3 except disposing of material off site would increase implementation risk to the community and environment related to truck traffic emissions and the increased potential for spills during transport. However, off site disposal reduces long term risk by removing contamination from the site.	2	$5,984,000 Same considerations as RAA-3.	15
1a, 1b, 1c, 2, 3, 4	RAA-5: Complete Removal and Offsite Disposal	This alternative is considered protective. The excavation and offsite disposal of all creosote NAPL-impacted sediment would directly remove contamination and reduce or eliminate long-term O&M. However, depth of contamination has not been fully characterized.	5	This alternative is the most effective as it removes the majority of hot spots and associated risks, resulting in shorter time to meet upland RAOs. However, depth of contamination has not been fully characterized.	5	Highly reliable. Established method with few uncertainties. However, depth of contamination has not been fully characterized. Long-term O&M needs are reduced or eliminated.	1	Uses established technologies. Large construction scope and extent of excavation reduces the implementability. Specialized equipment to shore the excavation area. Generation of significant volumes of excavated material and increase in construction time period. Would require significant truck loads to remove material or barge and/or rail cars. Dewatering is expected to be needed, and associated treatment of water.	1	Greater extent and complexity of construction. The large volume of excavated material corresponds to increased risk associated with material handling, increased potential for releases outside the work area, and increased risk to the community and environment related to truck traffic emissions and the increased potential for spills during transport. Some uncertainty with long-term liability at landfill.	1	$17,606,000. Extremely high cost to implement (disposal). Mitigates risks so reduced or eliminated long term O&M. Relies on permitted landfill.	13

Table 15. Cove Area PAA remedial action alternatives rankir**Table 15. Cove Area PAA remedial action alternatives rankings and rationale for evaluation criteria[1].**

RAO	Remedial Action Alternative	Additional Factors					Overall		
		Hot Spot Treatment 5 = likely		Green Remediation 5 = highly sustainable		Total Score[3]	Unknowns	Advantages	Disadvantages
None	RAA-1: No Action	As a result, Alternative 1 was not carried forward or evaluated for criteria as it does not achieve protectiveness.							
1-4	RAA-2: Armored Reactive Cap	**1**	Riverbank regrading limited to slope stabilization and is not expected to include removal of a significant volume of soil within the riverbank seepage area. Thus no hot spot treatment or removal.	**4**	Construction and associated emissions are low due to small scope of work. No expected generation of waste decreases effects on the environment.	21	Bench and/or pilot tests needed to determine the specific materials and thicknesses needed for the cap. The extent of debris and timber piles.	Established technology and materials, less construction requirements.	No hot spot treatment or removal.
1-4	RAA-3: Riverbank Restoration, Nearshore Removal Action, Upland Consolidation, and Reactive Capping of Residuals	**4**	Up to 90% of surface sediment currently exhibiting a moderate to heavy petroleum sheen is expected to be removed with the remaining 10% beyond the reach of land-based equipment, even with the use of a temporary cofferdam system. Potentially greater concentrations could be exposed from removal of surface material. Cap reduces remaining hot spot mobility.	**3**	Construction for streambank regrading and the on site consolidation system will result in emissions. However, on site consolidation would require less truck traffic and associated emissions.	21	The extent of hot spot material remaining after removal. Data gaps related to contamination with depth. Additional characterization needed for remedial design. Potential permitting or stakeholder negotiations complications related to on site consolidation	Established technology and materials. Includes some hot spot removal. Better cap integrity. Less truck traffic associated with off site disposal.	Increased construction requirements compared to RAA-2. Potential exposure of deeper contamination. On site consolidation of contaminated material presents risk.
1a, 1b, 1c, 2, 3, 4	RAA-4: Riverbank Restoration, Nearshore Removal Action, Offsite Disposal, and Reactive Capping of Residuals	**4**	Same considerations as RAA-3.	**2**	Additional construction is required compared to RAA-2 for streambank regrading. Off site disposal would require additional truck traffic and associated emissions.	21	The extent of hot spot material remaining after removal.	Established technology and materials. Includes some hot spot removal. Better cap integrity. Removal of contaminated material from site.	Increased truck traffic resulting in increased emissions required for off site disposal.
1a, 1b, 1c, 2, 3, 4	RAA-5: Complete Removal and Offsite Disposal	**5**	Includes extensive hot spot removal.	**1**	The extent of excavation is considerably larger than the other alternatives, resulting in increased greenhouse gas emissions during construction and disposal and larger volumes of waste material. Higher energy consumption related to longer-time frame required for implementation.	19	Ability to remove all creosote NAPL and potential for displacement during excavation.	Satisfies RAOs quickly and effectively meets hot spot rules.	Increased construction requirements compared to RAA-2, RAA-3, and RAA-4. Potential exposure of deeper contamination. Disproportionately-high capital cost due to transport and disposal costs. Increased community and environmental impacts due to truck traffic.

Notes:

1	Staff Report Sections 6.2 and 6.3 provide evaluation criteria considered for each of the balancing factors.	O&M	Operations and Maintenance
2	Initial score includes the combined scores from the 5 balancing factors described in OAR 340-122-0090(3)	PAA	Priority Action Area
3	The final score includes additional scores from additional preferred criteria, including hot spot treatment and green remediation.	RAA	Remedial Action Alternative
in/yr	inches per year	RAO	Remedial Action Objective
NAPL	Non-aqueous Phase Liquid	%	percent

Table 16. Upper Milton Creek PAA remedial action alternatives rankings and rationale for evaluation criteria.

RAO	Remedial Action Alternative	Protectiveness	Balancing Factors[1]										
			Effectiveness 5 = high effectiveness		**Long-Term Reliability 5 = high reliability**		**Implementability 5 = high implementability**		**Implementation Risk 5 = low risk**		**Cost 5 = low cost**		**Initial Total Score[2]**
None	RAA-1: No Action	Alternative does not provide protection because no action is taken to remove, treat, or contain residual contamination at the Site.											
1a, 1b, 1c, 2, 3, 4	RAA-2: Armored Reactive Cap	This alternative is considered protective. The cap over creosote-impacted groundwater seeps is expected to reduce contaminant mass flux and provide a barrier to direct contact.	2	The cap would effectively shield contaminants from entering the creek. However, without regrading the cap may be less stable. No impacted material would be removed, resulting in less certainty in the effectiveness.	2	The long-term reliability of the armoring to protect the cap when Milton Creek is subject to peak discharge event has yet to be determined. Long-term cap inspection and maintenance, possibly greater maintenance required than alternatives including streambank regrading.	3	Established technology, common materials. Logistical challenges associated with constructing a reactive cap along the outside bend of a steep channelized streambank.	4	Less intensive construction activities, but the steepness of the streambank and concerns about stability represents higher risk to construction workers.	4	$898,000 Installation cost is high, long term O&M costs low. Monitoring goes on indefinitely. May not address all risks due to no hot spot treatment or removal.	15
1a, 1b, 1c, 2, 3, 4	RAA-3: Regrade Streambank, Limited Removal Action, Upland Consolidation, and Armored Reactive Capping of Residuals	This alternative is considered protective. The cap will reduce contaminant mass flux to the creek and some hot spot removal will take place. Improved cap performance with streambank regrading. Material left on site presents different risk.	3	Flattening the steep east bank of the creek facilitates some hot spot removal, more controlled placement of cap material, and reduced erosional forces imposed on the cap. Material consolidated on site requires additional institutional and engineering controls.	3	Constructing the cap on a flatter streambank more reliable. Additional institutional and engineering controls needed compared to off site disposal. Long-term monitoring and maintenance needed.	3	Established technology, common materials. Increased construction associated with streambank regrading compared to RAA-2. Additional permitting and stakeholder negotiations needed for on site consolidation, particularly as material would be placed within the 100-year flood plain.	4	Flattening the streambank would improve cap constructability and construction worker safety. Managing material on site would reduce implementation risk to the community from truck traffic but would present longer-term risk based on the material remaining on site.	3	$1,146,000 Installation cost is high, long term O&M costs low. Monitoring goes on indefinitely. Some hot spot material removed, but may not address all risks due to incomplete hot spot treatment or removal.	16
1a, 1b, 1c, 2, 3, 4	RAA-4: Regrade Streambank, Limited Removal Action, Offsite Disposal, and Armored Reactive Capping of Residuals	Same considerations as RAA-3 except material removed from site removes associated risk.	4	Same considerations as RAA-3 except material removed from site removes associated risk.	4	Constructing the cap on a flatter streambank more reliable. Removing contaminated material off site improves long-term reliability. Long-term monitoring and maintenance needed.	4	Same considerations as RAA-3 except reduced permitting and stakeholder negotiations as contaminated material would be disposed off site.	3	Flattening the streambank would improve cap constructability and construction worker safety. Disposing of material off site would increase implementation risk to the community and environment related to truck traffic emissions and the increased potential for spills during transport. However, off site disposal reduces long term risk by removing contamination from the site.	2	$1,216,000 Same considerations as RAA-3.	17

Table 16. Upper Milton Creek PAA remedial action alternativ

RAO	Remedial Action Alternative	Additional Factors					Overall		
		Hot Spot Treatment 5 = likely		Green Remediation 5 = highly sustainable		Total Score[3]	Unknowns	Advantages	Disadvantages
None	RAA-1: No Action	As a result, Alternative 1 was not carried forward or evaluated for criteria as it does not achieve protectiveness.							
1a, 1b, 1c, 2, 3, 4	RAA-2: Armored Reactive Cap	**1**	No hot spot treatment or removal, but reduces hot spot mobility.	**4**	Compared to RAA-3 and RAA-4 the extent of construction is less, corresponding to less greenhouse gas emissions.	20	The impacts of peak flow in Milton Creek and lack of streambank regrading on cap integrity.	Established technology and materials, less construction requirements.	No hot spot treatment or removal, less certainty of cap integrity.
1a, 1b, 1c, 2, 3, 4	RAA-3: Regrade Streambank, Limited Removal Action, Upland Consolidation, and Armored Reactive Capping of Residuals	**2**	Streambank regrading allows the removal of some hot spot material. However, much of the hot spot contamination would remain.	**3**	Additional construction is required compared to RAA-2 for streambank regrading and the on site consolidation system. However, on site consolidation would require less truck traffic and associated emissions.	21	The extent of hot spot material remaining after removal. Potential permitting or stakeholder negotiations complications related to on site consolidation	Established technology and materials. Includes some hot spot removal. Better cap integrity. Less truck traffic associated with off site disposal.	Increased construction requirements compared to RAA-2. On site consolidation of contaminated material presents risk.
1a, 1b, 1c, 2, 3, 4	RAA-4: Regrade Streambank, Limited Removal Action, Offsite Disposal, and Armored Reactive Capping of Residuals	**2**	Streambank regrading allows the removal of some hot spot material. However, much of the hot spot contamination would remain.	**2**	Additional construction is required compared to RAA-2 for streambank regrading. Off site disposal would require additional truck traffic and associated emissions.	21	The extent of hot spot material remaining after removal.	Established technology and materials. Includes some hot spot removal. Better cap integrity. Removal of contaminated material from site.	Increased construction requirements compared to RAA-2. Increased truck traffic required for off site disposal.

Notes:

1	Staff Report Sections 6.2 and 6.3 provide evaluation criteria considered for each of the balancing factors.
2	Initial score includes the combined scores from the 5 balancing factors described in OAR 340-122-0090(3)
3	The final score includes additional scores from additional preferred criteria, including hot spot treatment and green remediation.
O&M	Operations and Maintenance
PAA	Priority Action Area
RAA	Remedial Action Alternative
RAO	Remedial Action Objective

Table 17. Summary of evaluation criteria scoring for each remedial action alternative for all PAAs.

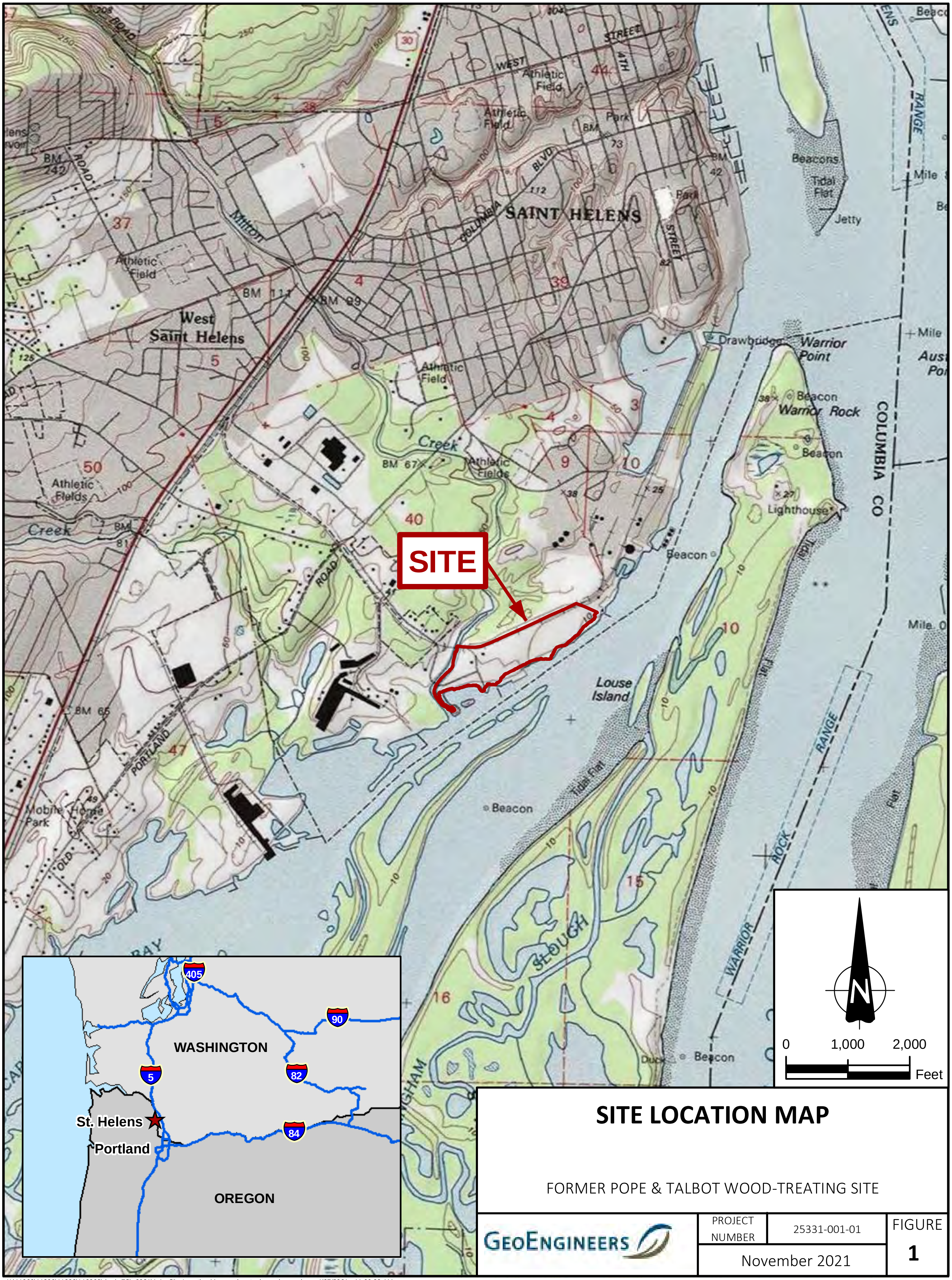
PAA	RAA	Protective-ness	Effective-ness	Long-Term Reliability	Implement-ability	Implement-ation Risk	Cost	Initial Score	Hot Spot Treatment	Green Remediation	Final Score
Area 1 Upland	RAA-1: No Action	No	Not further evaluated as not protective.								
	RAA-2: Impervious Surface Cap, MNA	Yes	2	2	4	4	4	**16**	2	4	**22**
	RAA-3: Impervious Surface Cap, Hydraulic Containment, Enhanced Bioremediation	Yes	4	3	2	2	2	**13**	4	2	**19**
	RAA-4: Impervious Surface Cap, MNA, Permeable Reactive Barrier	Yes	4	4	3	3	3	**17**	3	3	**23**
	RAA-5: Impervious Surface Cap, MNA, Impermeable Isolation Wall (NAPL Area)	Yes	4	4	2	2	3	**15**	3	2	**20**
	RAA-6: Excavation and Offsite Disposal, Impervious Surface Cap (over residuals), MNA	Yes	5	5	1	1	1	**13**	5	1	**19**
Area 1 Dock	RAA-1: No Action	No	Not further evaluated as not protective.								
	RAA-2: Installation of Armored Reactive Cap	Yes	2	2	4	4	4	**16**	1	4	**21**
	RAA-3: Nearshore Removal Action, Upland Consolidation, and Armored Reactive Capping of Residuals	Yes	3	3	2	3	3	**14**	3	3	**20**
	RAA-4: Nearshore Removal Action, Offsite Disposal, and Armored Reactive Capping of Residuals	Yes	4	4	3	2	2	**15**	3	2	**20**
	RAA-5: Complete Removal and Offsite Disposal	Yes	5	5	1	1	1	**13**	5	1	**19**
Area 2 Dock	RAA-1: No Action	No	Not further evaluated as not protective.								
	RAA-2: Installation of Armored Reactive Cap	Yes	2	2	4	4	4	**16**	1	4	**21**
	RAA-3: Nearshore Removal Action, Upland Consolidation, and Capping of Residuals	Yes	3	3	2	3	3	**14**	4	3	**21**
	RAA-4: Nearshore Removal Action, Offsite Disposal, and Capping of Residuals	Yes	4	4	3	2	3	**16**	4	2	**22**
Cove Area	RAA-1: No Action	No	Not further evaluated as not protective.								
	RAA-2: Installation of Armored Reactive Cap	Yes	2	2	4	4	4	**16**	1	4	**21**
	RAA-3: Riverbank Restoration, Nearshore Removal Action, Upland Consolidation, and Reactive Capping of Residuals	Yes	3	3	2	3	3	**14**	4	3	**21**
	RAA-4: Riverbank Restoration, Nearshore Removal Action, Offsite Disposal, and Reactive Capping of Residuals	Yes	4	4	3	2	2	**15**	4	2	**21**
	RAA-5: Complete Removal and Offsite Disposal	Yes	5	5	1	1	1	**13**	5	1	**19**
Upper Milton Creek	RAA-1: No Action	No	Not further evaluated as not protective.								
	RAA-2: Installation of Armored Reactive Cap	Yes	2	2	3	4	4	**15**	1	4	**20**
	RAA-3: Regrade Streambank, Limited Removal Action, Upland Consolidation, and Armored Reactive Capping of Residuals	Yes	3	3	3	4	3	**16**	2	3	**21**
	RAA-4: Regrade Streambank, Limited Removal Action, Offsite Disposal, and Armored Reactive Capping of Residuals	Yes	4	4	4	3	2	**17**	2	2	**21**

Notes:

RAA Remedial Action Alternative

PAA Priority Action Area

Selected Remedial Action



SITE LOCATION MAP

FORMER POPE & TALBOT WOOD-TREATING SITE

GeoEngineers

PROJECT NUMBER	25331-001-01	FIGURE
	November 2021	1

DRAWN BY: SD CHECKED BY: JKH

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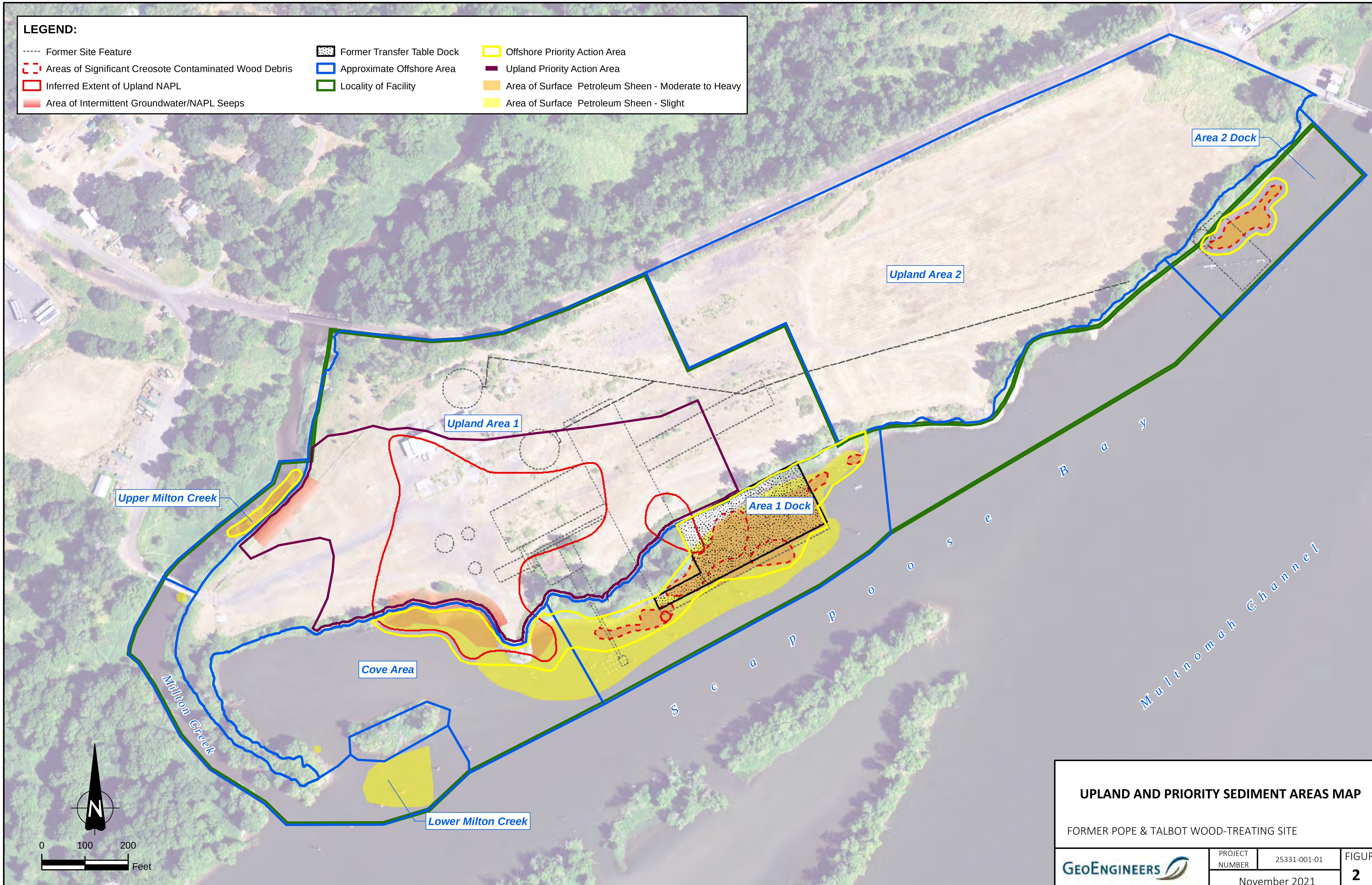

UPLAND AND PRIORITY SEDIMENT AREAS MAP

FORMER POPE & TALBOT WOOD-TREATING SITE

GEOENGINEERS

PROJECT NUMBER	25331-001-01	FIGURE
	November 2021	2

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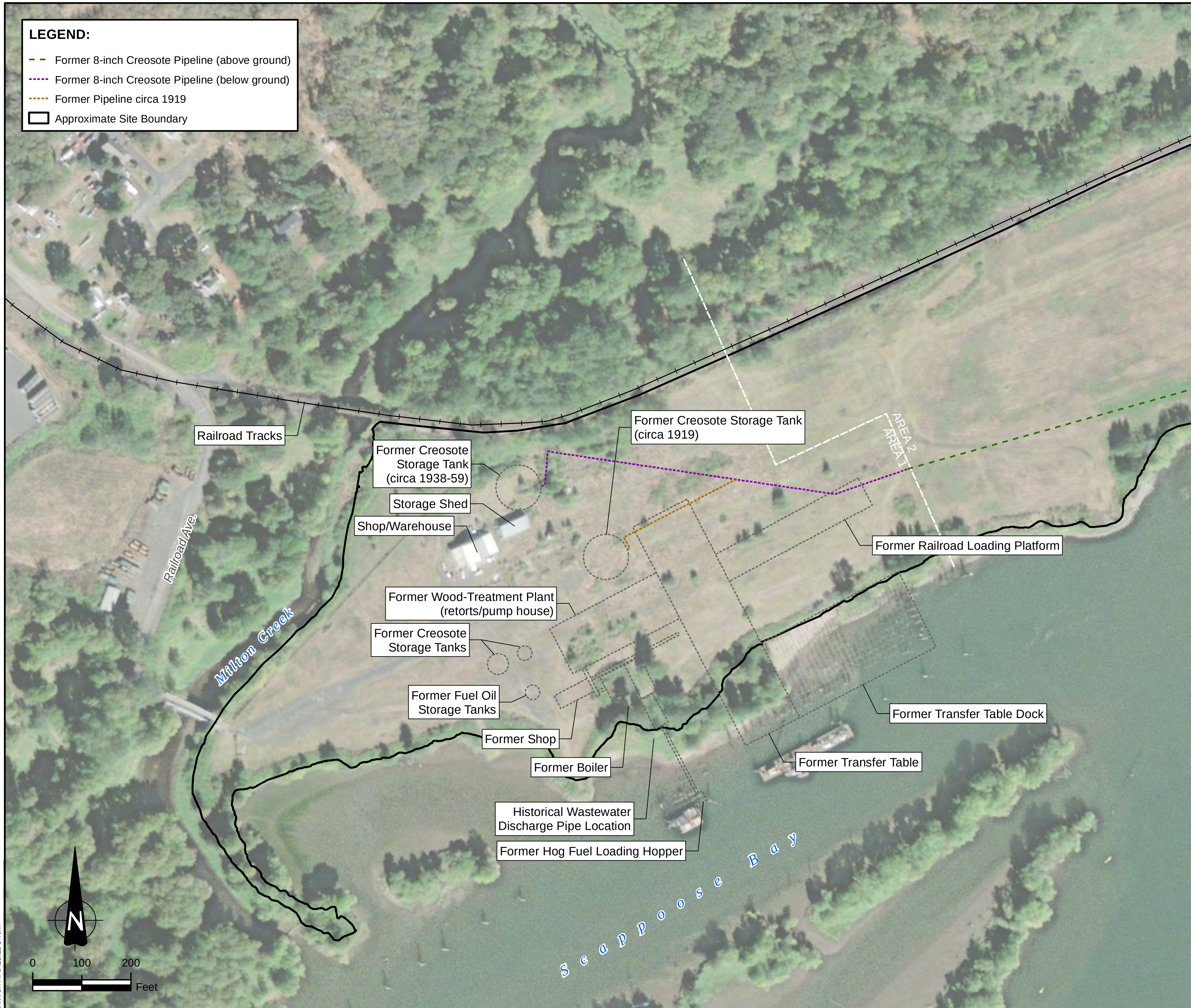

SITE PLAN

FORMER POPE & TALBOT WOOD-TREATING SITE

GeoEngineers

PROJECT NUMBER	25331-001-01	FIGURE
	November 2021	3A

DRAWN BY: PM CHECKED BY: JKH

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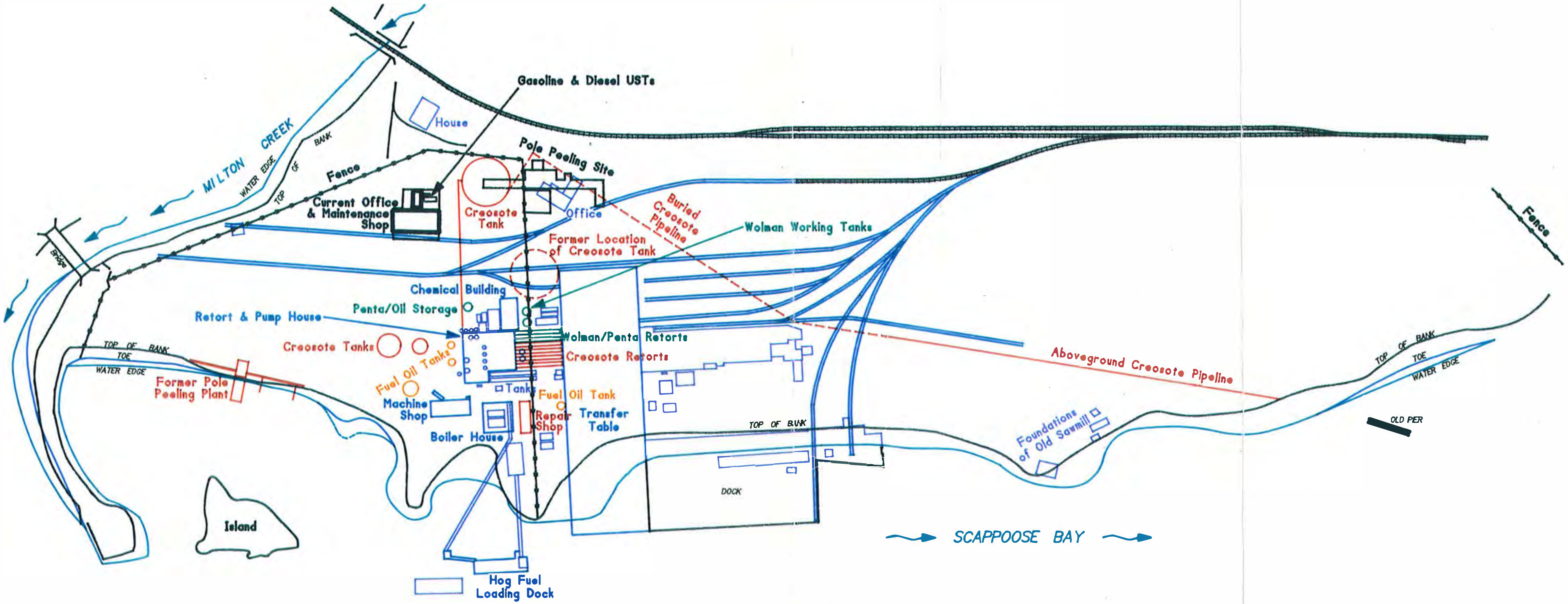


Current site features shown in black
(and light blue for river edge)
Former (ca. 1959) site features shown in color

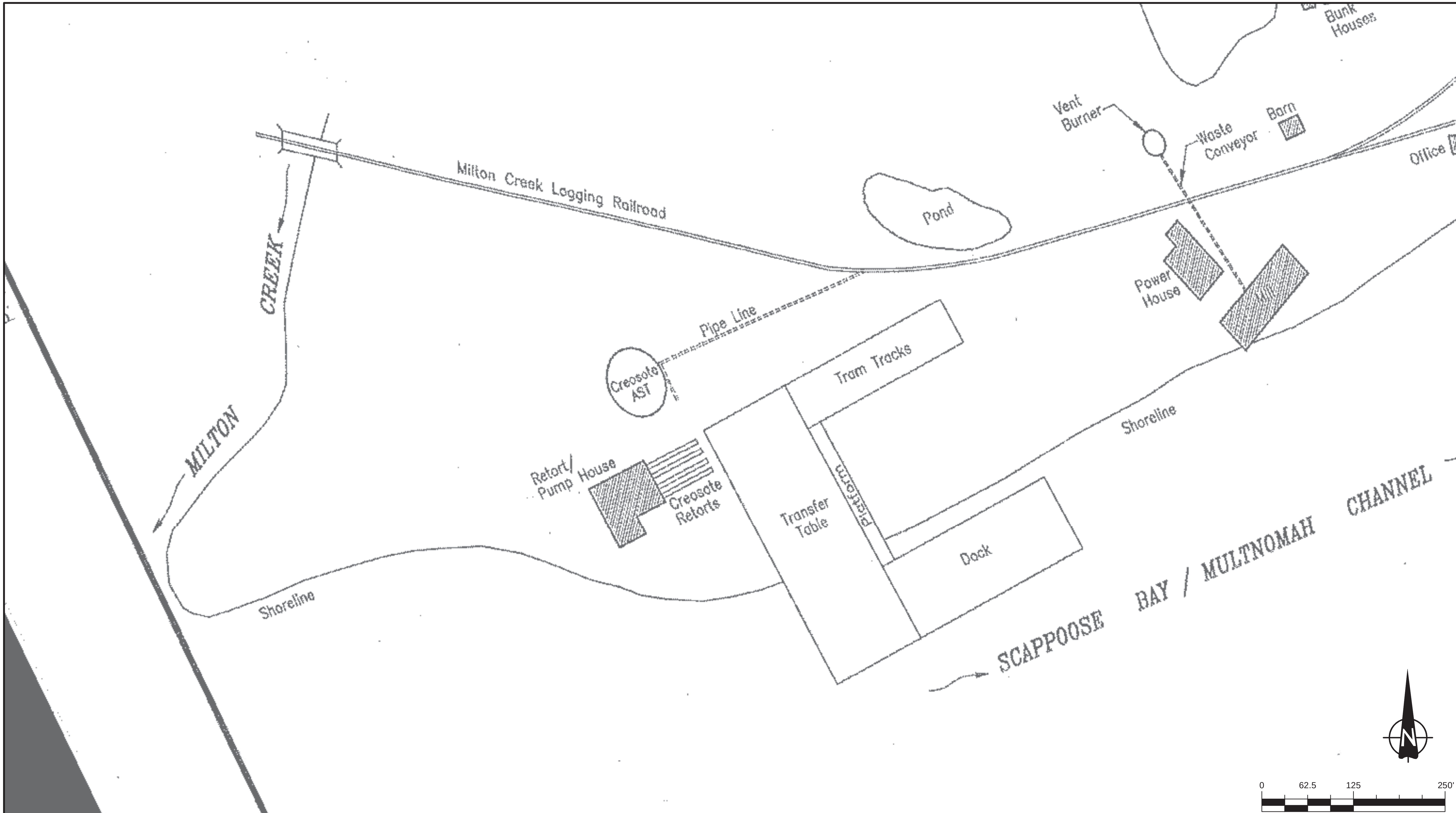
HLA Harding Lawson Associates
A Subsidiary of Harding Associates
227 SW Pine St., Third Floor
Portland, Oregon 97204
(503) 227-1326

Approximate Scale in Feet
0 50 100 200

N (project north)

Drw By WDM	Date 01/12/94	No.	Date	Revision Description	No.	Date	Revision Description
Chk By [signature]	Scale	1			5		
App By [signature]	As shown at left	2			6		
Layers 0 2 3 5 10		3			7		
Dwg No. \26031\P03CD012.GCD		4			8		

Figure 3B
Key Site Features



NOTE: The locations of all features shown are approximate. Site features from GeoEngineers Figures circa 1998.

CLIENT: PORT OF ST. HELENS

AMEC
7376 S.W. Durham Road
Portland, OR, U.S.A. 97224

amec

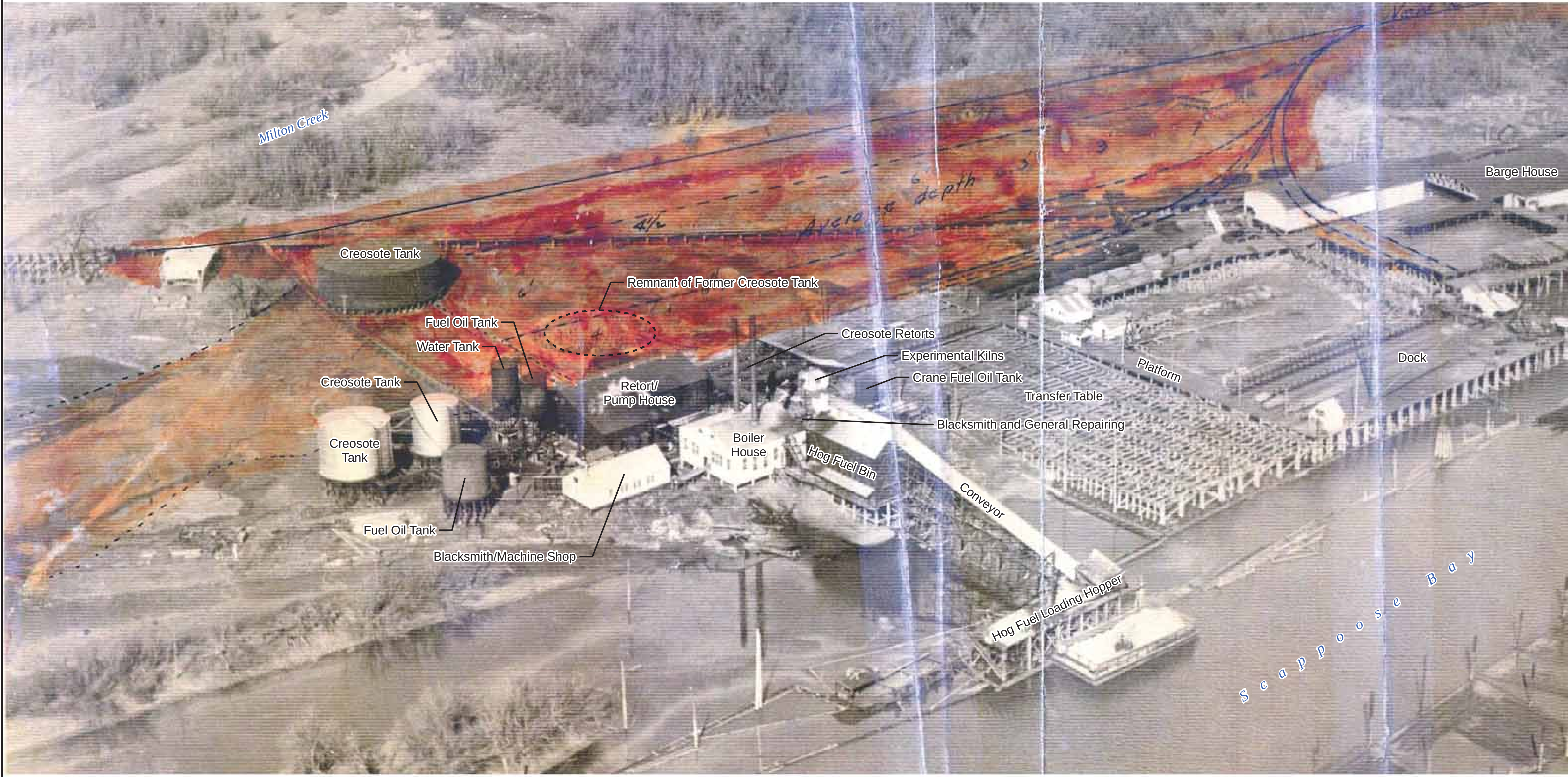
DWN BY: SD
CHK'D BY: MR
DATUM: NAD83
PROJECTION: OR SP N. Ft.
SCALE: 1 inch = 125 feet

PROJECT: FORMER POPE & TALBOT WOOD-TREATING SITE

TITLE: 1919 SITE LAYOUT DIAGRAM

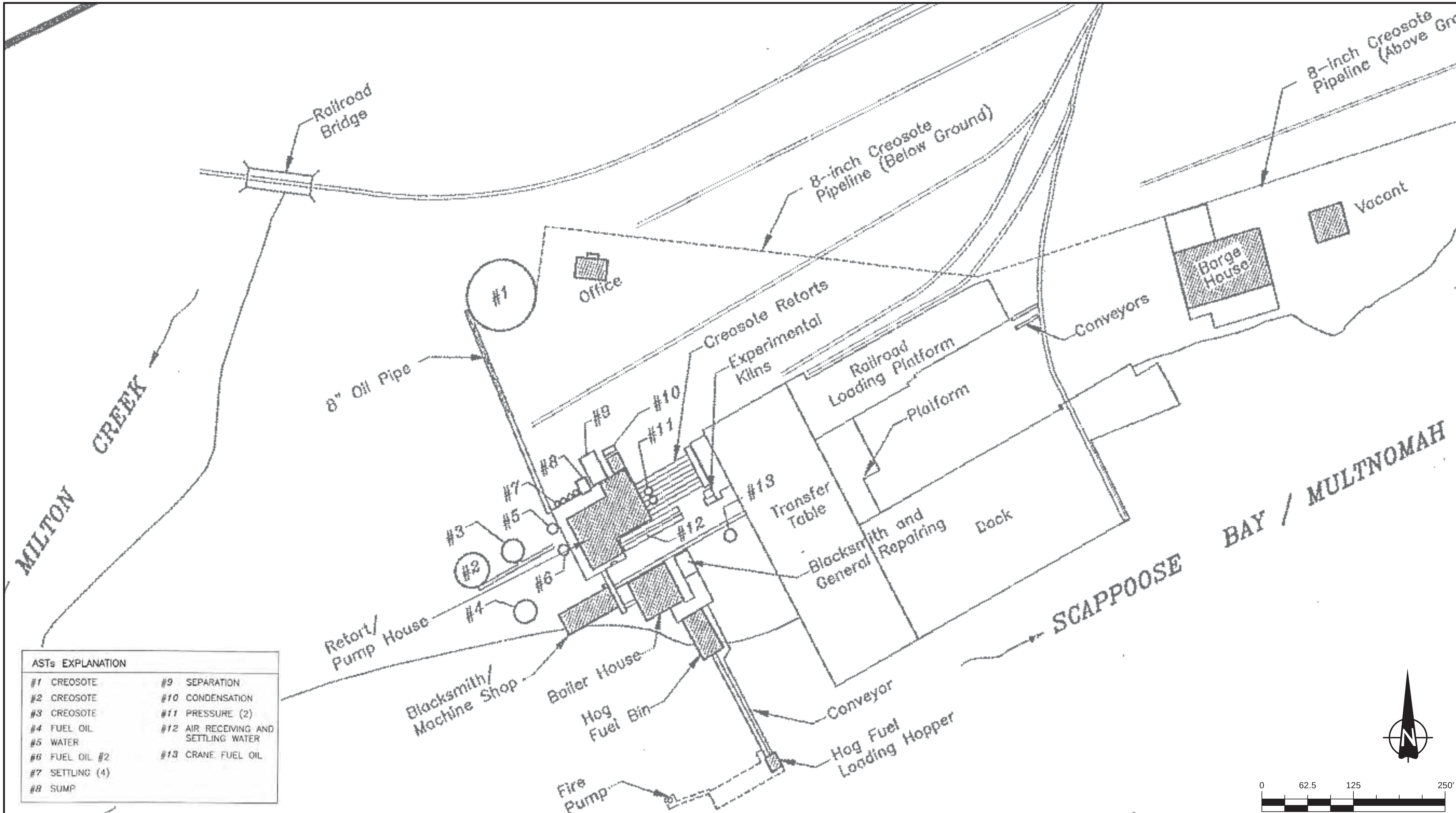
DATE: APRIL 2014
PROJECT NO.: 9-61M-112202.09
REV. NO.: -
FIGURE NO.: 4

K:\11000\11200\11220\112202\DWG_2014_SRI_Report\Figure A-1 - 1919 Site Layout Diagram.mxd



CLIENT: PORT OF ST. HELENS		DWN BY: SD	PROJECT: FORMER POPE & TALBOT WOOD-TREATING SITE	DATE: APRIL 2014
		CHK'D BY: MR		PROJECT NO.: 9-61M-112202.09
AMEC 7376 S.W. Durham Road Portland, OR, U.S.A. 97224	amec	DATUM: -	TITLE: 1929	REV. NO.: -
		PROJECTION: -		FIGURE NO.: 5
		SCALE: NOT TO SCALE		

K:\11000\11200\11220\112202\DWG_2014_SRI_Report\Figure A-2 - 1929 Aerial.mxd



NOTE: The locations of all features shown are approximate. Site features from GeoEngineers Figures circa 1998.

CLIENT: PORT OF ST. HELENS

AMEC
7376 S.W. Durham Road
Portland, OR, U.S.A. 97224

amec

DWN BY: SD
CHK'D BY: MR
DATUM: NAD83
PROJECTION: OR SP N. Ft.
SCALE: 1 inch = 125 feet

PROJECT: FORMER POPE & TALBOT WOOD-TREATING SITE

TITLE: 1938 SITE LAYOUT DIAGRAM

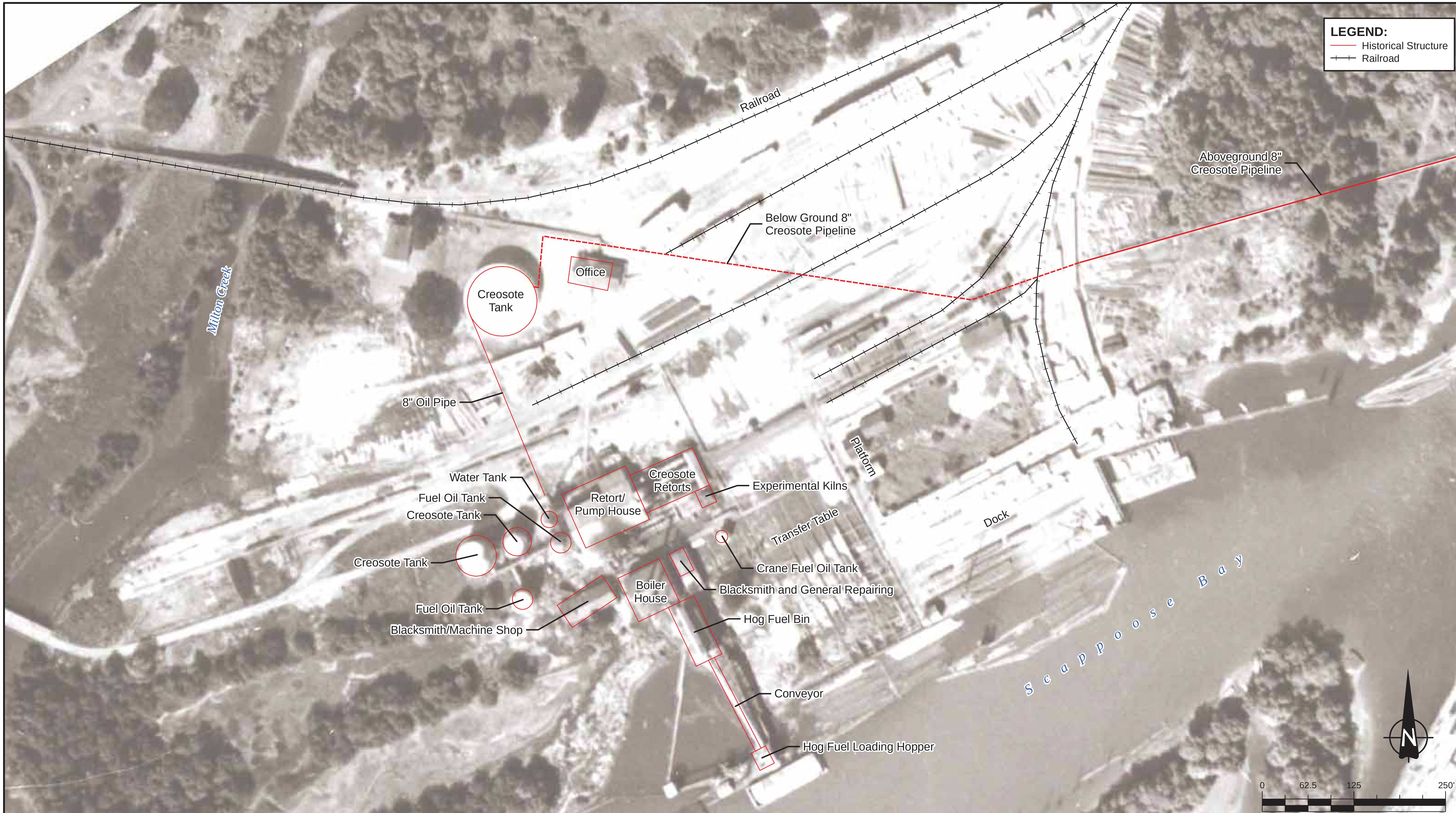
DATE: APRIL 2014
PROJECT NO.: 9-61M-112202.09
REV. NO.: -
FIGURE NO.: 6

K:\11000\11200\11220\112202\DWG_2014_SRI_Report\Figure A-3 - 1938 Site Layout Diagram.mxd

NOTE: The locations of all features shown are approximate. Site features from GeoEngineers Figures circa 1998.

CLIENT: PORT OF ST. HELENS	DWN BY: SD	PROJECT: FORMER POPE & TALBOT WOOD-TREATING SITE	DATE: APRIL 2014	
	CHK'D BY: MR		PROJECT NO.: 9-61M-112202.09	
AMEC 7376 S.W. Durham Road Portland, OR, U.S.A. 97224	DATUM: NAD83	TITLE: USACE 1939	REV. NO.: -	
	PROJECTION: OR SP N. Ft.		FIGURE NO.: 7	
	SCALE: 1 inch = 125 feet			

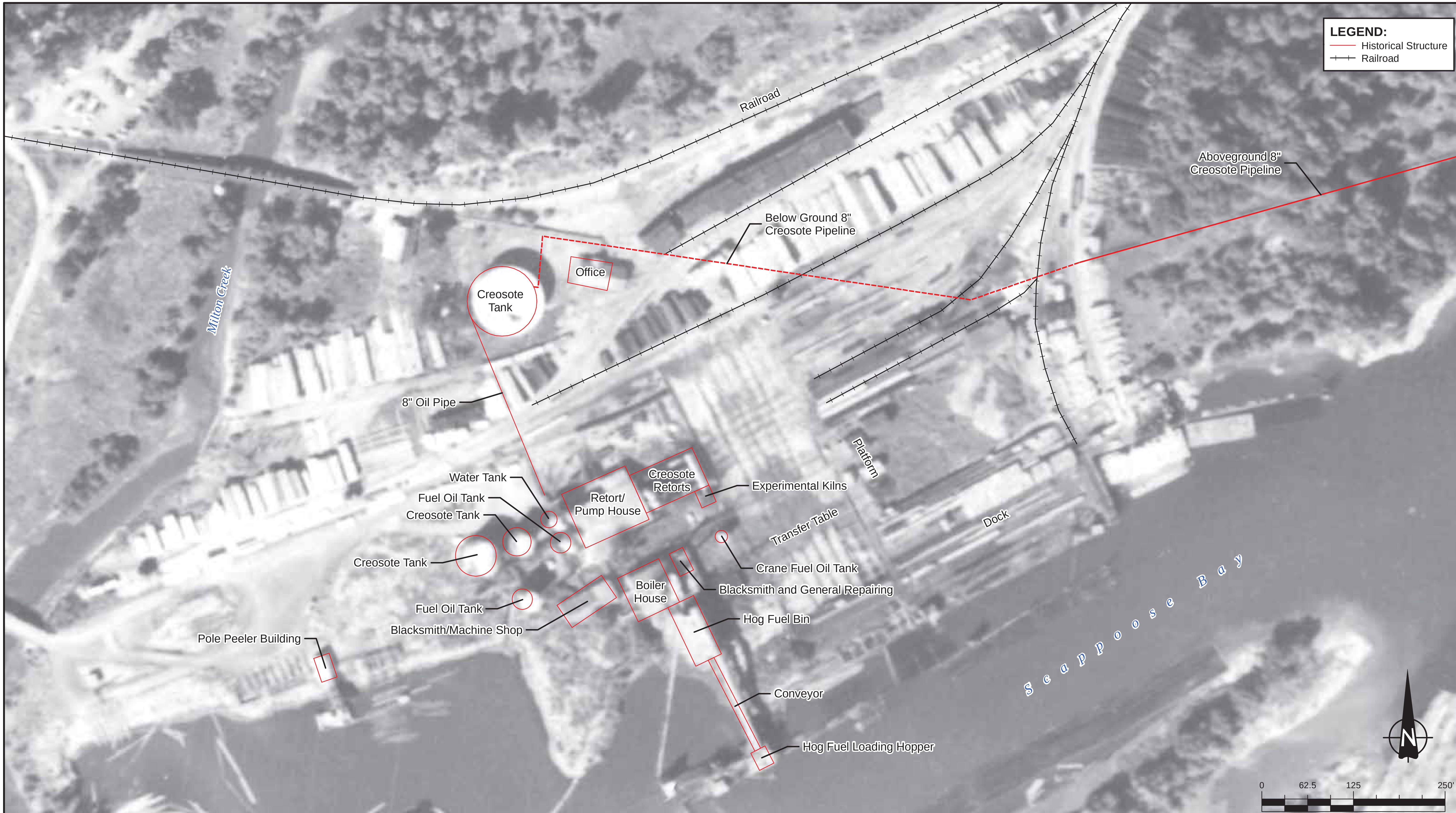
K:\11000\11200\11220\112202\DWG_2014_SRI_Report\Figure A-4 - 1939 Aerial.mxd



NOTE: The locations of all features shown are approximate. Site features from GeoEngineers Figures circa 1998.

CLIENT: PORT OF ST. HELENS	DWN BY: SD	PROJECT: FORMER POPE & TALBOT WOOD-TREATING SITE	DATE: APRIL 2014
	CHK'D BY: MR		PROJECT NO.: 9-61M-112202.09
AMEC 7376 S.W. Durham Road Portland, OR, U.S.A. 97224	DATUM: NAD83	TITLE: USACE 1948	REV. NO.: -
	PROJECTION: OR SP N. Ft.		FIGURE NO.: 8
	SCALE: 1 inch = 125 feet		

K:\11000\11200\11220\112202\DWG_2014_SRI_Report\Figure A-5 - 1948 Aerial.mxd



NOTE: The locations of all features shown are approximate. Site features from GeoEngineers Figures circa 1998.

CLIENT: PORT OF ST. HELENS

AMEC
7376 S.W. Durham Road
Portland, OR, U.S.A. 97224

amec

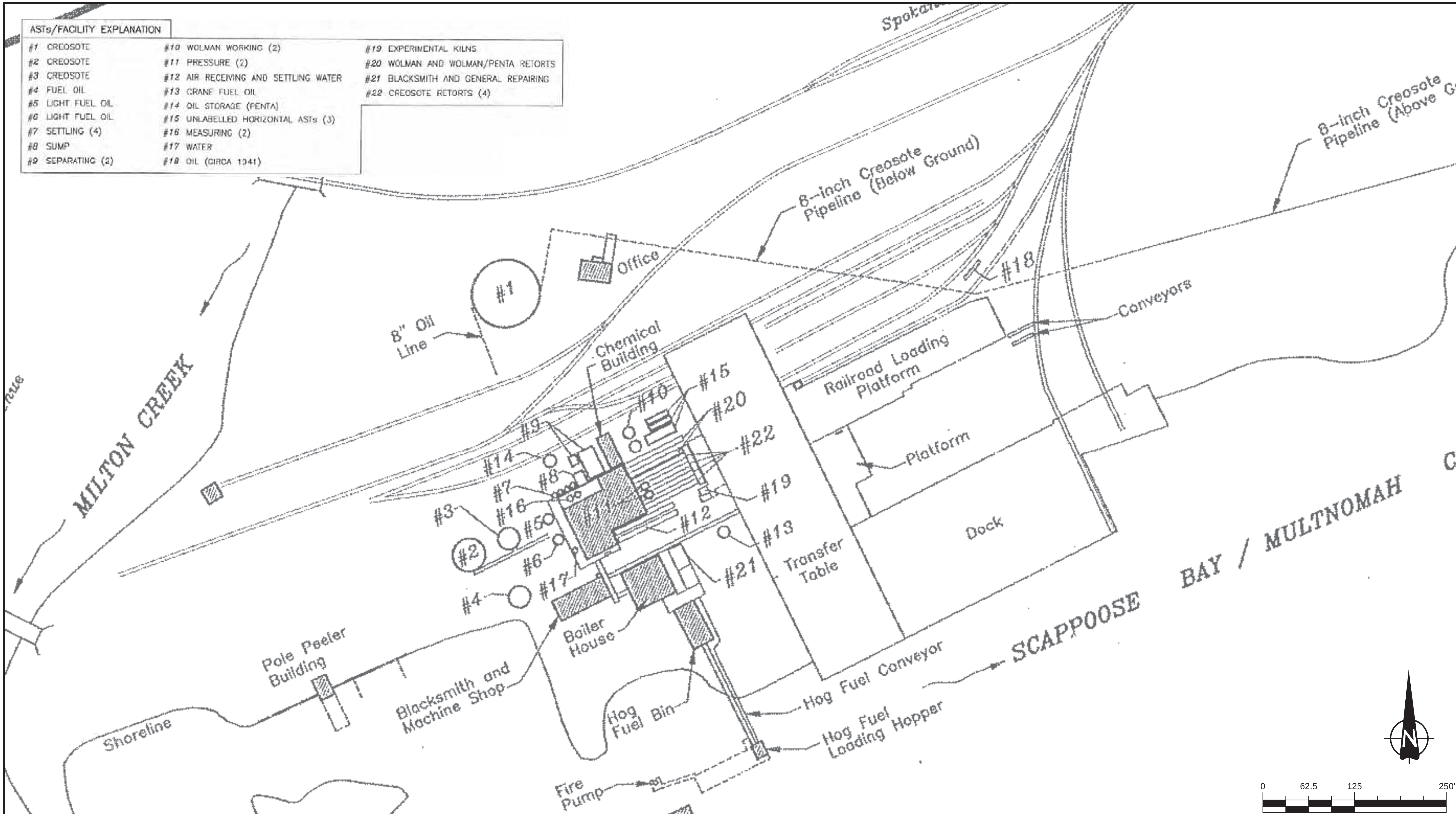
DWN BY:	SD
CHK'D BY:	MR
DATUM:	NAD83
PROJECTION:	OR SP N. Ft.
SCALE:	1 inch = 125 feet

PROJECT: FORMER POPE & TALBOT WOOD-TREATING SITE

TITLE: UO 1953

DATE:	APRIL 2014
PROJECT NO.:	9-61M-112202.09
REV. NO.:	-
FIGURE NO.:	9

K:\11000\11200\11220\112202\DWG_2014_SRI_Report\Figure A-6 - 1953 Aerial.mxd



NOTE: The locations of all features shown are approximate. Site features from GeoEngineers Figures circa 1998.	CLIENT: PORT OF ST. HELENS	DWN BY: SD CHK'D BY: MR	PROJECT: FORMER POPE & TALBOT WOOD-TREATING SITE	DATE: APRIL 2014 PROJECT NO.: 9-61M-112202.09
	AMEC 7376 S.W. Durham Road Portland, OR, U.S.A. 97224	DATUM: NAD83 PROJECTION: OR SP N. Ft. SCALE: 1 inch = 125 feet	TITLE: 1959 SITE LAYOUT DIAGRAM	REV. NO.: - FIGURE NO.: 10

K:\11000\11200\11220\112202\DWG_2014_SRI_Report\Figure A-7 - 1959 Site Layout Diagram.mxd

NOTE: The locations of all features shown are approximate. Site features from GeoEngineers Figures circa 1998.

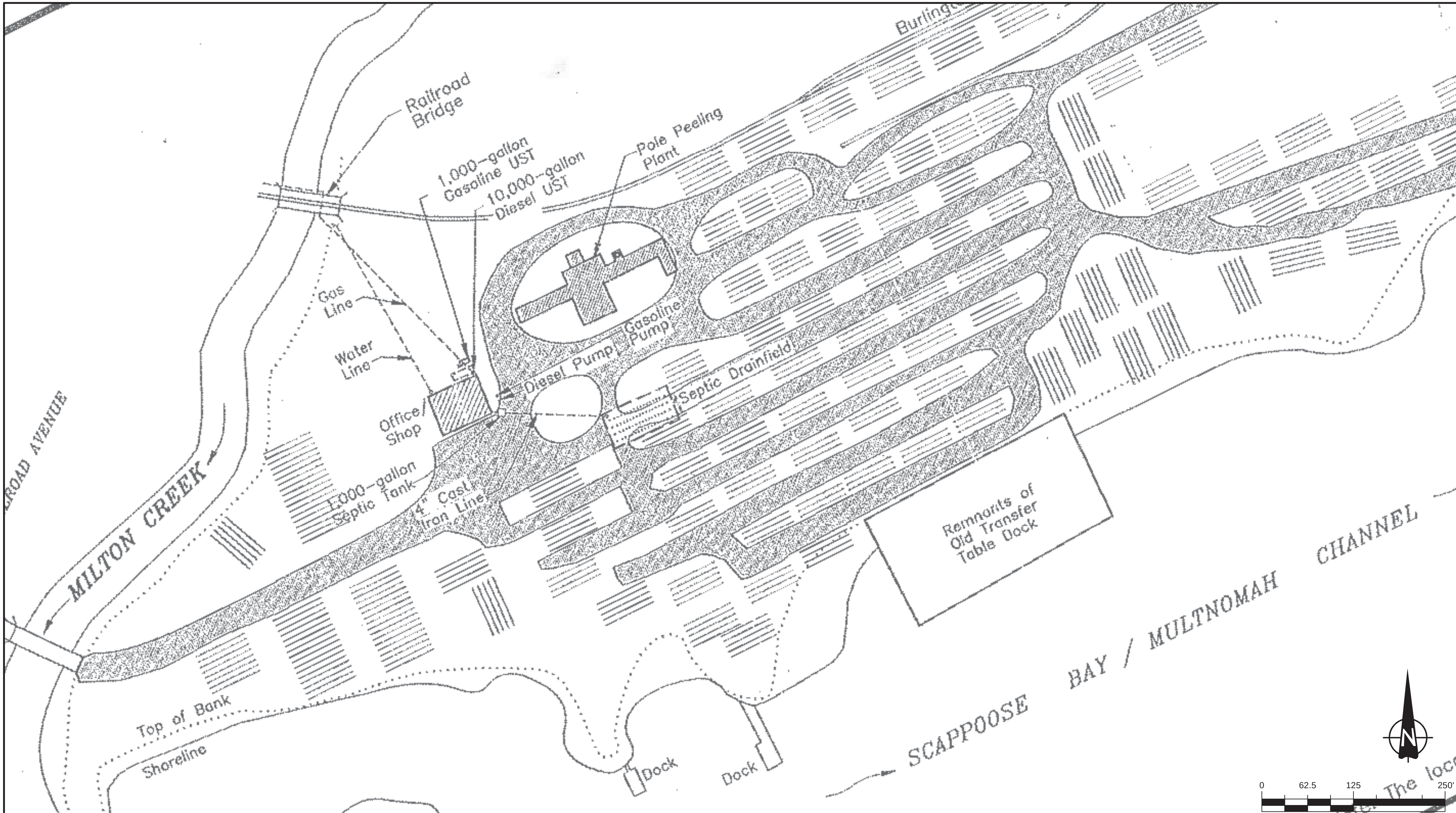
CLIENT: PORT OF ST. HELENS		DWN BY: SD	PROJECT: FORMER POPE & TALBOT WOOD-TREATING SITE	DATE: APRIL 2014
		CHK'D BY: MR		PROJECT NO.: 9-61M-112202.09
AMEC 7376 S.W. Durham Road Portland, OR, U.S.A. 97224	amec	DATUM: NAD83	TITLE: USACE 1966	REV. NO.: -
		PROJECTION: OR SP N. Ft.		FIGURE NO.: 11
		SCALE: 1 inch = 125 feet		

K:\11000\11200\11220\112202\DWG_2014_SRI_Report\Figure A-8 - 1966 Aerial.mxd

NOTE: The locations of all features shown are approximate. Site features from GeoEngineers Figures circa 1998.

CLIENT: PORT OF ST. HELENS	DWN BY: SD	PROJECT: FORMER POPE & TALBOT WOOD-TREATING SITE	DATE: APRIL 2014
	CHK'D BY: MR		PROJECT NO.: 9-61M-112202.09
AMEC 7376 S.W. Durham Road Portland, OR, U.S.A. 97224	DATUM: NAD83	TITLE: UO 1970	REV. NO.: -
	PROJECTION: OR SP N. Ft.		FIGURE NO.: 12
	SCALE: 1 inch = 125 feet		

K:\11000\11200\11220\112202\DWG_2014_SRI_Report\Figure A-9 - 1970 Aerial.mxd



NOTE: The locations of all features shown are approximate. Site features from GeoEngineers Figures circa 1998.

CLIENT: PORT OF ST. HELENS	DWN BY: SD	PROJECT: FORMER POPE & TALBOT WOOD-TREATING SITE	DATE: APRIL 2014
	CHK'D BY: MR		PROJECT NO.: 9-61M-112202.09
AMEC 7376 S.W. Durham Road Portland, OR, U.S.A. 97224	DATUM: NAD83	TITLE: 1974 SITE LAYOUT DIAGRAM	REV. NO.: -
	PROJECTION: OR SP N. Ft.		FIGURE NO.: 13
	SCALE: 1 inch = 125 feet		

K:\11000\11200\11220\112202\DWG_2014_SRI_Report\Figure A-10 - 1974 Site Layout Diagram.mxd

NOTE: The locations of all features shown are approximate. Site features from GeoEngineers Figures circa 1998.

CLIENT: PORT OF ST. HELENS	DWN BY: SD	PROJECT: FORMER POPE & TALBOT WOOD-TREATING SITE	DATE: APRIL 2014
	CHK'D BY: MR		PROJECT NO.: 9-61M-112202.09
AMEC 7376 S.W. Durham Road Portland, OR, U.S.A. 97224	DATUM: NAD83	TITLE: EDR 1977	REV. NO.: -
	PROJECTION: OR SP N. Ft.		FIGURE NO.: 14
	SCALE: 1 inch = 500 feet		

K:\11000\11200\11220\112202\DWG_2014_SRI_Report\Figure A-11 - 1977 Aerial.mxd

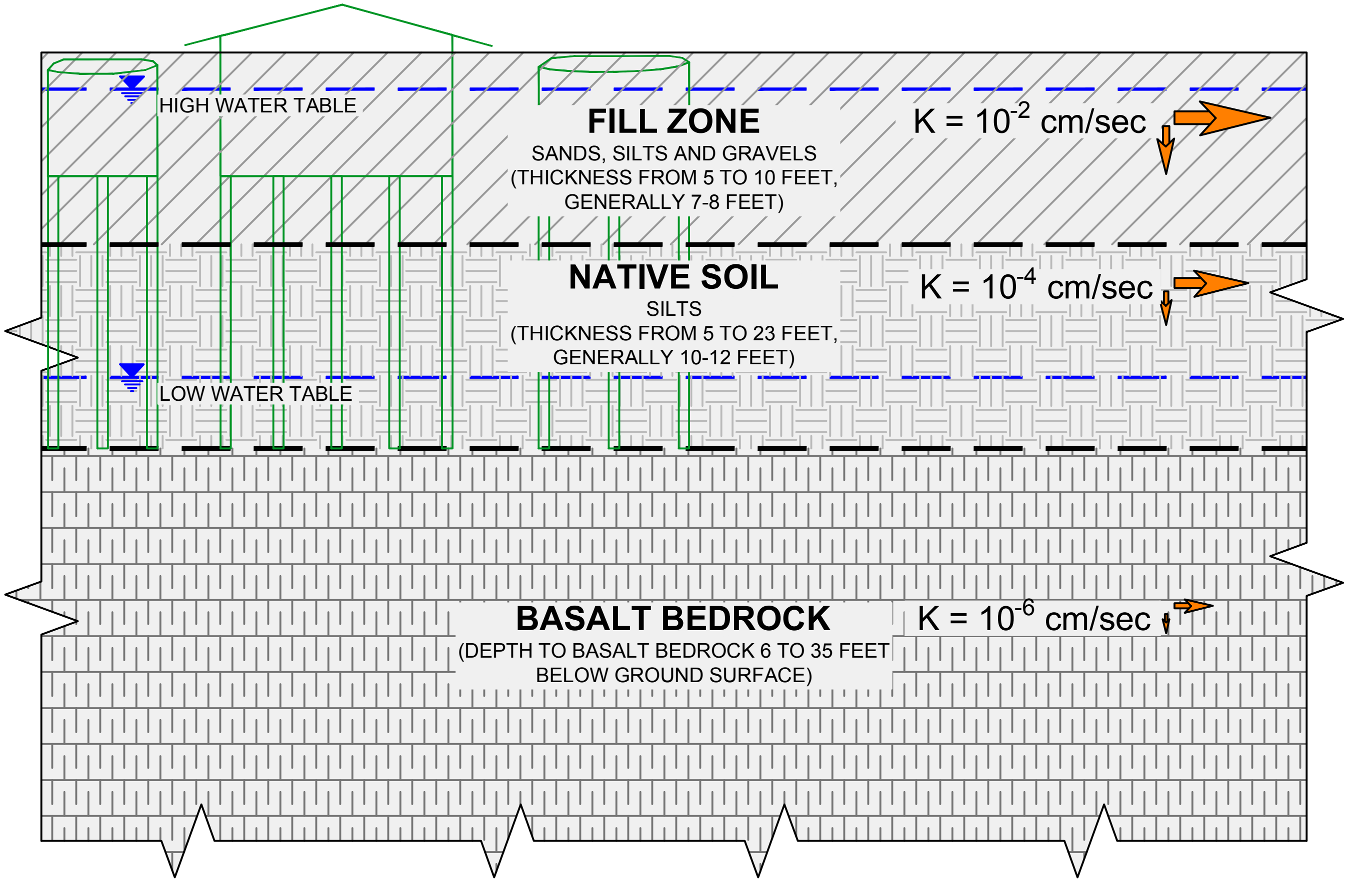
NOTE: The locations of all features shown are approximate. Site features from GeoEngineers Figures circa 1998.

CLIENT: PORT OF ST. HELENS	DWN BY: SD	PROJECT: FORMER POPE & TALBOT WOOD-TREATING SITE	DATE: APRIL 2014
	CHK'D BY: MR		PROJECT NO.: 9-61M-112202.09
AMEC 7376 S.W. Durham Road Portland, OR, U.S.A. 97224	DATUM: NAD83	TITLE: EDR 1990	REV. NO.: -
	PROJECTION: OR SP N. Ft.		FIGURE NO.: 15
	SCALE: 1 inch = 500 feet		

K:\11000\11200\11220\112202\DWG_2014_SRI_Report\Figure A-12 - 1990 Aerial.mxd

CLIENT: PORT OF ST. HELENS	DWN BY: SD	PROJECT: FORMER POPE & TALBOT WOOD-TREATING SITE	DATE: APRIL 2014
	CHK'D BY: MR		PROJECT NO.: 9-61M-112202.09
AMEC 7376 S.W. Durham Road Portland, OR, U.S.A. 97224	DATUM: -	TITLE: 2013	REV. NO.: -
	PROJECTION:		FIGURE NO.: 16
	SCALE: NOT TO SCALE		

K:\11000\11200\11220\112202\DWG_2014_SRI_Report\Figure A-13 - 2013 Aerial.mxd



NOTES:

HISTORICAL SITE FEATURES

- K = HYDRAULIC CONDUCTIVITY
- GROUNDWATER ELEVATION DATA FROM SEPTEMBER 2010 TO AUGUST 2012.
- IN GENERAL, FILL PLACEMENT (DREDGE SAND) AT THE SITE OCCURRED IN THE EARLY 1970s. ADDITIONAL DREDGE FILL WAS PLACED ON THE EASTERN PORTION OF THE SITE IN 1975, AND APPROXIMATELY 5,000 CUBIC YARDS OF ROCK WAS PLACED IMMEDIATELY ADJACENT TO THE NORTH OF THE FORMER TRANSFER TABLE DOCK IN 1977 FOR BARGE LOADING (2000 RI REPORT).
- ZONE THICKNESSES ARE GENERAL THICKNESSES PRESENTED IN THE 2000 RI REPORT AND SUPPLEMENTAL RI REPORT.
- HYDRAULIC CONDUCTIVITY VALUES ARE APPROXIMATE AVERAGE VALUES OF RANGE PRESENTED IN 2000 RI REPORT.

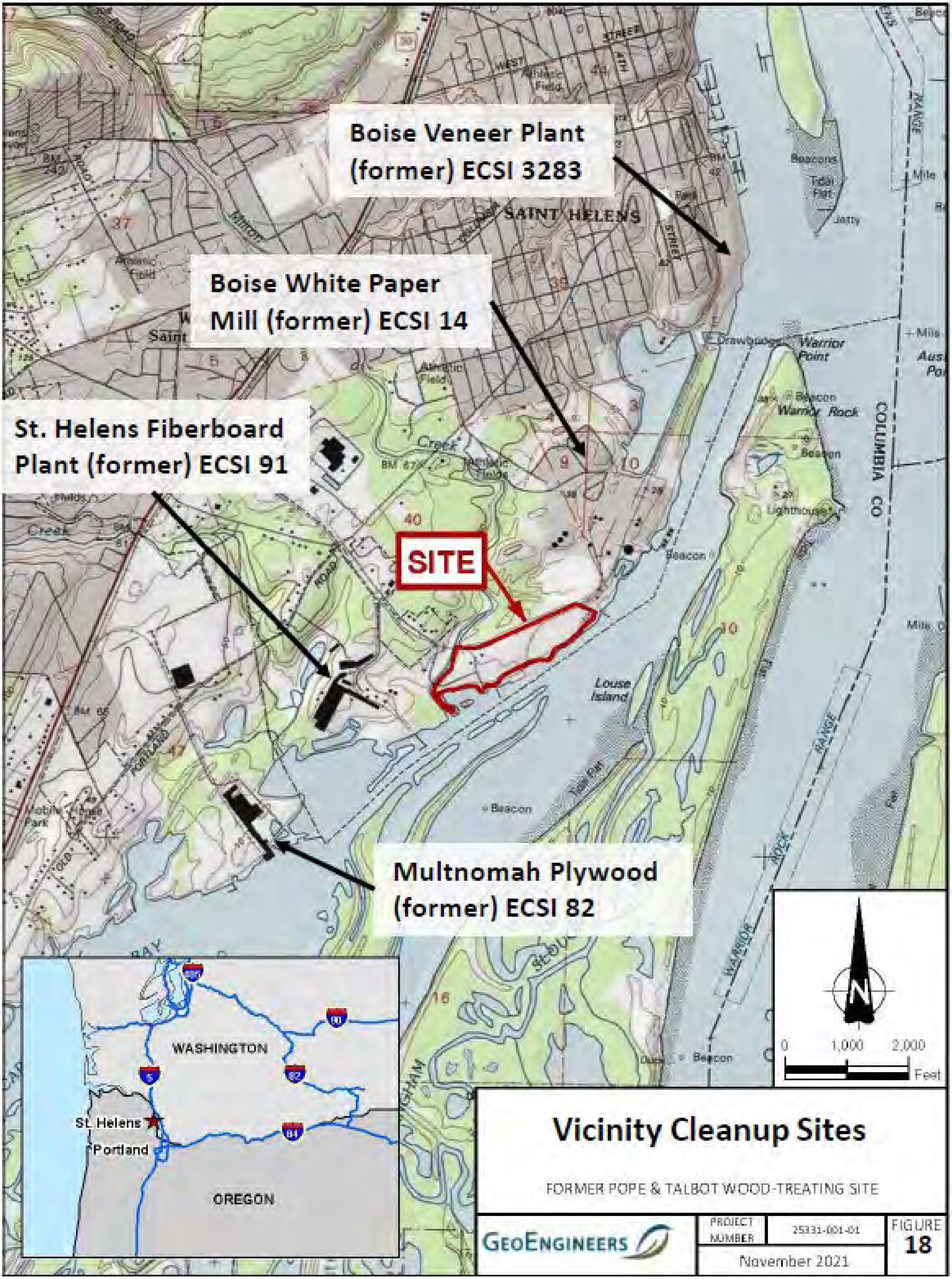
DRAWN BY: PM CHECKED BY: JKH

GENERALIZED AREA 1 CROSS SECTION

FORMER POPE & TALBOT WOOD-TREATING SITE

Cascadia Associates, LLC

PROJECT NUMBER	0034-001-005	FIGURE
DECEMBER 2019		17

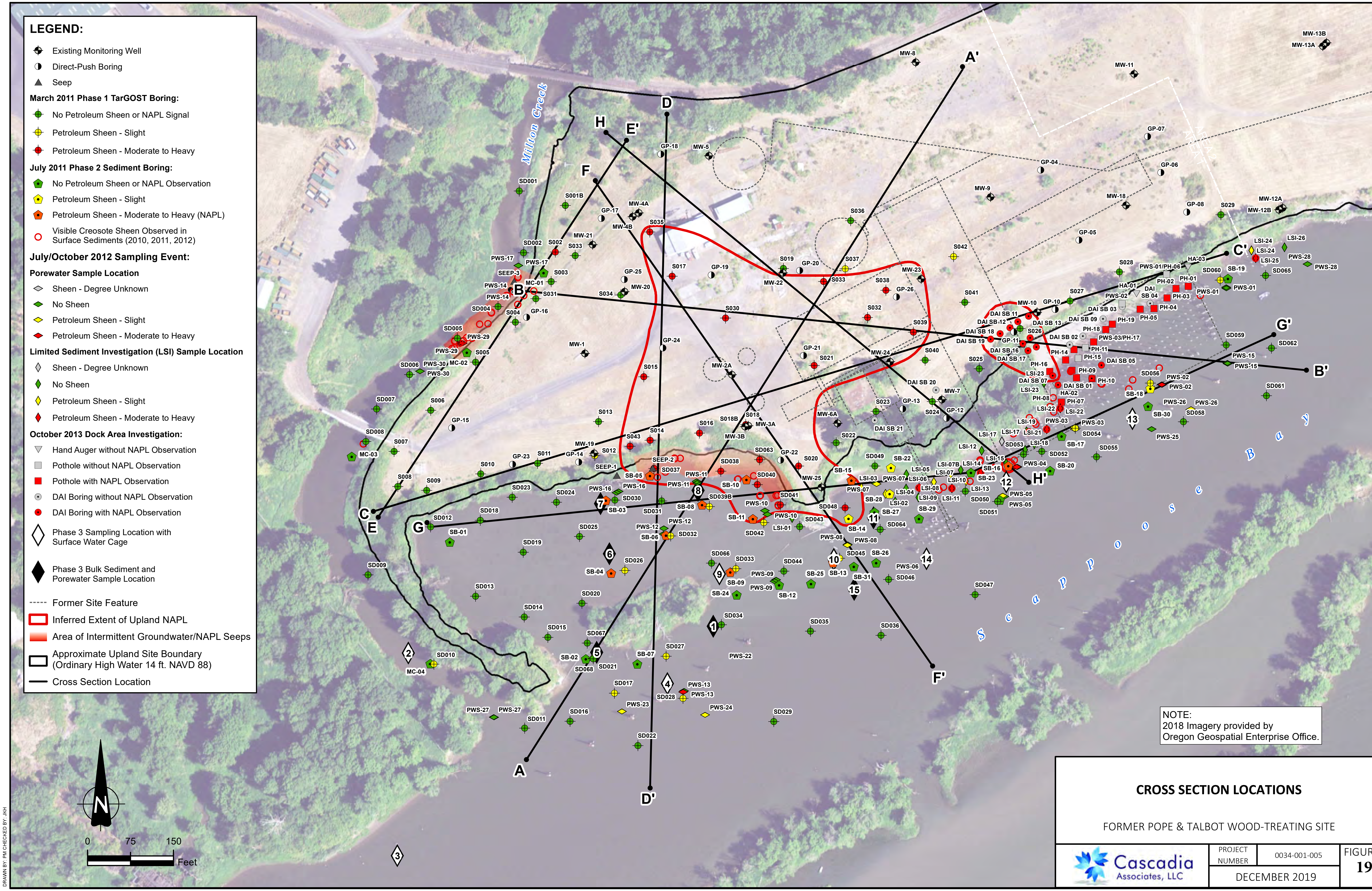


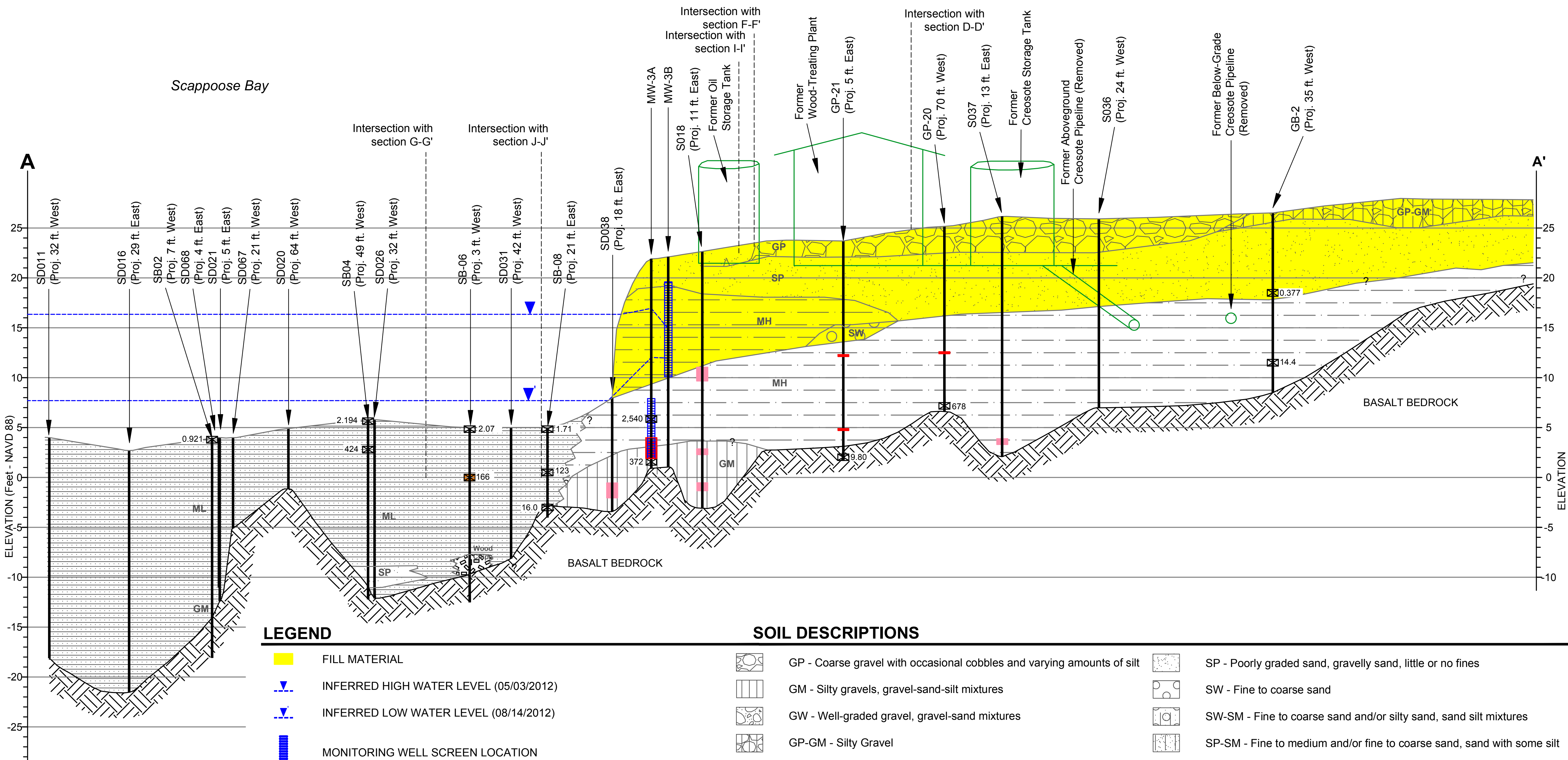
Vicinity Cleanup Sites

FORMER POPE & TALBOT WOOD-TREATING SITE

GeoEngineers

PROJECT NUMBER	25331-001-01	FIGURE 18
November 2021		


LEGEND:
Existing Monitoring Well
Direct-Push Boring
Seep
March 2011 Phase 1 TarGOST Boring:
No Petroleum Sheen or NAPL Signal
Petroleum Sheen - Slight
Petroleum Sheen - Moderate to Heavy
July 2011 Phase 2 Sediment Boring:
No Petroleum Sheen or NAPL Observation
Petroleum Sheen - Slight
Petroleum Sheen - Moderate to Heavy (NAPL)
Visible Creosote Sheen Observed in Surface Sediments (2010, 2011, 2012)
July/October 2012 Sampling Event:
Porewater Sample Location
Sheen - Degree Unknown
No Sheen
Petroleum Sheen - Slight
Petroleum Sheen - Moderate to Heavy
Limited Sediment Investigation (LSI) Sample Location
Sheen - Degree Unknown
No Sheen
Petroleum Sheen - Slight
Petroleum Sheen - Moderate to Heavy
October 2013 Dock Area Investigation:
Hand Auger without NAPL Observation
Pothole without NAPL Observation
Pothole with NAPL Observation
DAI Boring without NAPL Observation
DAI Boring with NAPL Observation
Phase 3 Sampling Location with Surface Water Cage
Phase 3 Bulk Sediment and Porewater Sample Location
Former Site Feature
Inferred Extent of Upland NAPL
Area of Intermittent Groundwater/NAPL Seeps
Approximate Upland Site Boundary (Ordinary High Water 14 ft. NAVD 88)
Cross Section Location
Milton Creek
Scappoose Bay
0 75 150 Feet
NOTE:
2018 Imagery provided by Oregon Geospatial Enterprise Office.
CROSS SECTION LOCATIONS
FORMER POPE & TALBOT WOOD-TREATING SITE
Cascadia Associates, LLC
PROJECT NUMBER 0034-001-005
DECEMBER 2019
FIGURE 19
DRAWN BY: PM CHECKED BY: JKH
\\POR-FS1\ClientData\11000\11200\11220\112203\dwg_SRI_Report_2019\4-1 - Cross-Section Locations.mxd - brian johnson - 12/13/2019 - 7:09:12 AM



LEGEND

- FILL MATERIAL
- INFERRED HIGH WATER LEVEL (05/03/2012)
- INFERRED LOW WATER LEVEL (08/14/2012)
- MONITORING WELL SCREEN LOCATION
- TarGOST® SIGNAL INDICATIVE OF NAPL
- VISUAL OBSERVATION OF NAPL IN SOIL CORE
- PETROLEUM SHEEN - MODERATE
- NAPL — NON-AQUEOUS PHASE LIQUIDS (CREOSOTE)

SOIL DESCRIPTIONS

- GP - Coarse gravel with occasional cobbles and varying amounts of silt
- GM - Silty gravels, gravel-sand-silt mixtures
- GW - Well-graded gravel, gravel-sand mixtures
- GP-GM - Silty Gravel
- ML - Inorganic silt rock flour, or silt with slight plasticity
- MH - Inorganic silt, micaceous or diatomaceous silty soil
- SM - Silty-sand, sand-silt mixtures
- SP - Poorly graded sand, gravelly sand, little or no fines
- SW - Fine to coarse sand
- SW-SM - Fine to coarse sand and/or silty sand, sand silt mixtures
- SP-SM - Fine to medium and/or fine to coarse sand, sand with some silt
- Wood Chips
- Basalt Bedrock

NOTE: THE LOCATIONS OF ALL FEATURES SHOWN ARE APPROXIMATE.

HORIZONTAL SCALE: 0' 50' 100' 150' — 1" = 100'

VERTICAL SCALE: 0' 5' 10' 15' — 1" = 10'

10X VERTICAL SCALE EXAGGERATION

CROSS SECTION A-A'

FORMER POPE & TALBOT WOOD-TREATING SITE

Cascadia Associates, LLC

PROJECT NUMBER	0034-001-005	FIGURE
DECEMBER 2019		20

DRAWN BY: BRJSD CHECKED BY: -

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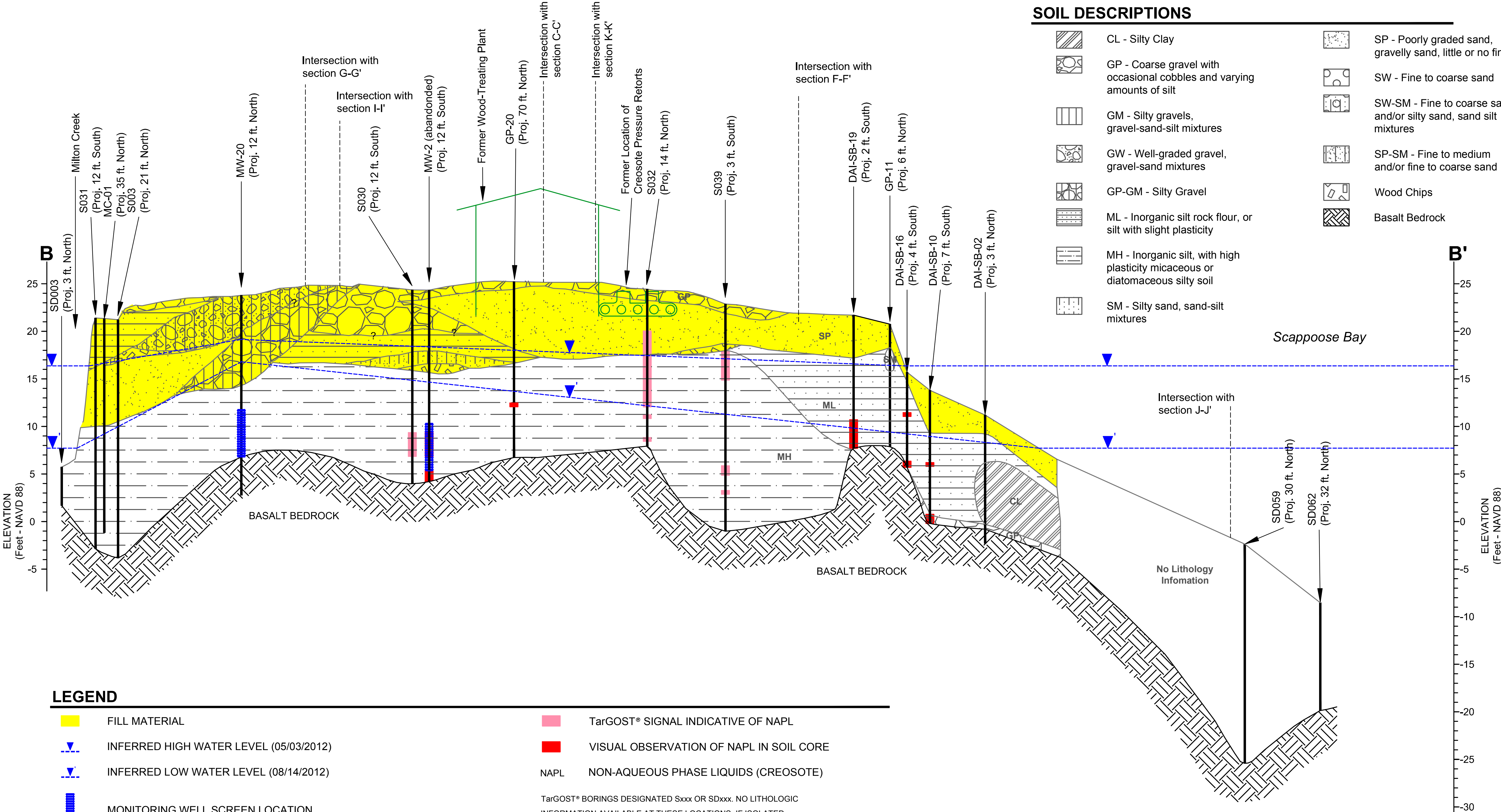

NOTE: THE LOCATIONS OF ALL FEATURES SHOWN ARE APPROXIMATE.

HORIZONTAL SCALE: 0' 50' 100' 150' — 1" = 100'

VERTICAL SCALE: 0' 5' 10' 15' — 1" = 10'

10X VERTICAL SCALE EXAGGERATION

CROSS SECTION B-B'

FORMER POPE & TALBOT WOOD-TREATING SITE

Cascadia Associates, LLC

PROJECT NUMBER	0034-001-005	FIGURE
DECEMBER 2019		21

DRAWN BY: BRJ/SD CHECKED BY: -

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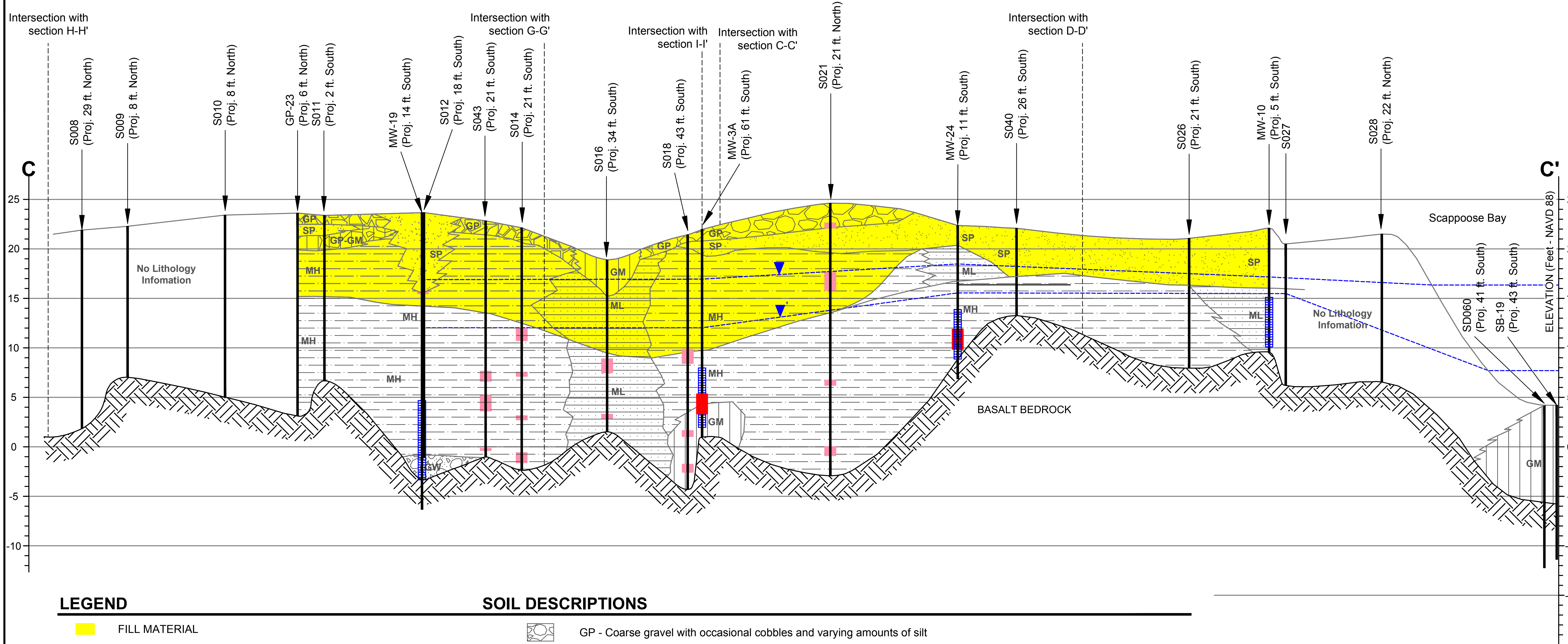

LEGEND

- FILL MATERIAL
- INFERRED HIGH WATER LEVEL (05/03/2012)
- INFERRED LOW WATER LEVEL (08/14/2012)
- MONITORING WELL SCREEN LOCATION
- TarGOST® SIGNAL INDICATIVE OF NAPL
- VISUAL OBSERVATION OF NAPL IN SOIL CORE
- NAPL NON-AQUEOUS PHASE LIQUIDS (CREOSOTE)

TarGOST® BORINGS DESIGNATED Sxxx OR SDxxx. NO LITHOLOGIC INFORMATION AVAILABLE AT THESE LOCATIONS, IF ISOLATED.

SOIL DESCRIPTIONS

- GP - Coarse gravel with occasional cobbles and varying amounts of silt
- GM - Silty gravels, gravel-sand-silt mixtures
- GW - Well-graded gravel, gravel-sand mixtures
- GP-GM - Silty Gravel
- ML - Inorganic silt rock flour, or silt with slight plasticity
- MH - Inorganic silt, micaceous or diatomaceous silty soil
- SP - Poorly graded sand, gravelly sand, little or no fines
- Basalt Bedrock

NOTE: THE LOCATIONS OF ALL FEATURES SHOWN ARE APPROXIMATE.

HORIZONTAL SCALE: 0' 50' 100' 150' — 1" = 100'

VERTICAL SCALE: 0' 5' 10' 15' — 1" = 10'

10X VERTICAL SCALE EXAGGERATION

DRAWN BY: BRJ/SD CHECKED BY: -

CROSS SECTION C-C'

FORMER POPE & TALBOT WOOD-TREATING SITE

Cascadia Associates, LLC

PROJECT NUMBER	0034-001-005	FIGURE
	DECEMBER 2019	22

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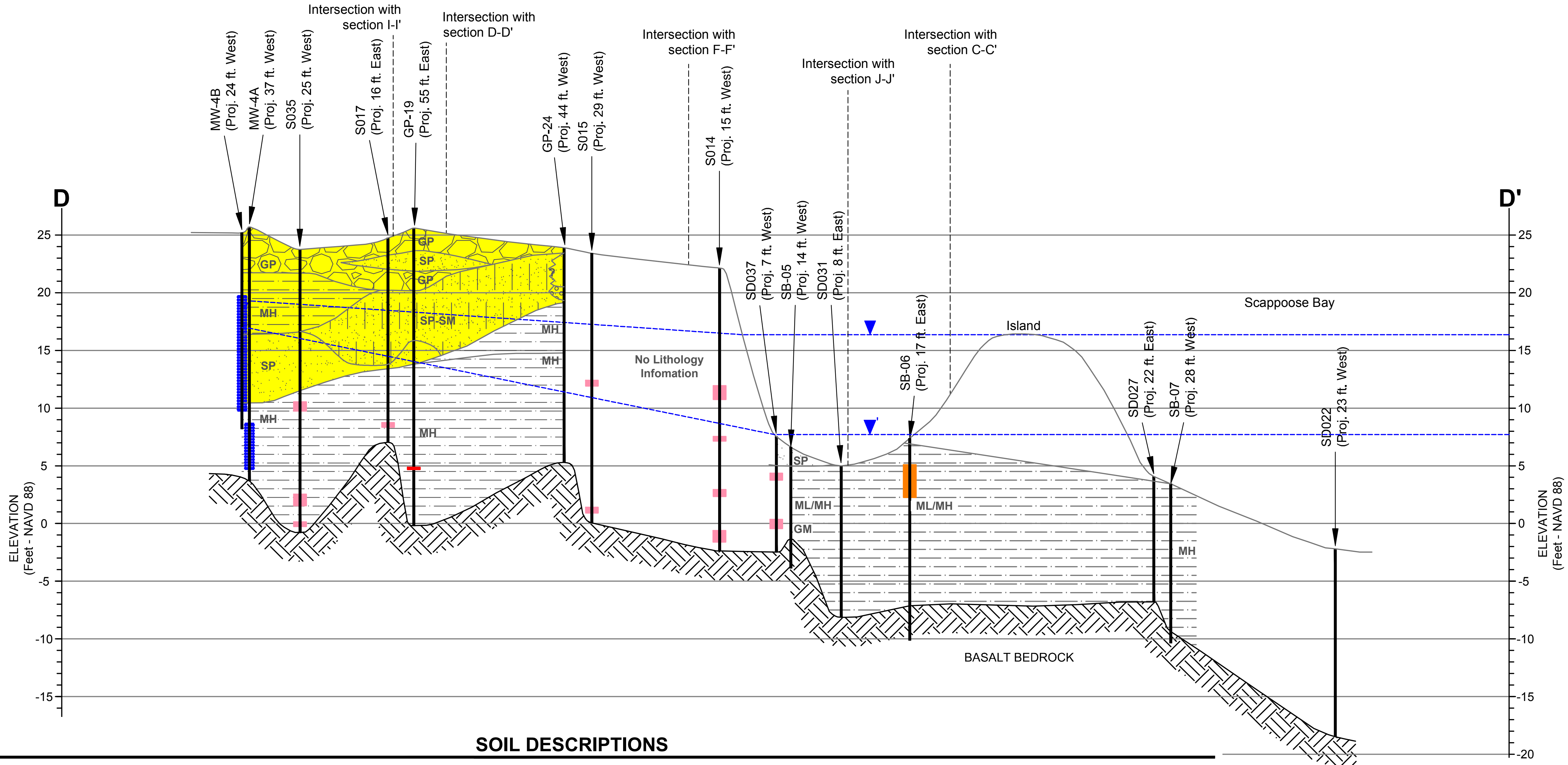

LEGEND

- FILL MATERIAL
- INFERRED HIGH WATER LEVEL (05/03/2012)
- INFERRED LOW WATER LEVEL (08/14/2012)
- MONITORING WELL SCREEN LOCATION
- TarGOST® SIGNAL INDICATIVE OF NAPL
- VISUAL OBSERVATION OF NAPL IN SOIL CORE
- PETROLEUM SHEEN - MODERATE
- NAPL NON-AQUEOUS PHASE LIQUIDS (CREOSOTE)

SOIL DESCRIPTIONS

- GP - Coarse gravel with occasional cobbles and varying amounts of silt
- MH - Inorganic silt, with high-plasticity micaceous or diatomaceous silty soil
- SP - Poorly graded sand, gravelly sand, little or no fines
- SP-SM - Fine to medium and/or fine to coarse sand
- SW-SM - Fine to coarse sand and/or silty sand, sand silt mixtures
- Basalt Bedrock
- GM - Silty gravels, gravel-sand-silt mixtures
- ML - Inorganic silt rock flour, or silt with slight plasticity

TarGOST® BORINGS DESIGNATED Sxxx OR SDxxx. NO LITHOLOGIC INFORMATION AVAILABLE AT THESE LOCATIONS, IF ISOLATED.

HORIZONTAL SCALE: 0' 50' 100' 150' — 1" = 100'

VERTICAL SCALE: 0' 5' 10' 15' — 1" = 10'

10X VERTICAL SCALE EXAGGERATION

NOTE: THE LOCATIONS OF ALL FEATURES SHOWN ARE APPROXIMATE.

CROSS SECTION D-D'

FORMER POPE & TALBOT WOOD-TREATING SITE

Cascadia Associates, LLC

PROJECT NUMBER	0034-001-005	FIGURE
DECEMBER 2019		23

DRAWN BY: BR/JSD CHECKED BY: -

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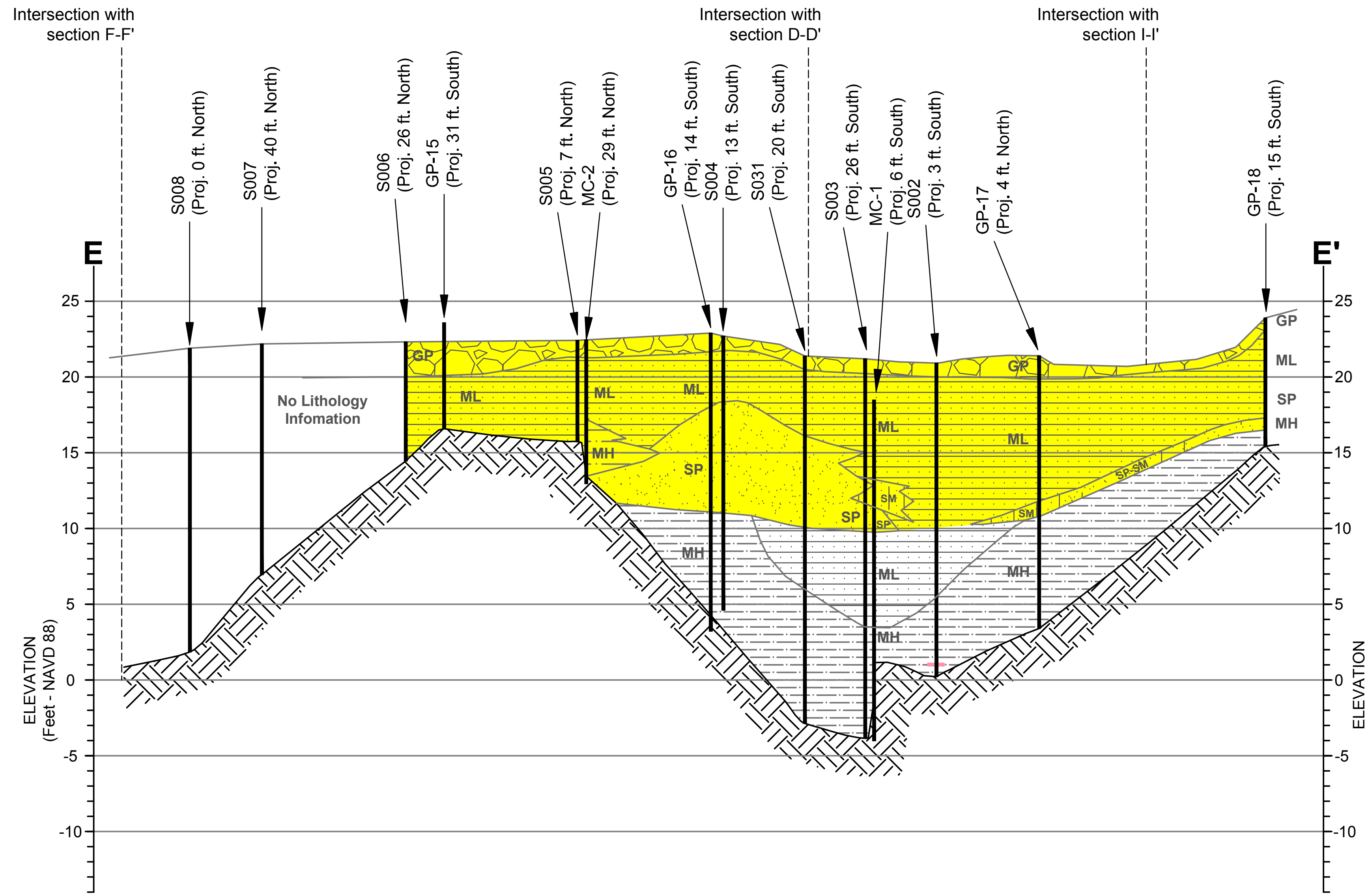

LEGEND

FILL MATERIAL

TarGOST® SIGNAL INDICATIVE OF NAPL

VISUAL OBSERVATION OF NAPL IN SOIL CORE

NAPL NON-AQUEOUS PHASE LIQUIDS (CREOSOTE)

TarGOST® BORINGS DESIGNATED Sxxx OR SDxxx. NO LITHOLOGIC INFORMATION AVAILABLE AT THESE LOCATIONS, IF ISOLATED.

SOIL DESCRIPTIONS

GP - Coarse gravel with occasional cobbles and varying amounts of silt

ML - Inorganic silt rock flour, or silt with slight plasticity

MH - Inorganic silt, micaceous or diatomaceous silty soil

SP - Poorly graded sand, gravelly sand, little or no fines

SP-SM - Fine to medium and/or fine to coarse sand

SM - Silty-sand, sand-silt mixtures

Basalt Bedrock

NOTE: THE LOCATIONS OF ALL FEATURES SHOWN ARE APPROXIMATE.

HORIZONTAL SCALE: 0' 50' 100' 150' 1" = 100'

VERTICAL SCALE: 0' 5' 10' 15' 1" = 10'

10X VERTICAL SCALE EXAGGERATION

CROSS SECTION E-E'

FORMER POPE & TALBOT WOOD-TREATING SITE

Cascadia Associates, LLC

PROJECT NUMBER	0034-001-005	FIGURE
DECEMBER 2019		24

DRAWN BY: BRJ/SD CHECKED BY: -

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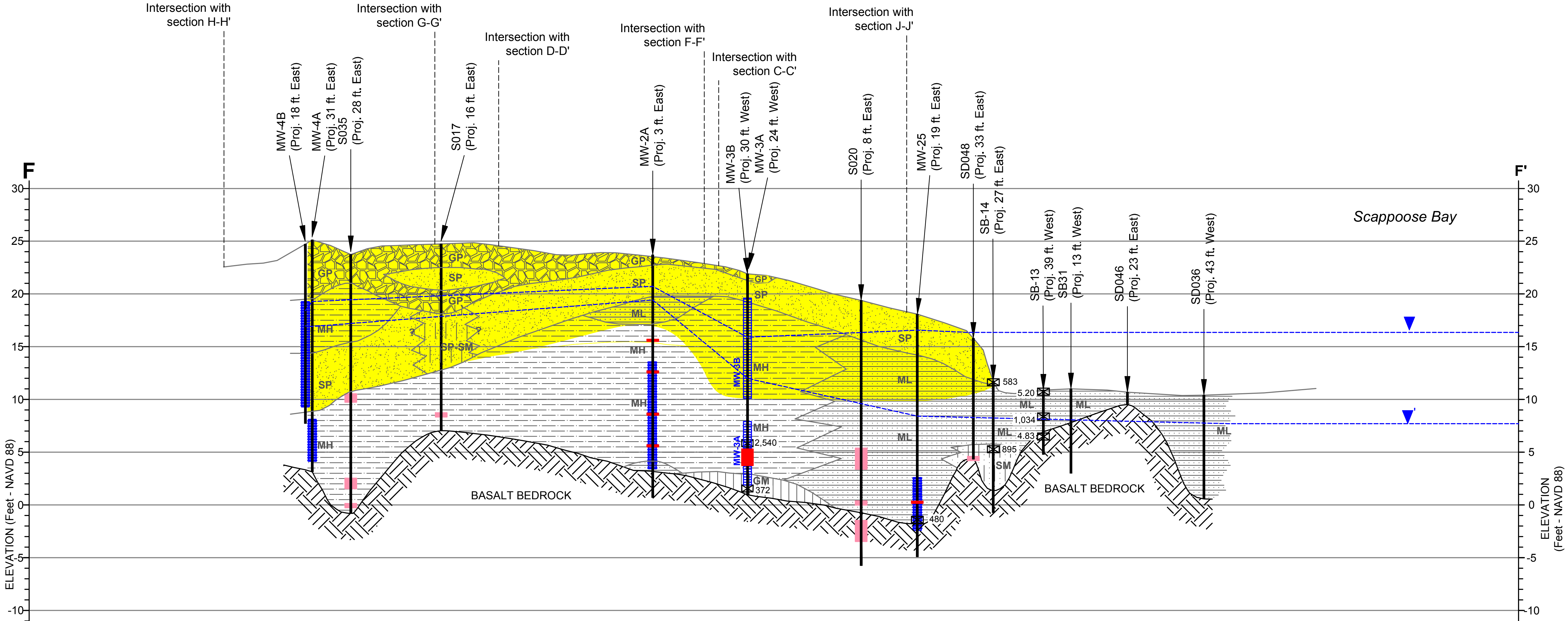

LEGEND

	FILL MATERIAL
	INFERRED HIGH WATER LEVEL (05/03/2012)
	INFERRED LOW WATER LEVEL (08/14/2012)
	MONITORING WELL SCREEN LOCATION
	TarGOST® SIGNAL INDICATIVE OF NAPL
	VISUAL OBSERVATION OF NAPL IN SOIL CORE
NAPL	NON-AQUEOUS PHASE LIQUIDS (CREOSOTE)

SOIL DESCRIPTIONS

- GP - Coarse gravel with occasional cobbles and varying amounts of silt
- GM - Silty gravels, gravel-sand-silt mixtures
- GW - Well-graded gravel, gravel-sand mixtures
- GP-GM - Silty Gravel
- ML - Inorganic silt rock flour, or silt with slight plasticity
- MH - Inorganic silt, micaceous or diatomaceous silty soil
- SM - Silty-sand, sand-silt mixtures
- SP - Poorly graded sand, gravelly sand, little or no fines
- SW - Fine to coarse sand
- SW-SM - Fine to coarse sand and/or silty sand, sand silt mixtures
- SP-SM - Fine to medium and/or fine to coarse sand, sand with some silt
- Wood Chips
- Basalt Bedrock

NOTE: THE LOCATIONS OF ALL FEATURES SHOWN ARE APPROXIMATE.

HORIZONTAL SCALE: 0' 50' 100' 150' — 1" = 100'

VERTICAL SCALE: 0' 5' 10' 15' — 1" = 10'

10X VERTICAL SCALE EXAGGERATION

CROSS SECTION F-F'

FORMER POPE & TALBOT WOOD-TREATING SITE

Cascadia Associates, LLC

PROJECT NUMBER 0034-001-005

DECEMBER 2019

FIGURE 25

DRAWN BY: BRJ/SD CHECKED BY: -

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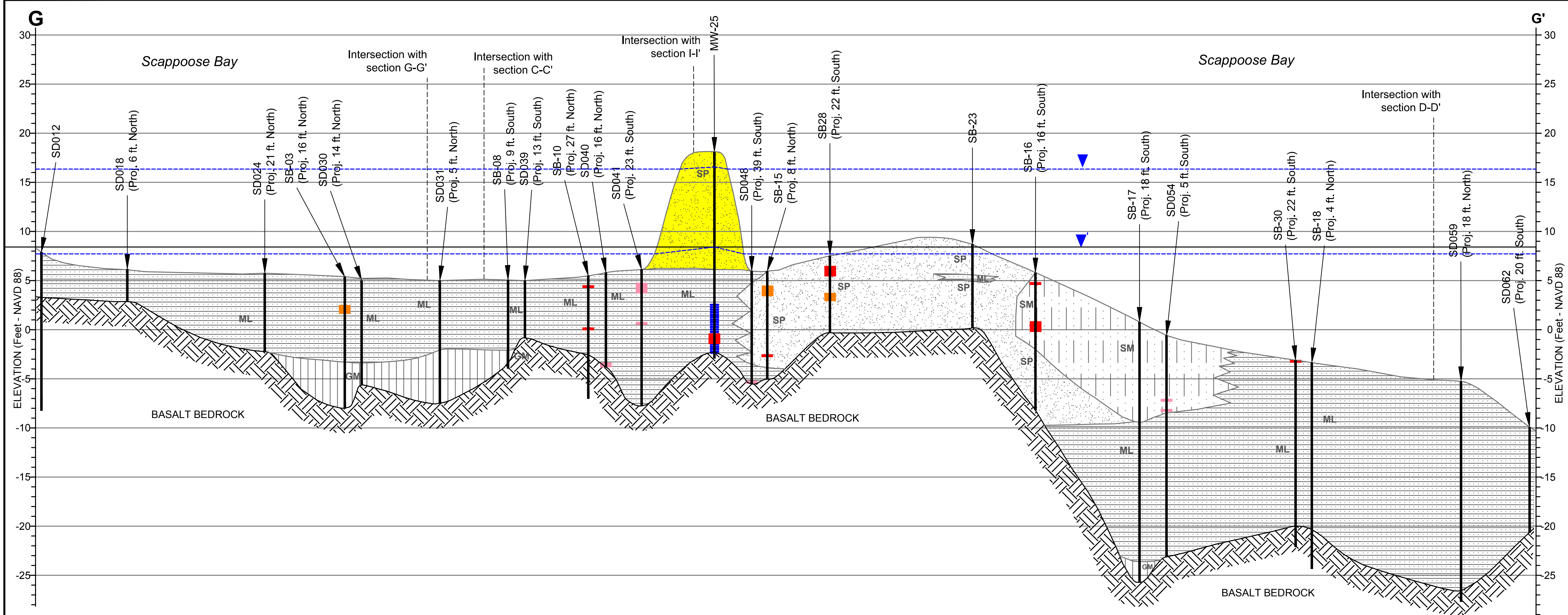

LEGEND

- FILL MATERIAL
- INFERRED HIGH WATER LEVEL (05/03/2012)
- INFERRED LOW WATER LEVEL (08/14/2012)
- MONITORING WELL SCREEN LOCATION
- TarGOST® SIGNAL INDICATIVE OF NAPL
- VISUAL OBSERVATION OF NAPL IN SOIL CORE
- PETROLEUM SHEEN - MODERATE
- NAPL NON-AQUEOUS PHASE LIQUIDS (CREOSOTE)

SOIL DESCRIPTIONS

- GP - Coarse gravel with occasional cobbles and varying amounts of silt
- GM - Silty gravels, gravel-sand-silt mixtures
- GW - Well-graded gravel, gravel-sand mixtures
- GP-GM - Silty Gravel
- ML - Inorganic silt rock flour, or silt with slight plasticity
- MH - Inorganic silt, micaceous or diatomaceous silty soil
- SM - Silty-sand, sand-silt mixtures
- SP - Poorly graded sand, gravelly sand, little or no fines
- SW - Fine to coarse sand
- SW-SM - Fine to coarse sand and/or silty sand, sand silt mixtures
- SP-SM - Fine to medium and/or fine to coarse sand, sand with some silt
- Wood Chips
- Basalt Bedrock

HORIZONTAL SCALE: 0' 50' 100' 150' — 1" = 100'

VERTICAL SCALE: 0' 5' 10' 15' — 1" = 10'

10X VERTICAL SCALE EXAGGERATION

NOTE: THE LOCATIONS OF ALL FEATURES SHOWN ARE APPROXIMATE.

CROSS SECTION G-G'

FORMER POPE & TALBOT WOOD-TREATING SITE

Cascadia Associates, LLC

PROJECT NUMBER	0034-001-005
DECEMBER 2019	
FIGURE	26

DRAWN BY: BRJ/SD CHECKED BY: -

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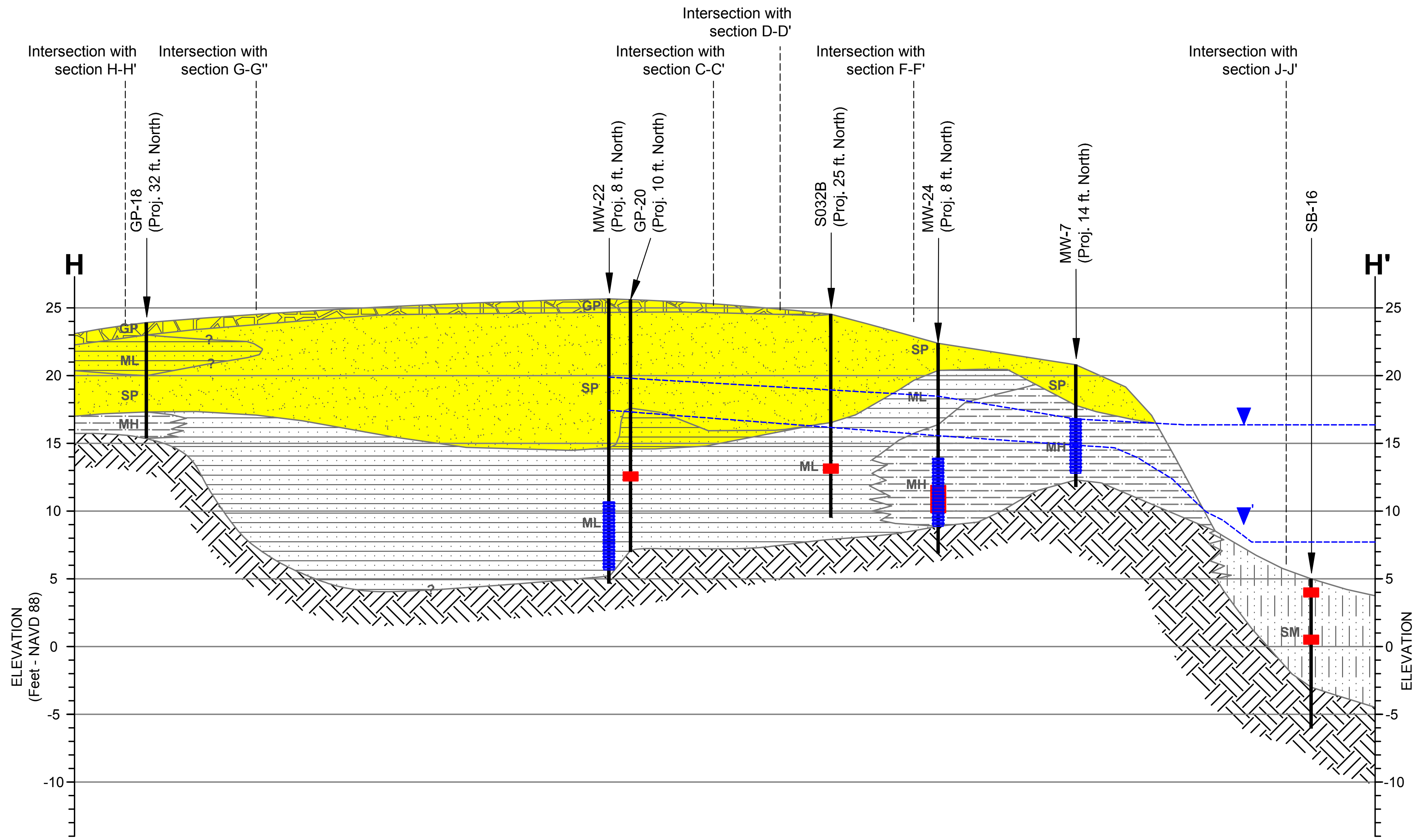


LEGEND

- FILL MATERIAL
- TarGOST® SIGNAL INDICATIVE OF NAPL
- VISUAL OBSERVATION OF NAPL IN SOIL CORE
- MONITORING WELL SCREEN LOCATION
- INFERRED HIGH WATER LEVEL (05/03/2012)
- INFERRED LOW WATER LEVEL (08/14/2012)

NOTE: THE LOCATIONS OF ALL FEATURES SHOWN ARE APPROXIMATE.

HORIZONTAL SCALE: 0' 50' 100' 150' — 1" = 100'

VERTICAL SCALE: 0' 5' 10' 15' — 1" = 10'

10X VERTICAL SCALE EXAGGERATION

SOIL DESCRIPTIONS

- GP - Coarse gravel with occasional cobbles and varying amounts of silt
- ML - Inorganic silt rock flour, or silt with slight plasticity
- MH - Inorganic silt, micaceous or diatomaceous silty soil
- SP - Poorly-graded sand, gravelly sand, little or no fines
- SP-SM - Fine to medium and/or fine to coarse sand
- SM - Silty-sand, sand-silt mixtures
- Basalt Bedrock

NAPL NON-AQUEOUS PHASE LIQUIDS (CREOSOTE)

CROSS SECTION H-H'

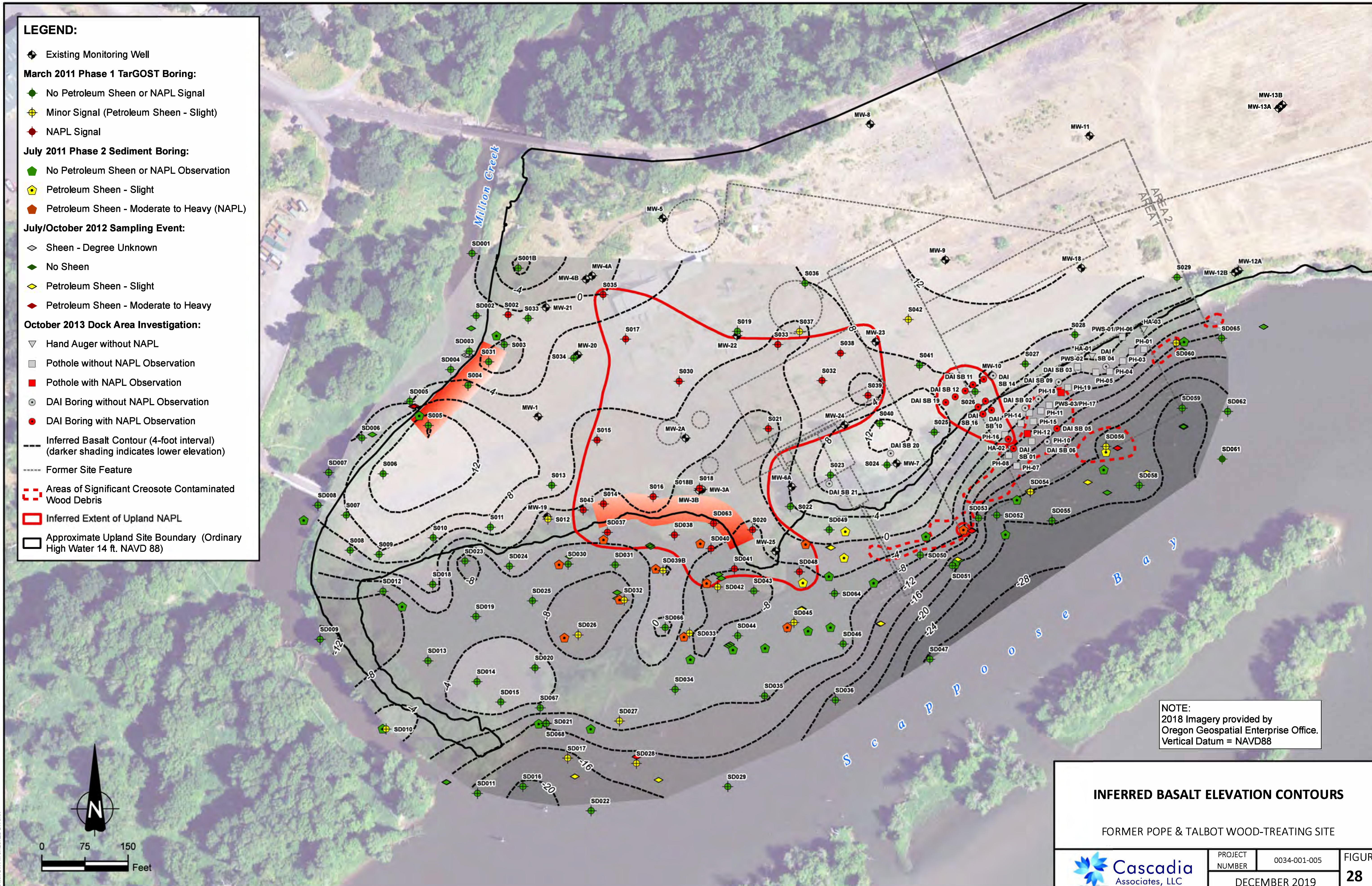
FORMER POPE & TALBOT WOOD-TREATING SITE

Cascadia Associates, LLC

PROJECT NUMBER	0034-001-005	FIGURE
	DECEMBER 2019	27

DRAWN BY: BRJ/SD CHECKED BY: -

K:\11000\11200\11220\112203\dwg_SRI_Report_2019\4-2 - Cross Section C-C'.dwg - - May. 28, 2019 7:00am - brian.johnson



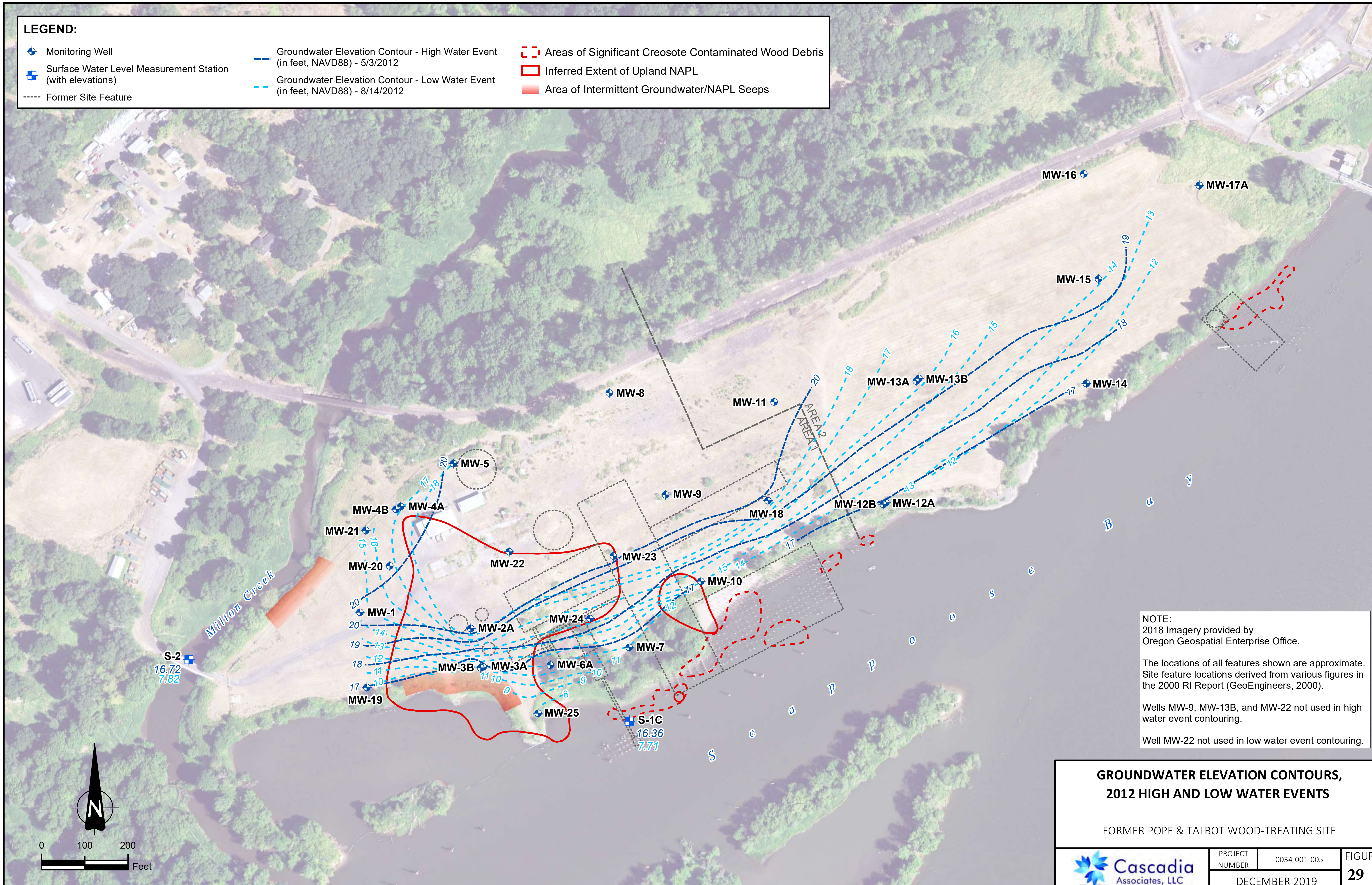
INFERRED BASALT ELEVATION CONTOURS

FORMER POPE & TALBOT WOOD-TREATING SITE

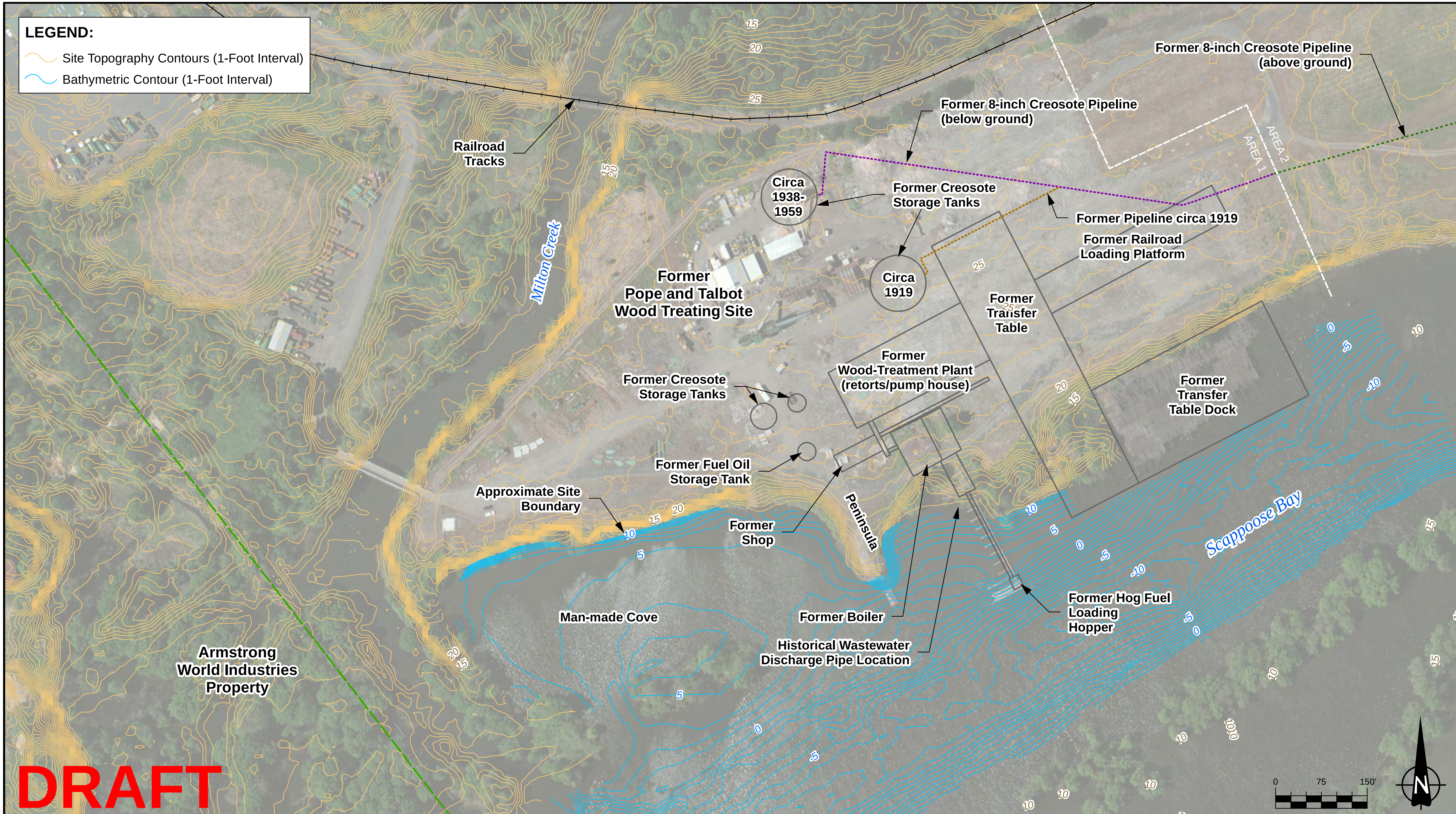
Cascadia Associates, LLC

PROJECT NUMBER	0034-001-005	FIGURE
DECEMBER 2019		28

C:\DATA\POCC_0034_001\Projects\SRI_Dec_2019\Fig_4_10_Inferred Basalt Elevation Contours.mxd - ErikStrandhagen - 12/13/2019 - 2:20:56 PM



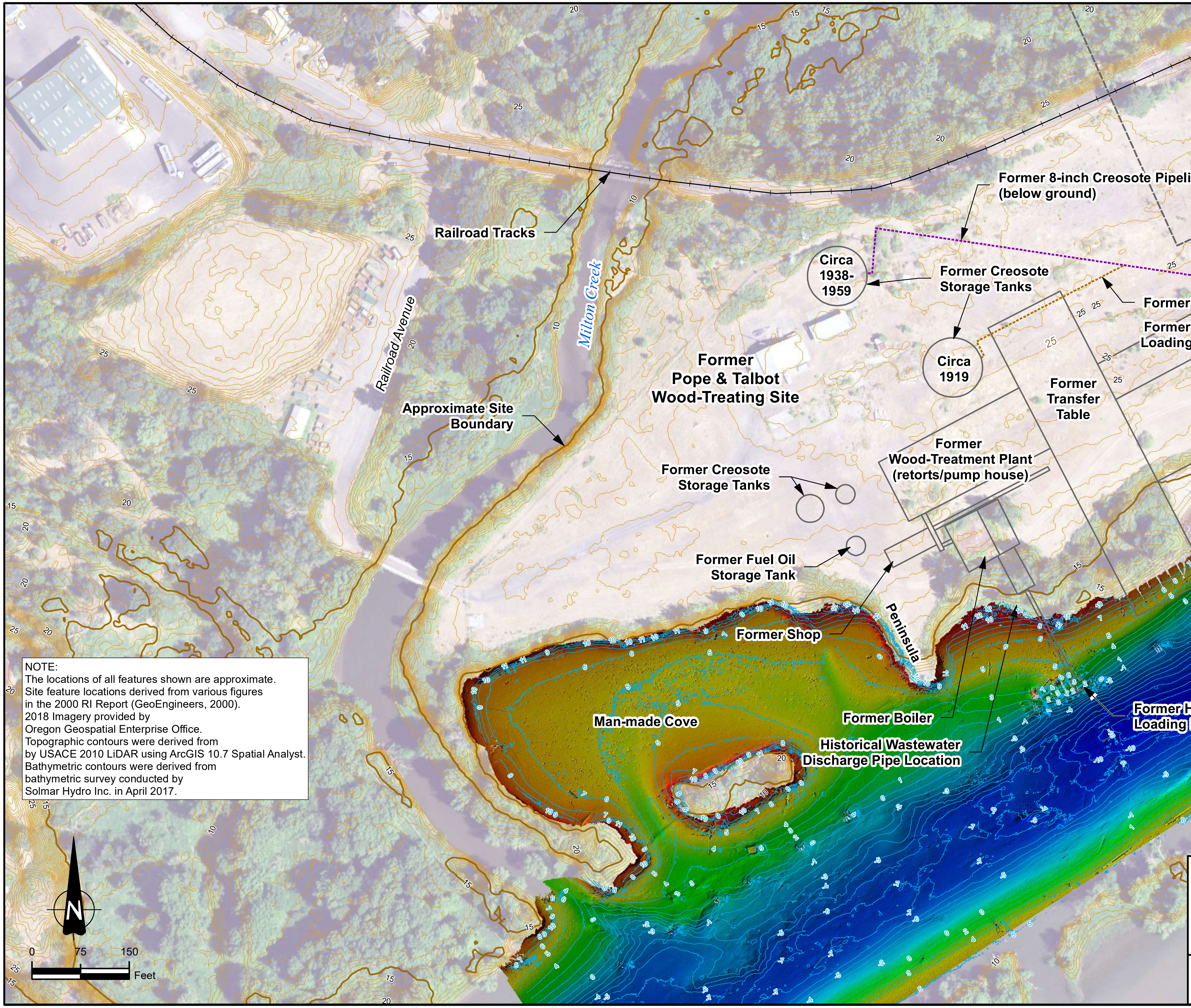
C:\DATA\POCC_0034_001\Projects\SRI_Dec_2019\Fig_04_11_Groundwater Elevation Contours.mxd - ErikStrandhagen - 12/12/2019 - 2:20:58 PM



NOTE: The locations of all features shown are approximate. Site feature locations derived from various figures in the 2000 RI Report (GeoEngineers, 2000).
2010 Imagery from live web service provided by ESRI online mapping system.
Bathymetric contours were derived from bathymetric survey conducted by Minister-Glaeser Surveying Inc. in October 2010, 1015T01.dwg.
Topographic contours were derived from Lower Columbia River 2005 LiDAR using ArcGIS 10.1 Spatial Analyst.

CLIENT:	PORT OF ST. HELENS
	AMEC 7376 S.W. Durham Road Portland, OR, U.S.A. 97224
DWN BY:	PM
CHK'D BY:	RJ
DATUM:	NAD83
PROJECTION:	OR SP N. Ft.
SCALE:	1 inch = 150 feet
PROJECT:	FORMER POPE & TALBOT WOOD-TREATING SITE
TITLE:	SITE TOPOGRAPHY AND BATHYMETRY (2010)
DATE:	MAY 2014
PROJECT NO.:	9-61M-112202.09
REV. NO.:	1
FIGURE NO.:	30

K:\11000\11200\11220\112202\DWG_2014_SRI_Report\Figure 2-1 - Site Topography and Bathymetry.mxd



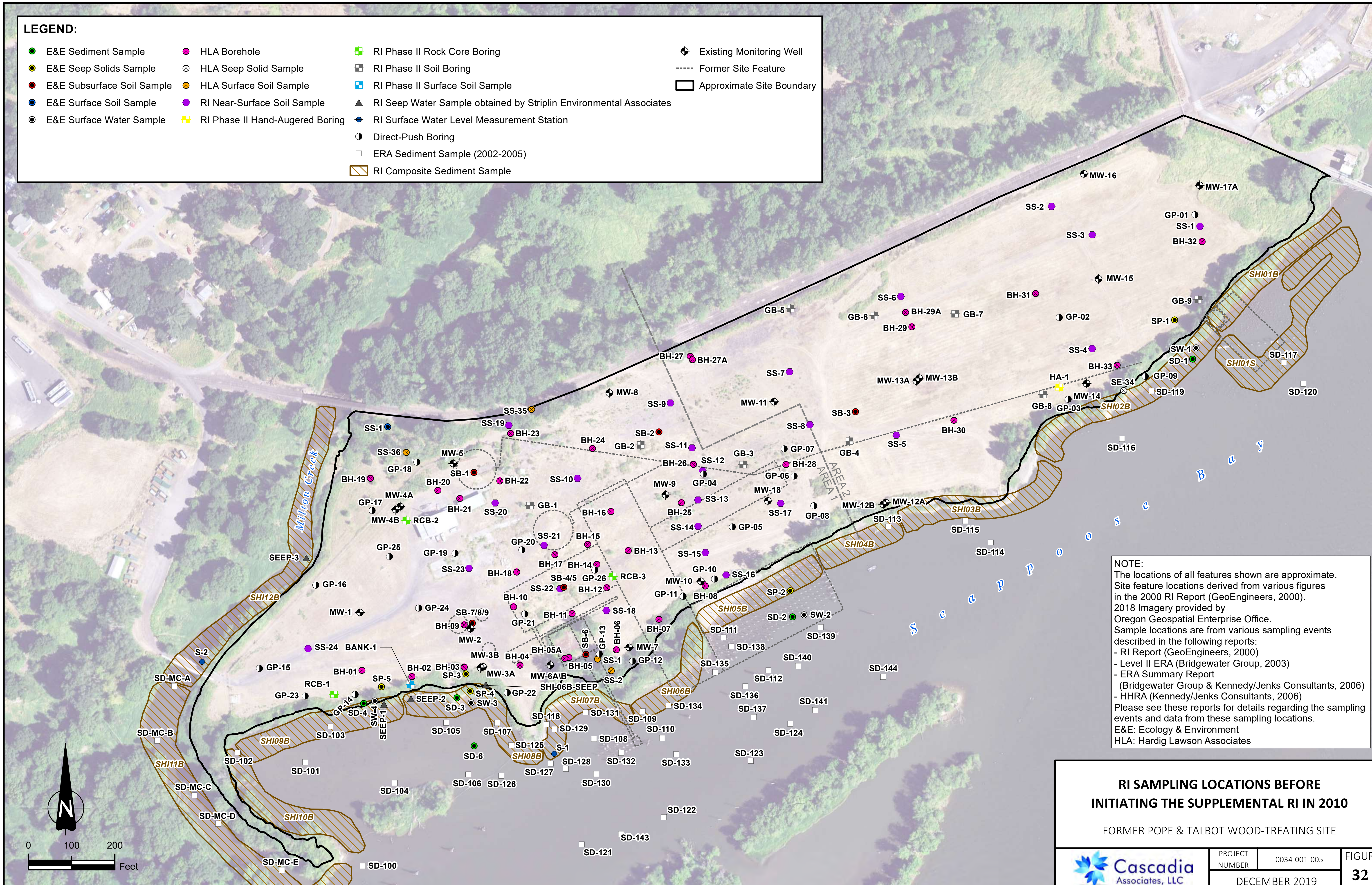
AREA 1 SITE TOPOGRAPHY AND BATHYMETRY (2017)

FORMER POPE & TALBOT WOOD-TREATING SITE

Cascadia Associates, LLC

PROJECT NUMBER	0034-001-005	FIGURE
	DECEMBER 2019	31

C:\DATA\POCC_0034_001\Projects\SRI_Dec_2019\Fig_02_01_Topo_Bathy.mxd - ErikStrandhagen - 12/9/2019 - 1:54:58 PM



NOTE:
The locations of all features shown are approximate.
Site feature locations derived from various figures in the 2000 RI Report (GeoEngineers, 2000).
2018 Imagery provided by Oregon Geospatial Enterprise Office.
Sample locations are from various sampling events described in the following reports:
- RI Report (GeoEngineers, 2000)
- Level II ERA (Bridgewater Group, 2003)
- ERA Summary Report (Bridgewater Group & Kennedy/Jenks Consultants, 2006)
- HHRA (Kennedy/Jenks Consultants, 2006)
Please see these reports for details regarding the sampling events and data from these sampling locations.
E&E: Ecology & Environment
HLA: Hardig Lawson Associates

RI SAMPLING LOCATIONS BEFORE INITIATING THE SUPPLEMENTAL RI IN 2010

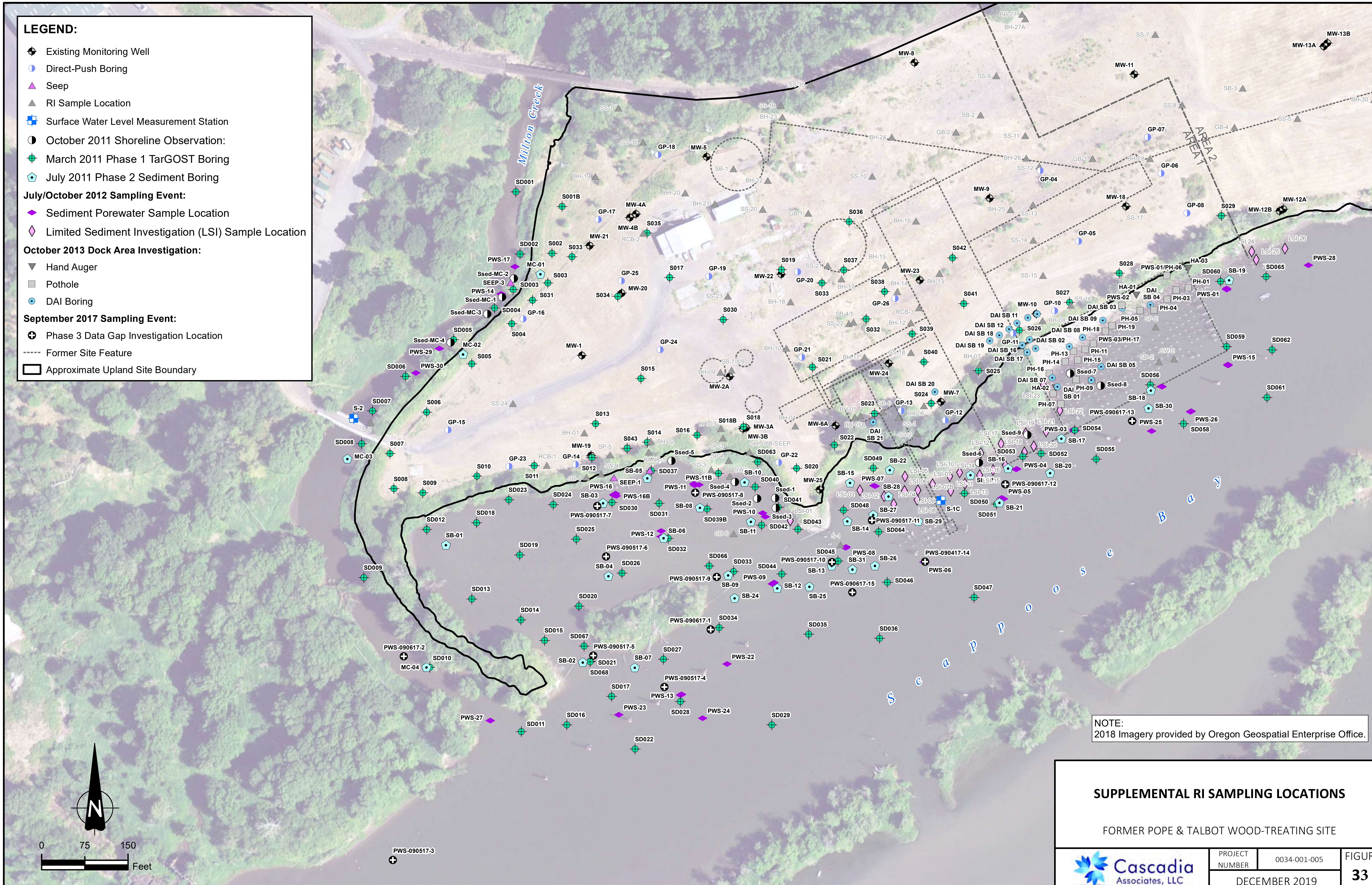
FORMER POPE & TALBOT WOOD-TREATING SITE

Cascadia Associates, LLC

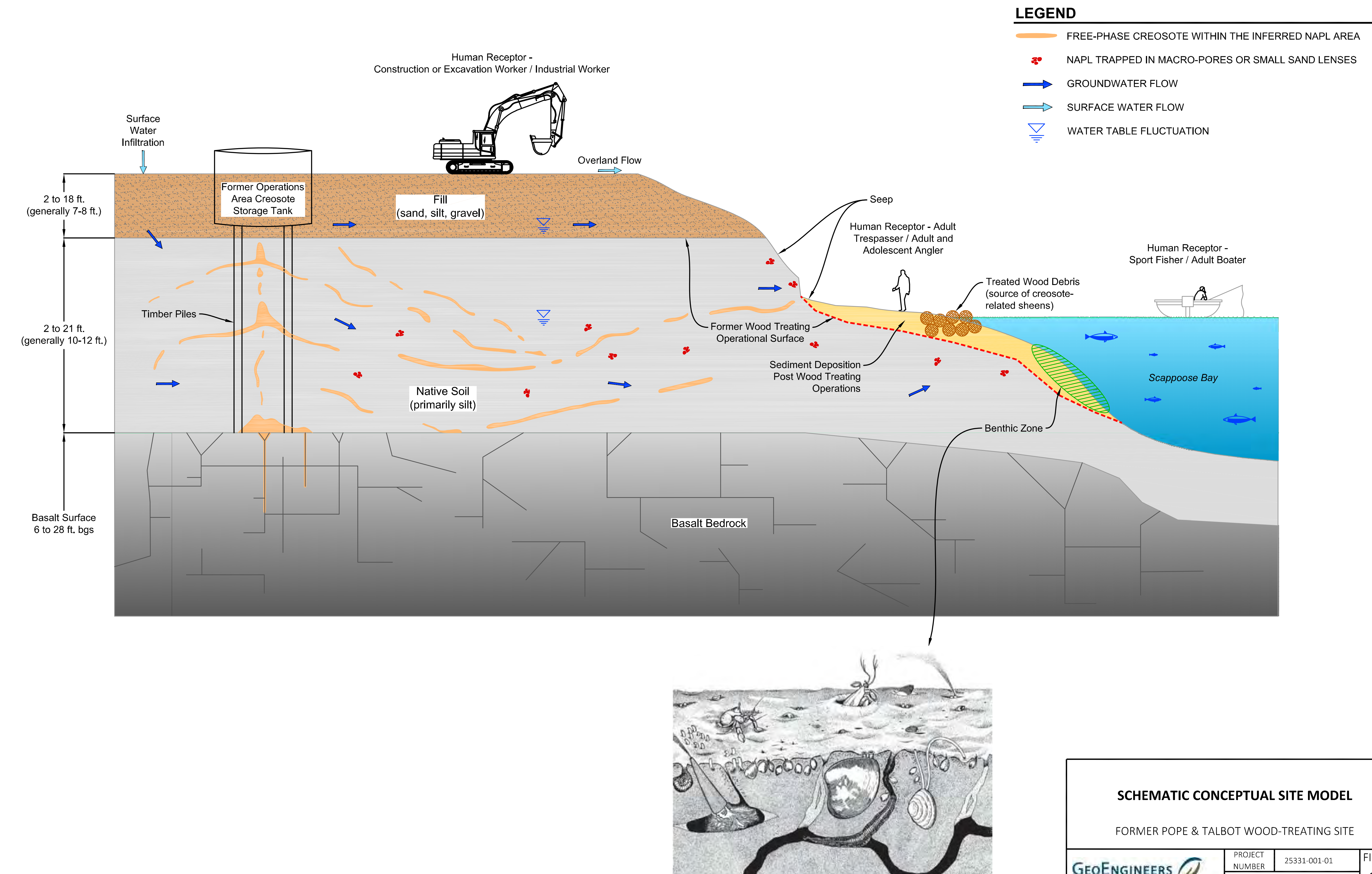
PROJECT NUMBER 0034-001-005

DECEMBER 2019

FIGURE 32



C:\DATA\POCC_0034_001\Projects\SRI_Dec_2019\Fig_03_01_Supplemental RI Sampling Locations.mxd - ErikStrandhagen - 12/9/2019 - 3:10:05 PM



SCHEMATIC CONCEPTUAL SITE MODEL

FORMER POPE & TALBOT WOOD-TREATING SITE

GeoEngineers	PROJECT NUMBER	25331-001-01	FIGURE
	November 2021		34

DRAWN BY: BR/JSD CHECKED BY: -

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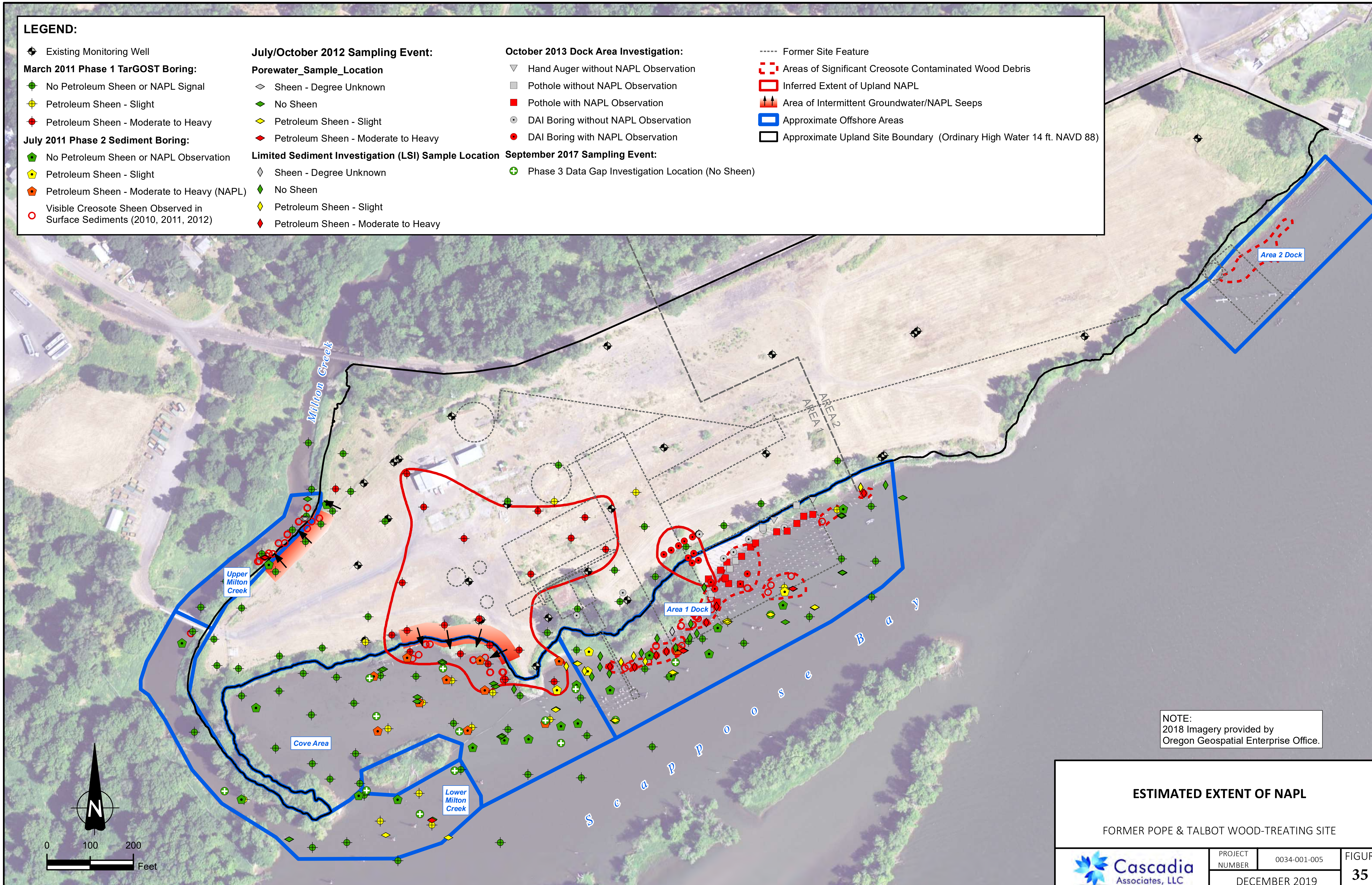
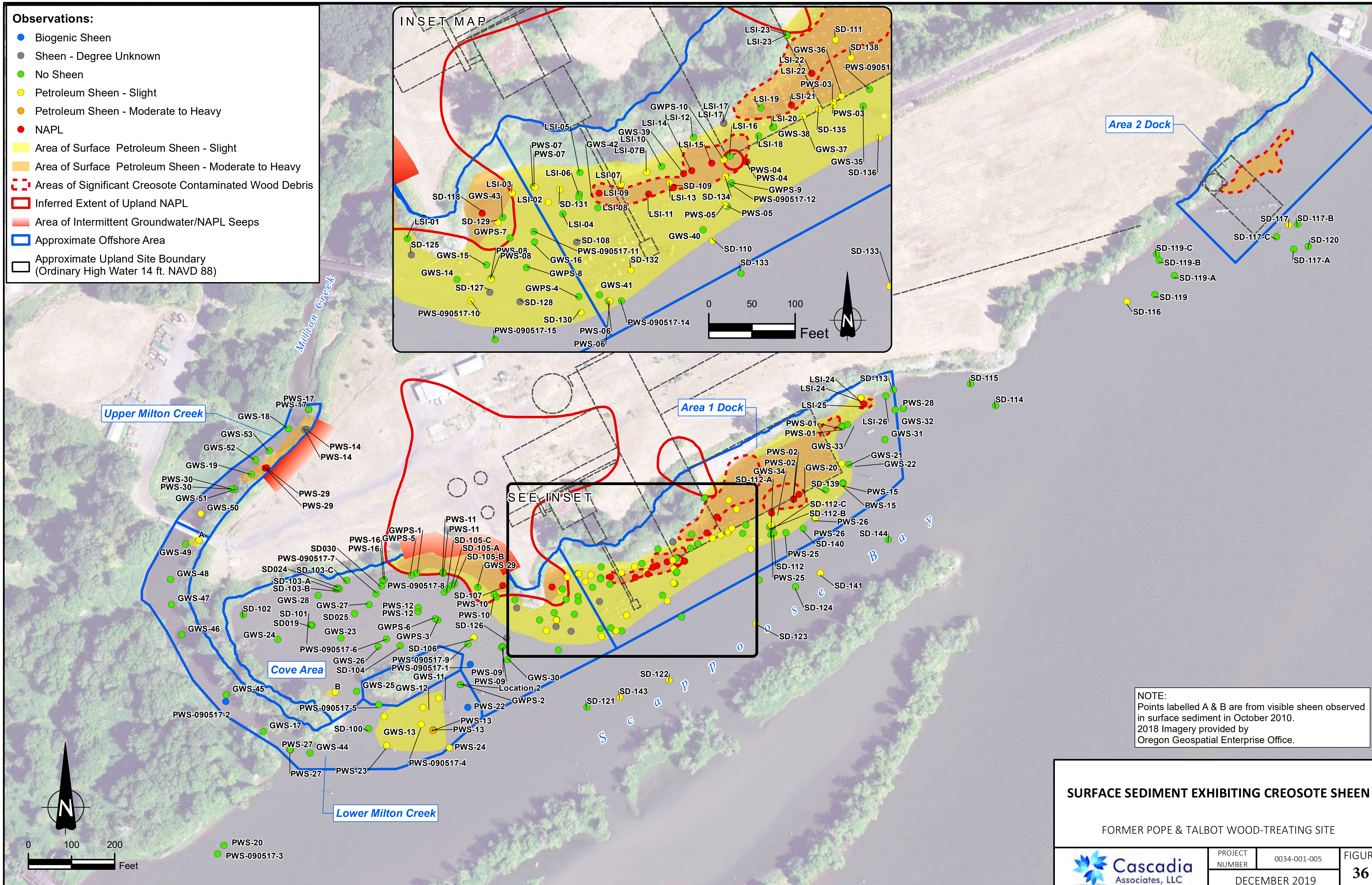


LEGEND:
Existing Monitoring Well
March 2011 Phase 1 TarGOST Boring:
No Petroleum Sheen or NAPL Signal
Petroleum Sheen - Slight
Petroleum Sheen - Moderate to Heavy
July 2011 Phase 2 Sediment Boring:
No Petroleum Sheen or NAPL Observation
Petroleum Sheen - Slight
Petroleum Sheen - Moderate to Heavy (NAPL)
Visible Creosote Sheen Observed in Surface Sediments (2010, 2011, 2012)
July/October 2012 Sampling Event:
Porewater_Sample_Location
Sheen - Degree Unknown
No Sheen
Petroleum Sheen - Slight
Petroleum Sheen - Moderate to Heavy
Limited Sediment Investigation (LSI) Sample Location
Sheen - Degree Unknown
No Sheen
Petroleum Sheen - Slight
Petroleum Sheen - Moderate to Heavy
October 2013 Dock Area Investigation:
Hand Auger without NAPL Observation
Pothole without NAPL Observation
Pothole with NAPL Observation
DAI Boring without NAPL Observation
DAI Boring with NAPL Observation
September 2017 Sampling Event:
Phase 3 Data Gap Investigation Location (No Sheen)
Former Site Feature
Areas of Significant Creosote Contaminated Wood Debris
Inferred Extent of Upland NAPL
Area of Intermittent Groundwater/NAPL Seeps
Approximate Offshore Areas
Approximate Upland Site Boundary (Ordinary High Water 14 ft. NAVD 88)
Milton Creek
Upper Milton Creek
Cove Area
Lower Milton Creek
Area 1 Dock
Area 2 Dock
AREA 2
AREA 1
Scappoose Bay
NOTE:
2018 Imagery provided by
Oregon Geospatial Enterprise Office.
0
100
200
Feet
N
ESTIMATED EXTENT OF NAPL
FORMER POPE & TALBOT WOOD-TREATING SITE
Cascadia Associates, LLC
PROJECT NUMBER
0034-001-005
DECEMBER 2019
FIGURE
35



SURFACE SEDIMENT EXHIBITING CREOSOTE SHEEN

FORMER POPE & TALBOT WOOD-TREATING SITE

Cascadia Associates, LLC

PROJECT NUMBER 0034-001-005

DECEMBER 2019

FIGURE 36

DRAWN BY: PM CHECKED BY: JKH

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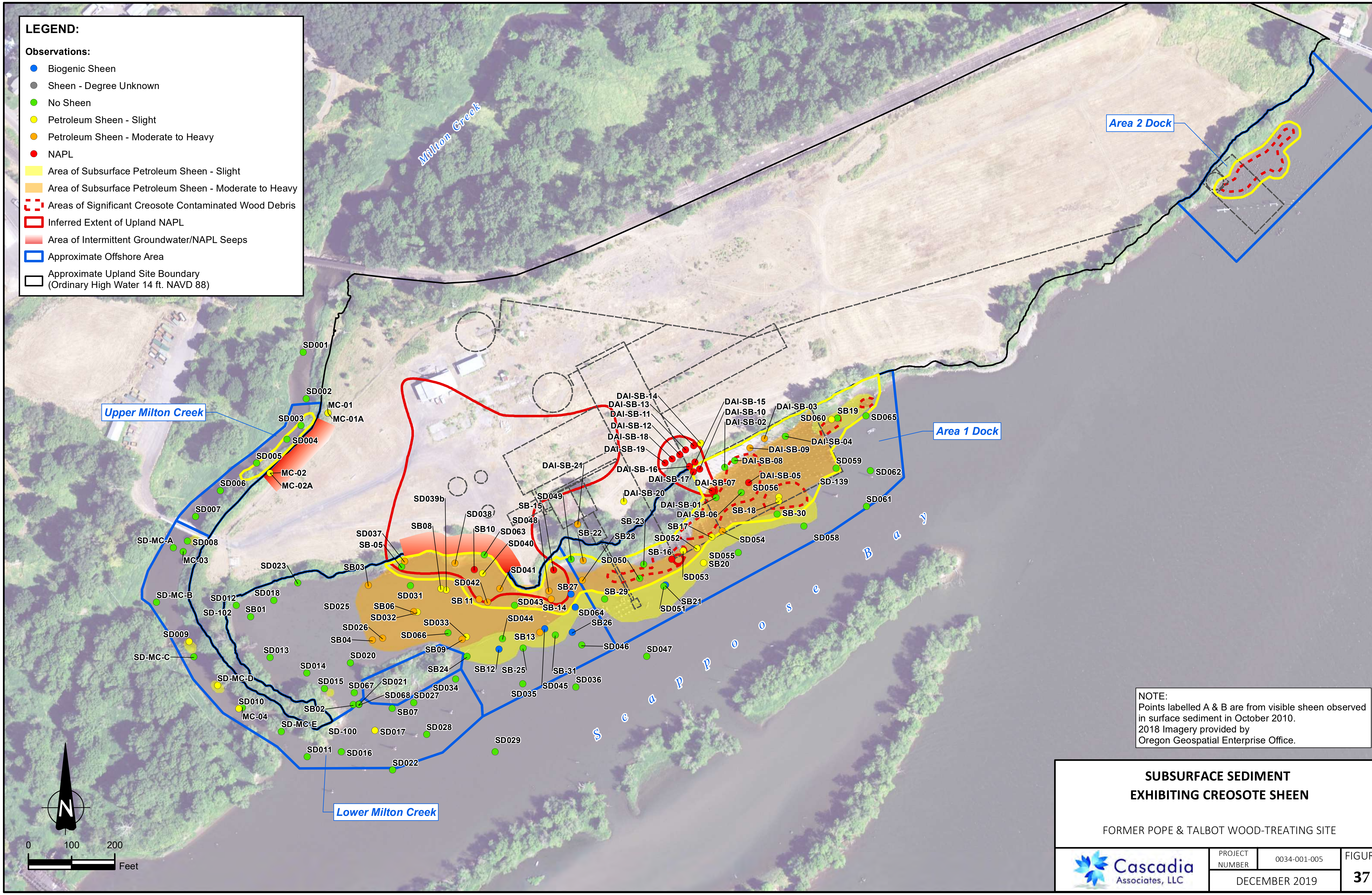
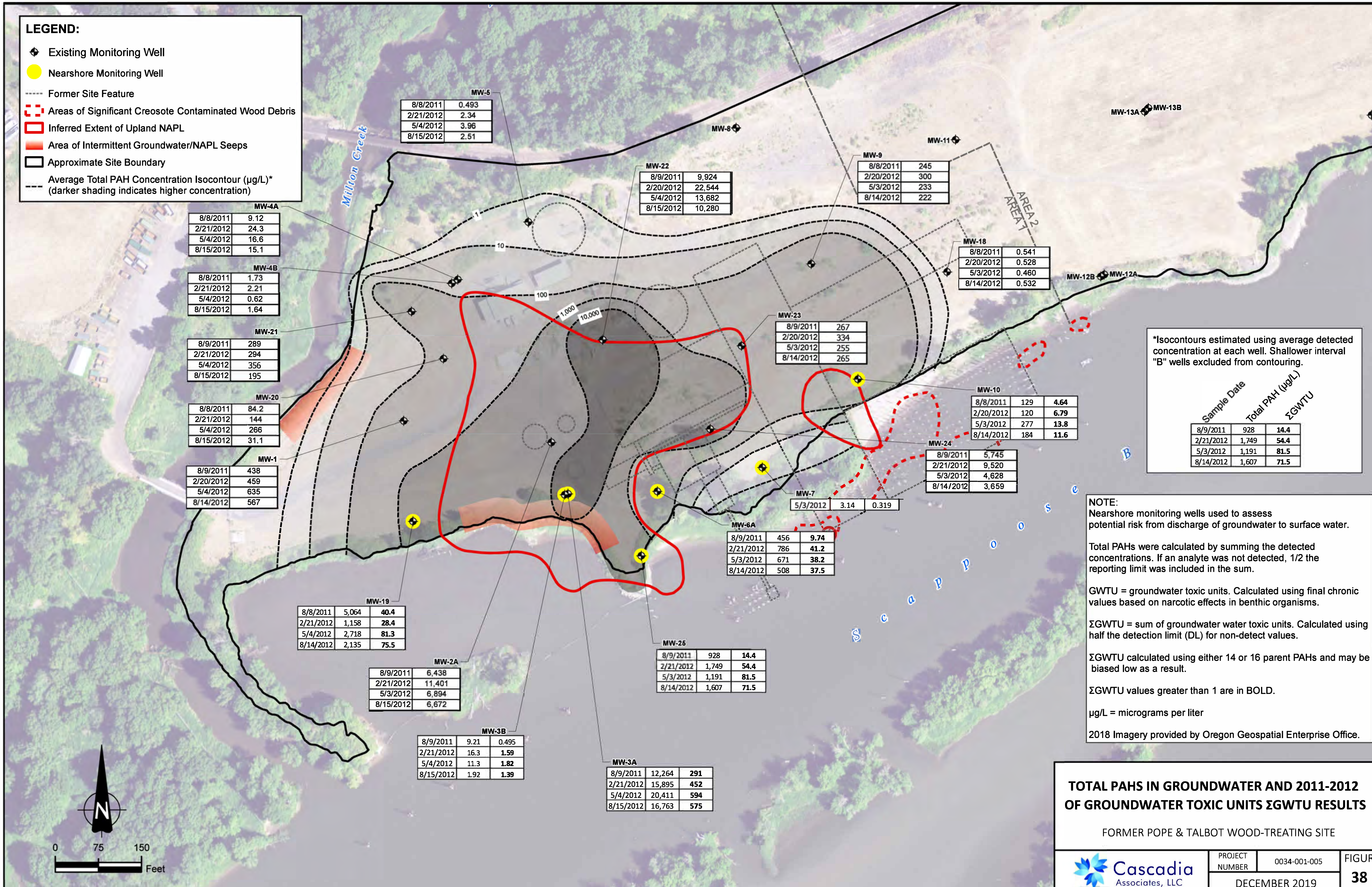


SUBSURFACE SEDIMENT EXHIBITING CREOSOTE SHEEN

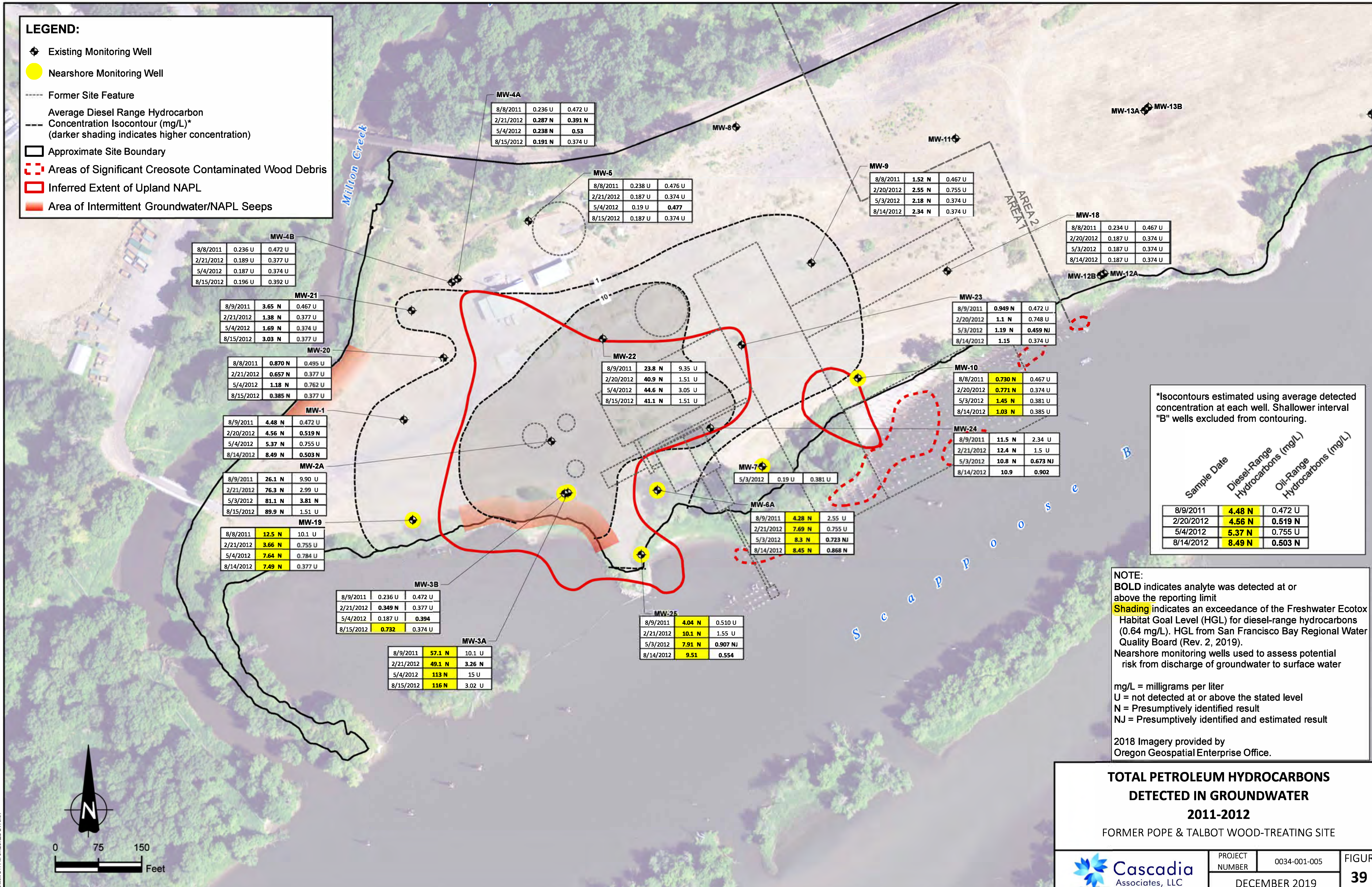
FORMER POPE & TALBOT WOOD-TREATING SITE

Cascadia Associates, LLC

PROJECT NUMBER	0034-001-005	FIGURE
	DECEMBER 2019	37



C:\DATA\POCC_0034_001\Projects\SRI_Dec_2019\Fig_05_04_PAHs_GW.mxd - ErikStrandhagen - 12/12/2019 - 7:49:38 AM



TOTAL PETROLEUM HYDROCARBONS DETECTED IN GROUNDWATER 2011-2012

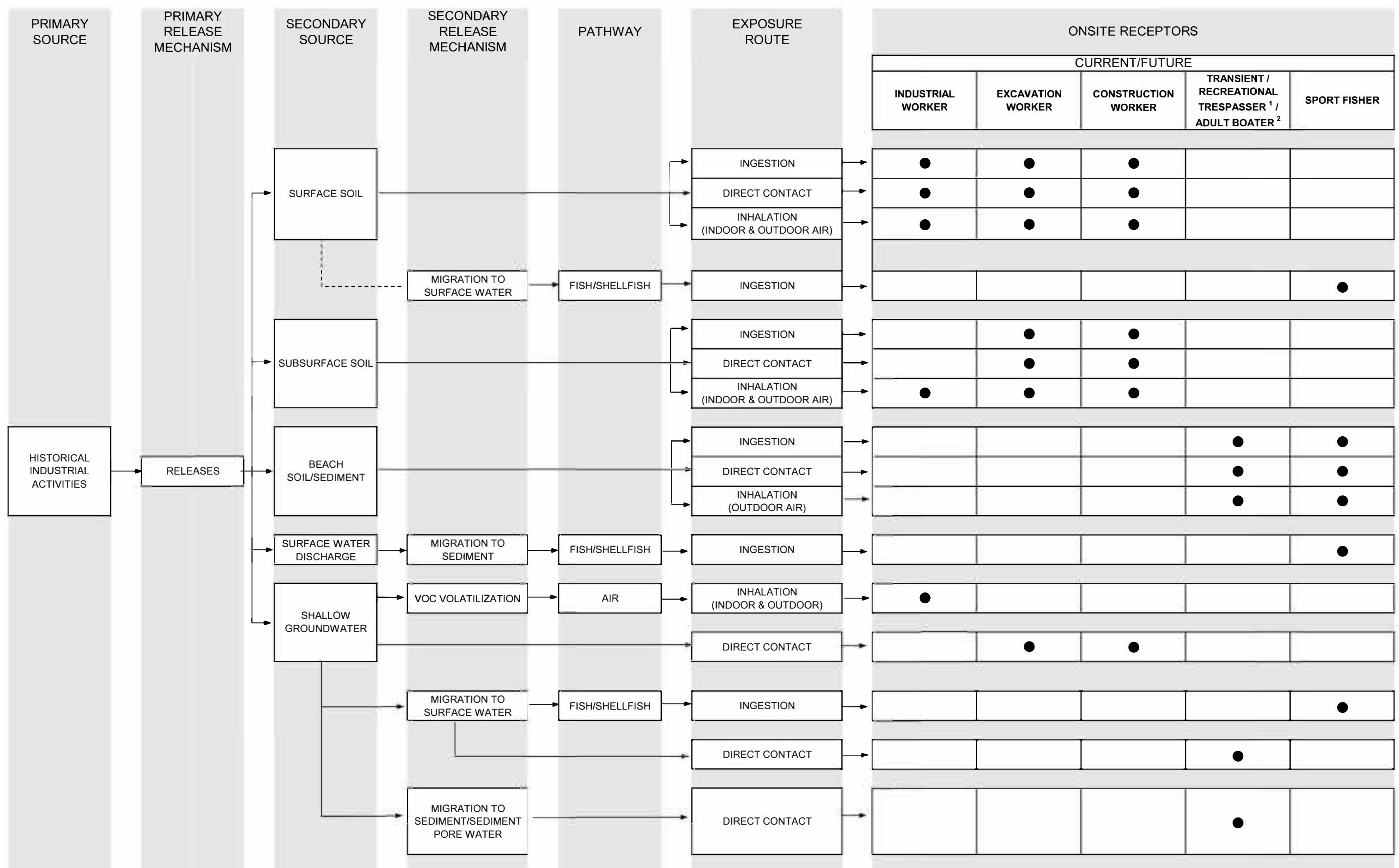
FORMER POPE & TALBOT WOOD-TREATING SITE

Cascadia Associates, LLC

PROJECT NUMBER	0034-001-005	FIGURE
	DECEMBER 2019	39

C:\DATA\POCC_0034_001\Projects\SRI_Dec_2019\Fig_05_05_PAH_hydrocarbons_GW.mxd - ErikStrandhagen - 12/12/2019 - 8:01:51 AM

HUMAN HEALTH RISK ASSESSMENT (HHRA) CONCEPTUAL SITE MODEL (CSM)



LEGEND

- ● POTENTIALLY COMPLETE PATHWAY; QUANTITATIVE EVALUATION
- → COMPLETE PATHWAY
- - - - INCOMPLETE PATHWAY
- 1 THE RECREATIONAL TRESPASSER IS AN OLDER CHILD AS DESCRIBED IN THE 2006 HHRA.
- 2 THE ADULT BOATER WOULD BE EXPOSED TO SEDIMENT AND SEDIMENT PORE WATER IN THE SAME MANNER AS THE OLDER CHILD RECREATIONAL TRESPASSER

HUMAN HEALTH RISK ASSESSMENT CONCEPTUAL SITE MODEL

FORMER POPE & TALBOT WOOD-TREATING SITE

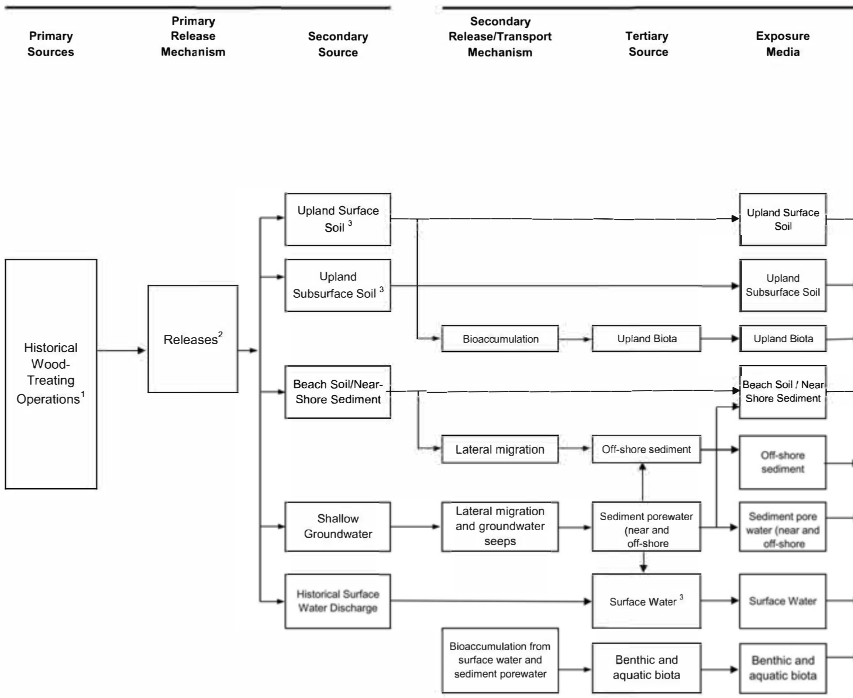
Cascadia Associates, LLC

PROJECT NUMBER 0034-001-005

December 2019

FIGURE 40

ECOLOGICAL RISK ASSESSMENT (ERA) CONCEPTUAL SITE MODEL (CSM)



Potential Ecological Receptors

Exposure Media	Exposure Route	Terrestrial[4]: Upland plants	Soil Invertebrates	Herbivorous birds and mammals	Insectivorous birds and mammals	Carnivorous birds and mammals	Aquatic[4]: Wetland and aquatic plants	Benthic Invertebrates	Fish	Invertivorous birds	Piscivorous birds and mammals	Notes
Upland Surface Soil	Ingestion	○	●	●	●	●	○	○	○	◍	◍	Potential for risk to upland ecological receptors previously evaluated
	Absorption/Direct Contact	●	●	◍	◍	◍	○	○	○	◍	◍	
Upland Subsurface Soil	Ingestion	○	●	◍	◍	◍	○	○	○	○	◍	
	Absorption/Direct Contact	●	●	◍	◍	◍	○	○	○	○	◍	
Upland Biota	Ingestion	○	○	●	●	●	○	○	○	◍	◍	
Beach Soil / Near Shore Sediment	Ingestion	○	○	◍	◍	◍	○	●	●	●	●	
	Absorption/Direct Contact	○	○	◍	◍	◍	●	●	●	●	●	
Off-shore sediment	Ingestion	○	○	○	○	○	○	●	●	○	○	
	Absorption/Direct Contact	○	○	○	○	○	●	●	●	○	○	
Sediment pore water (near and off-shore	Direct Contact	○	○	○	○	○	●	●	●	○	○	
Surface Water	Ingestion	○	○	◍	◍	◍	○	●	●	●	●	
	Absorption/Direct Contact	○	○	◍	◍	◍	●	●	●	◍	◍	
Benthic and aquatic biota	Ingestion	○	○	○	○	○	○	◍	●	●	●	

Notes:

1 The former wood-treating operations resulted in releases of contaminants of interest (mainly PAHs derived from creosote) and wastes to the historical (1919 through 1959) ground surface within Area 1.

2 Specific releases are not documented; for the purpose of the RI, sources are defined based on knowledge of historical operations and investigation results that are indicative of creosote releases to the former ground surface (i.e., contamination near the Fill Zone/Native Soil contact). The main upland source area at the Site includes the former wood-treatment plant (i.e., retort pump house and retorts) and former creosote and fuel oil storage tanks located west of the wood treatment plant; collectively these are referred to as the "Former Operations Area" for the purposes of this report (Figure 1-2). This area generally is encompassed by the extent of DNAPL as defined through RI activities. Other ancillary operations immediately adjacent to Area 1 appear to have contributed to more localized shoreline and in-water areas of surface and/or near-surface sediment contamination, such as the historical wastewater discharge pipe, former hog fuel loading dock and hopper, and former transfer table dock.

3 There have been no significant changes to the surface soil and subsurface soil data used in the 2006 ERA. Therefore, no revision to the ERA CSM for those exposure media has been completed.

4 See the 2006 ERA for representative receptors.

● Complete Pathway
◍ Potentially Complete Pathway
○ Incomplete Pathway

ECOLOGICAL RISK ASSESSMENT CONCEPTUAL SITE MODEL

FORMER POPE & TALBOT WOOD-TREATING SITE

Cascadia Associates, LLC

PROJECT NUMBER 0034-001-005

NOVEMBER 2019

FIGURE 41

DRAWN BY: BRJ/ED CHECKED BY: -

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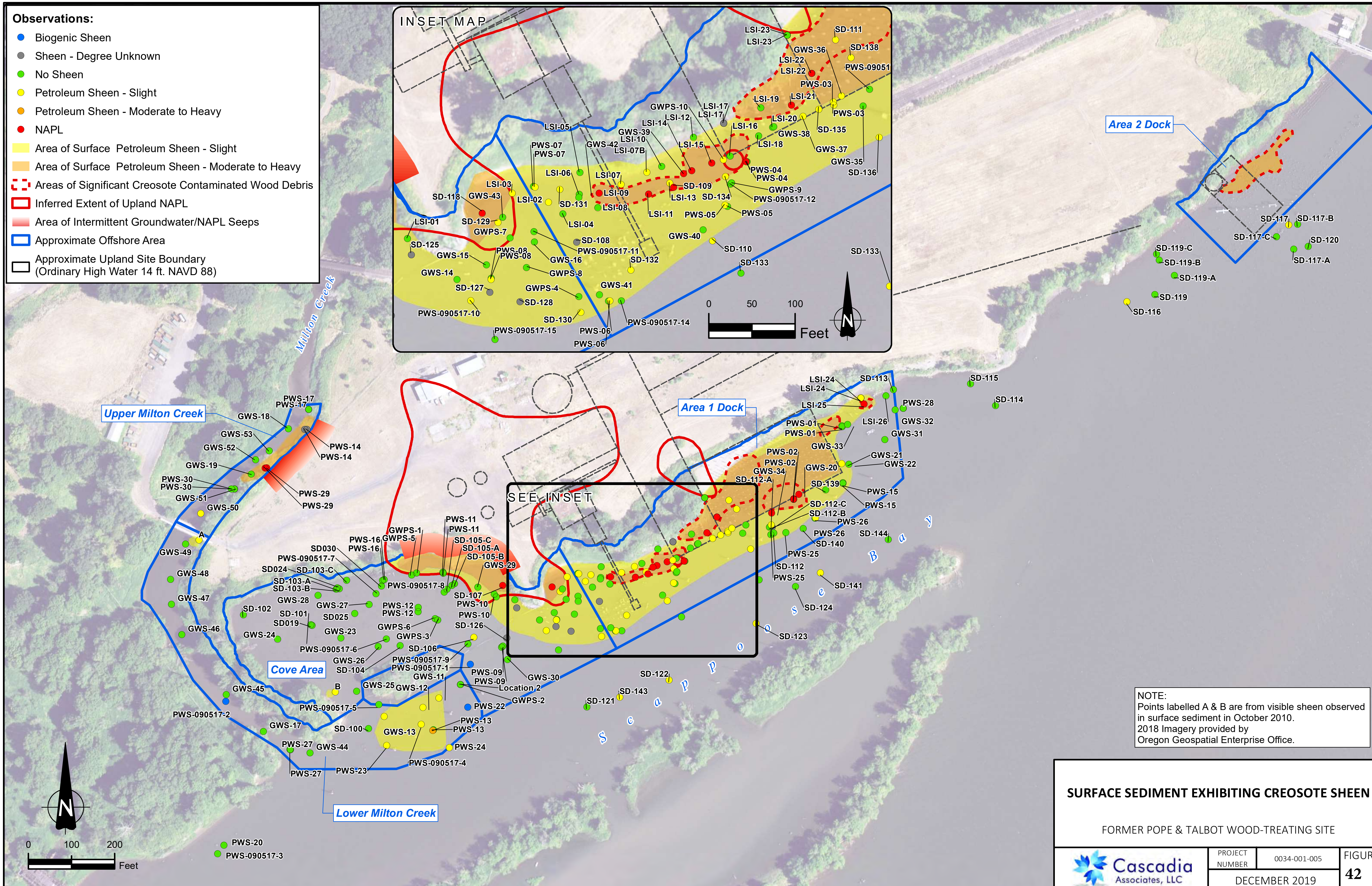

SURFACE SEDIMENT EXHIBITING CREOSOTE SHEEN

FORMER POPE & TALBOT WOOD-TREATING SITE

Cascadia Associates, LLC

PROJECT NUMBER 0034-001-005

DECEMBER 2019

FIGURE 42

DRAWN BY: PM CHECKED BY: JKH

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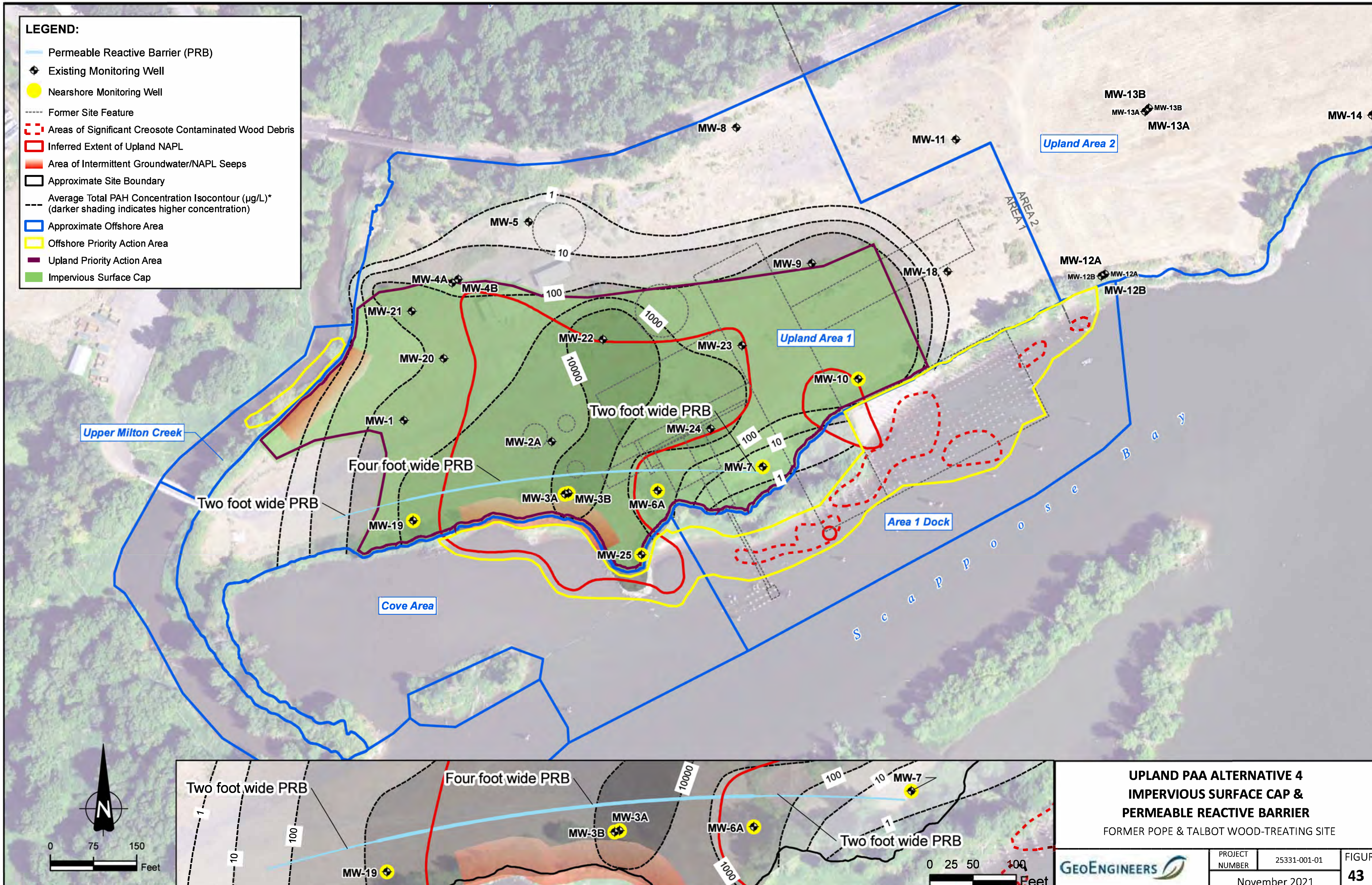


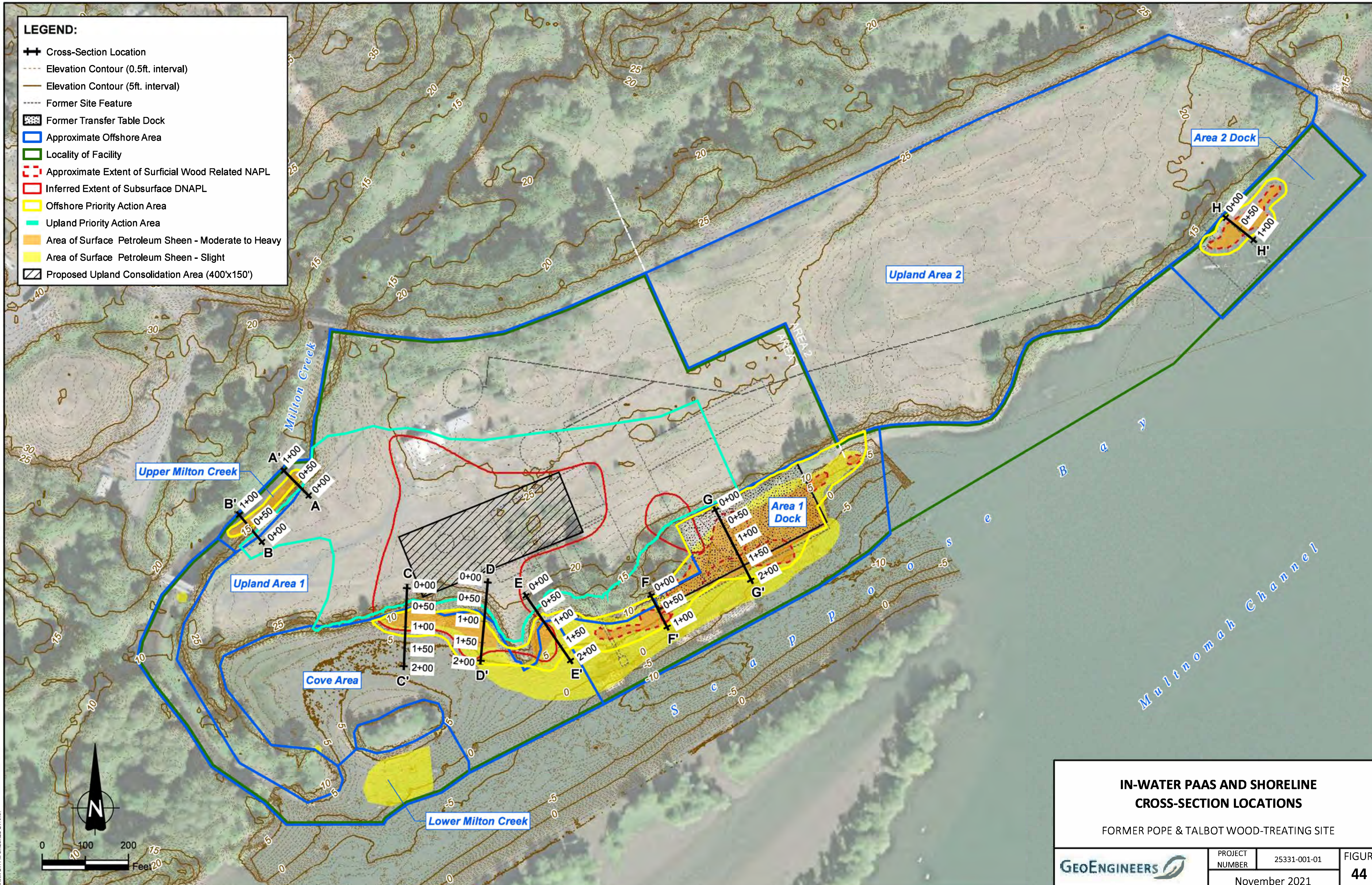
UPLAND PAA ALTERNATIVE 4 IMPERVIOUS SURFACE CAP & PERMEABLE REACTIVE BARRIER

FORMER POPE & TALBOT WOOD-TREATING SITE

GEOENGINEERS

PROJECT NUMBER	25331-001-01	FIGURE
	November 2021	43

K:\11000\11200\11220\112203\dwg_FS_2021\7-3 - Upland PAA Alternative 4.mxd - stephane.descombes - 5/3/2021 - 9:04:29 AM



IN-WATER PAAS AND SHORELINE CROSS-SECTION LOCATIONS

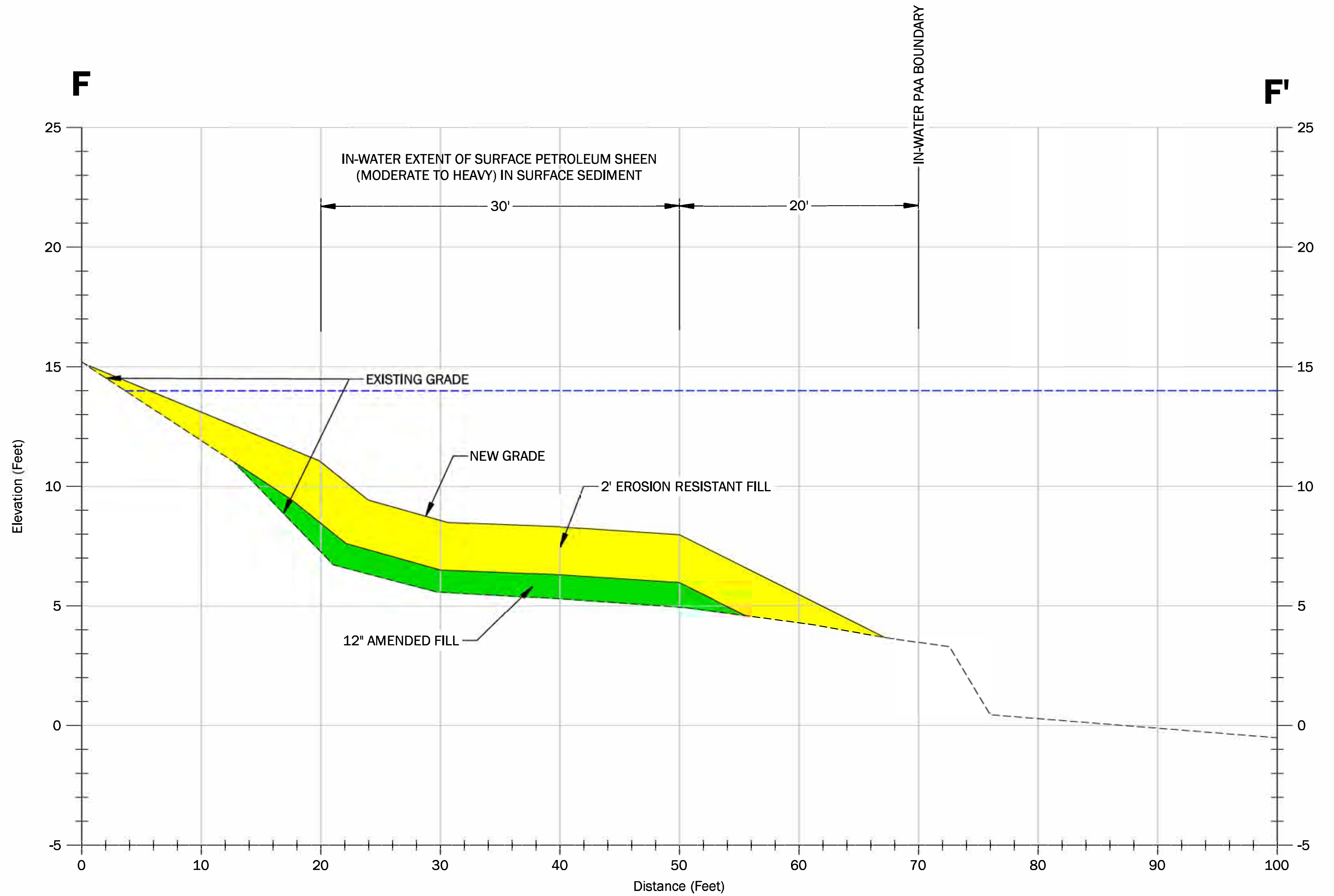
FORMER POPE & TALBOT WOOD-TREATING SITE

GeoEngineers

PROJECT NUMBER	25331-001-01	FIGURE
November 2021		44

DRAWN BY: PM CHECKED BY: JKH

K:\11000\11200\11220\112203\dwg_FS_2021\7-6 - In-Water PAAs and Shoreline.mxd - stephane.descombes - 4/28/2021 - 8:52:20 AM



Notes:

1. The subsurface conditions shown are based on interpolation between widely spaced explorations and should be considered approximate; actual subsurface conditions may vary from those shown.
2. This figure is for informational purposes only. It is intended to assist in the identification of features discussed in a related document. Data were compiled from sources as listed in this figure. The data sources do not guarantee these data are accurate or complete. There may have been updates to the data since the publication of this figure. This figure is a copy of a master document. The hard copy is stored by GeoEngineers, Inc. and will serve as the official document of record.

Vertical Datum: North American Vertical Datum of 1988 (NAVD88)

Legend

- Angular Riprap with Voids Filled by Smooth, Rounded Rock (e.g., Fish Mix)
- 50/50 Mixture of Sand and Organoclay
- Ordinary High Water Mark (14 ft.)

10 0 10
Horizontal Scale in Feet

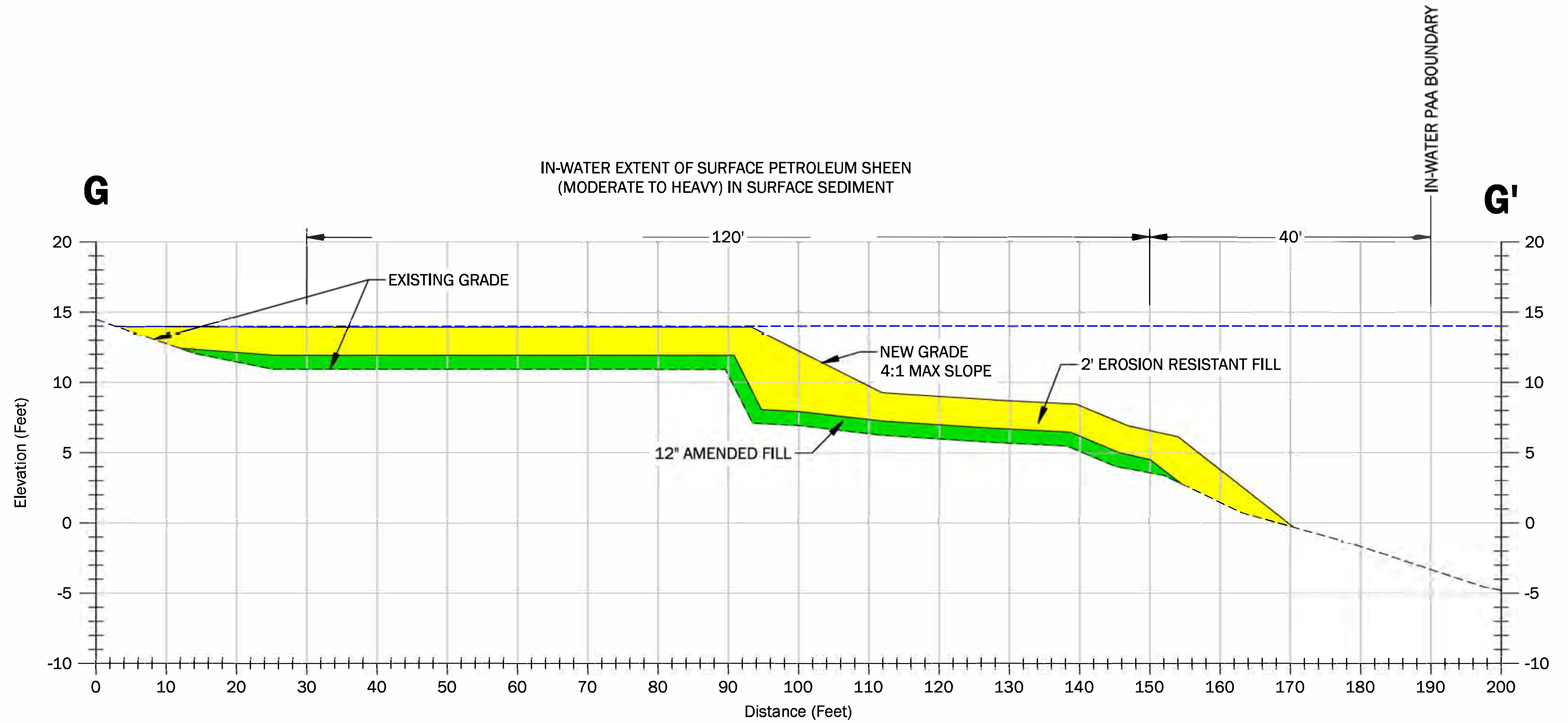
5 0 5
Vertical Scale in Feet
Vertical Exaggeration = 2X

Cross-Sections F-F'
Area 1 Dock - Alternative 2
Installation of Armored Reactive Cap

Former Pope & Talbot Wood Treating Site
St. Helens, Oregon

GEOENGINEERS

Figure 45A



Notes:

1. The subsurface conditions shown are based on interpolation between widely spaced explorations and should be considered approximate; actual subsurface conditions may vary from those shown.
2. This figure is for informational purposes only. It is intended to assist in the identification of features discussed in a related document. Data were compiled from sources as listed in this figure. The data sources do not guarantee these data are accurate or complete. There may have been updates to the data since the publication of this figure. This figure is a copy of a master document. The hard copy is stored by GeoEngineers, Inc. and will serve as the official document of record.

Vertical Datum: North American Vertical Datum of 1988 (NAVD88)

Legend

- Angular Riprap with Voids Filled by Smooth, Rounded Rock (e.g., Fish Mix)
- 50/50 Mixture of Sand and Organoclay
- Ordinary High Water Mark (14 ft.)

20 0 20
Horizontal Scale in Feet

10 0 10
Vertical Scale in Feet
Vertical Exaggeration = 2X

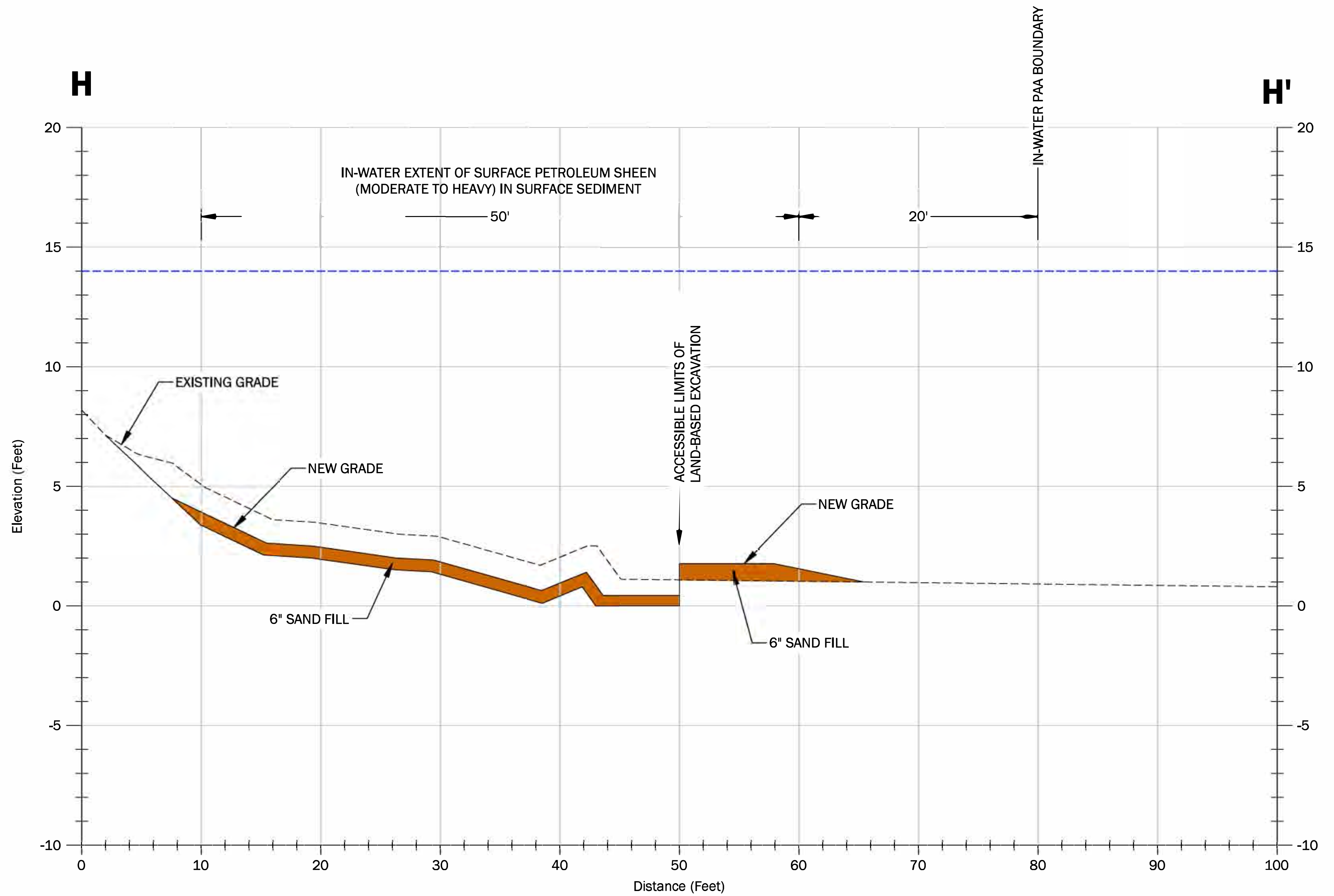
Cross-Section G-G'
Area 1 Dock - Alternative 2
Installation of Armored Reactive Cap

Former Pope & Talbot Wood Treating Site
St. Helens, Oregon

GEOENGINEERS

Figure 45B

\\geoengineers.com\WAN\Projects\25\2533100101\CAD\01\Feasability Study\2533100101_FOX_Sections.dwg 7-19 Date Exported:9/9/2022 6:38 PM - by Michael R. Woods



Notes:
1. The subsurface conditions shown are based on interpolation between widely spaced explorations and should be considered approximate; actual subsurface conditions may vary from those shown.
2. This figure is for informational purposes only. It is intended to assist in the identification of features discussed in a related document. Data were compiled from sources as listed in this figure. The data sources do not guarantee these data are accurate or complete. There may have been updates to the data since the publication of this figure. This figure is a copy of a master document. The hard copy is stored by GeoEngineers, Inc. and will serve as the official document of record.

Vertical Datum: North American Vertical Datum of 1988 (NAVD88)

Legend

Sand

Ordinary High Water Mark (14 ft.)

10 0 10
Horizontal Scale in Feet

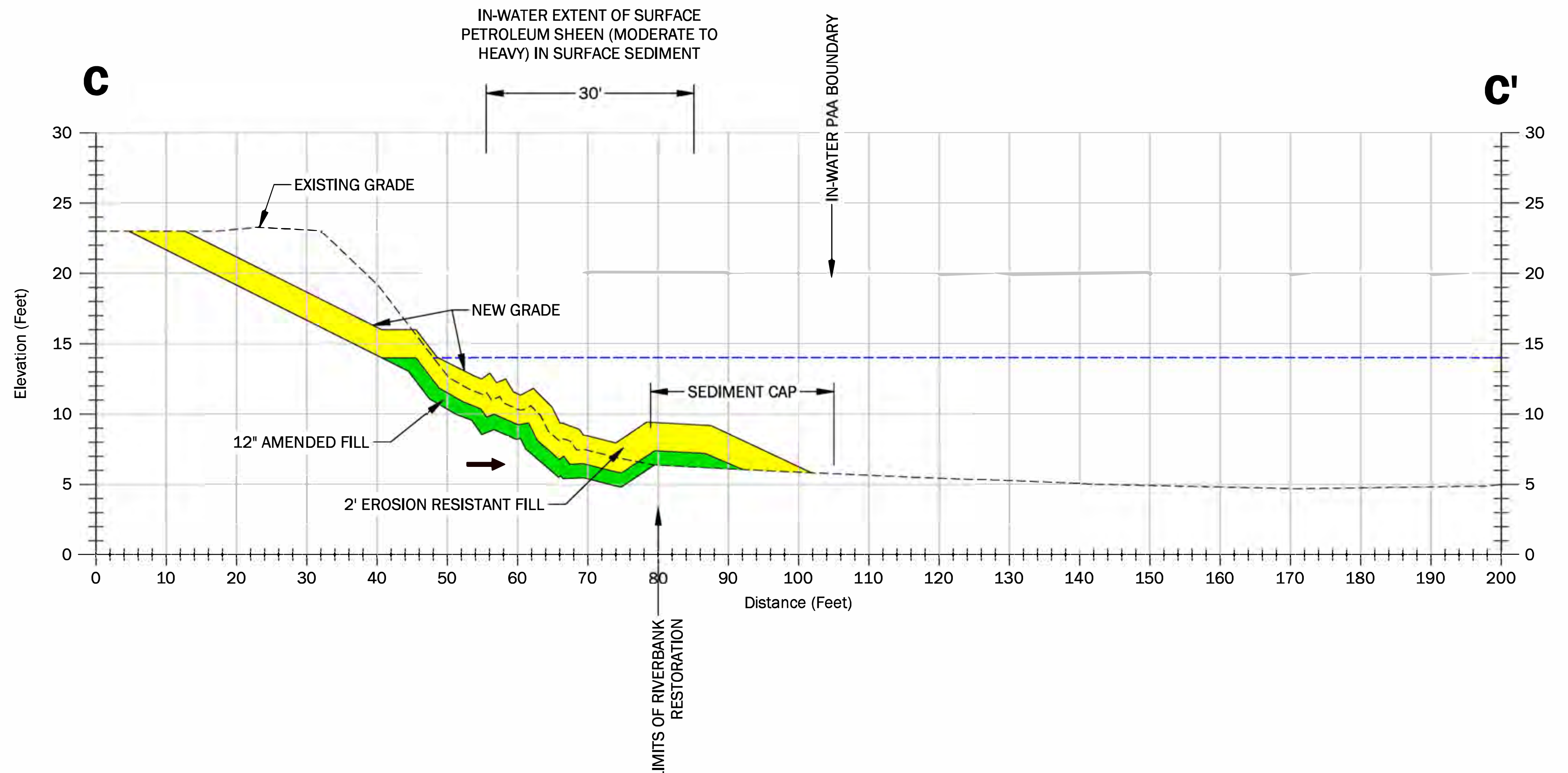
5 0 5
Vertical Scale in Feet
Vertical Exaggeration = 2X

Cross-Sections H-H'
Area 2 Dock - Alternative 4
Nearshore Removal, Cap Residuals

Former Pope & Talbot Wood Treating Site
St. Helens, Oregon

GEOENGINEERS

Figure 46



Notes:

1. The subsurface conditions shown are based on interpolation between widely spaced explorations and should be considered approximate; actual subsurface conditions may vary from those shown.
2. This figure is for informational purposes only. It is intended to assist in the identification of features discussed in a related document. Data were compiled from sources as listed in this figure. The data sources do not guarantee these data are accurate or complete. There may have been updates to the data since the publication of this figure. This figure is a copy of a master document. The hard copy is stored by GeoEngineers, Inc. and will serve as the official document of record.

Vertical Datum: North American Vertical Datum of 1988 (NAVD88)

Legend

- Angular Riprap with Voids Filled by Smooth, Rounded Rock (e.g., Fish Mix)
- 50/50 Mixture of Sand and Organoclay
- NAPL Seep
- Ordinary High Water Mark (14 ft.)

20 0 20
Horizontal Scale in Feet

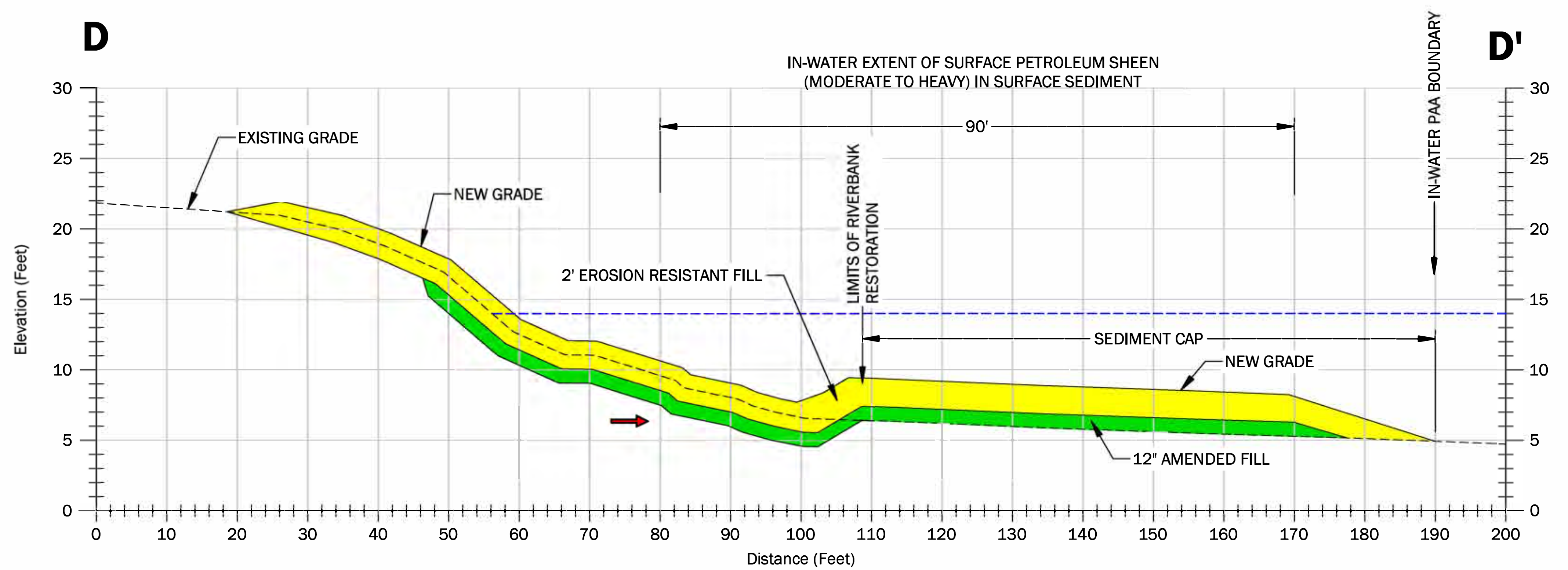
10 0 10
Vertical Scale in Feet
Vertical Exaggeration = 2X

Cross-Section C-C'
Cove Area - Alternative 4 - Riverbank Restoration, Armored Reactive Capping of Residuals

Former Pope & Talbot Wood Treating Site
St. Helens, Oregon

GEOENGINEERS

Figure 47A



Notes:
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Vertical Datum: North American Vertical Datum of 1988 (NAVD88)

Legend

- Angular Riprap with Voids Filled by Smooth, Rounded Rock (e.g., Fish Mix)
- 50/50 Mixture of Sand and Organoclay
- NAPL Seep
- Ordinary High Water Mark (14 ft.)

20 0 20
Horizontal Scale in Feet
10 0 10
Vertical Scale in Feet
Vertical Exaggeration = 2X

Cross-Section D-D'
Cove Area - Alternative 4 - Riverbank Restoration, Armored Reactive Capping of Residuals

Former Pope & Talbot Wood Treating Site
St. Helens, Oregon

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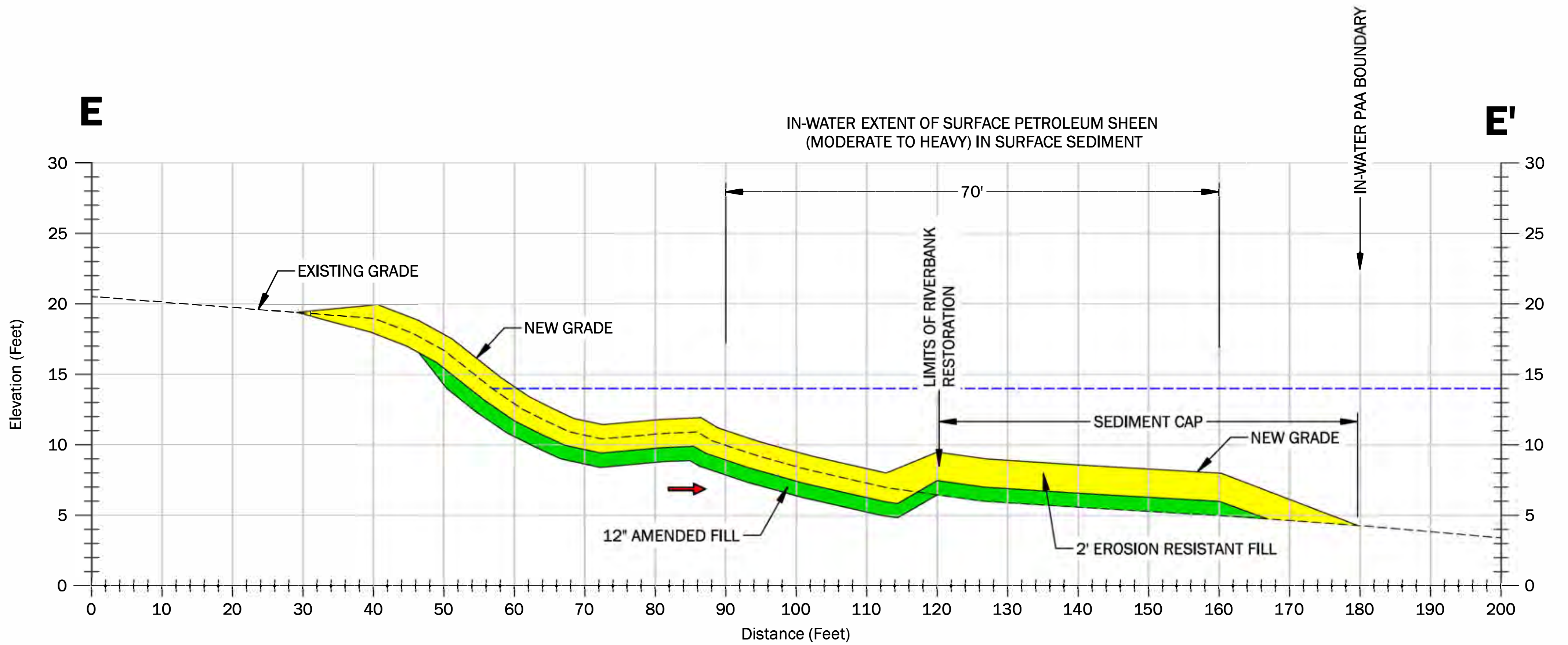
Figure 47B



Notes:

1. The subsurface conditions shown are based on interpolation between widely spaced explorations and should be considered approximate; actual subsurface conditions may vary from those shown.
2. This figure is for informational purposes only. It is intended to assist in the identification of features discussed in a related document. Data were compiled from sources as listed in this figure. The data sources do not guarantee these data are accurate or complete. There may have been updates to the data since the publication of this figure. This figure is a copy of a master document. The hard copy is stored by GeoEngineers, Inc. and will serve as the official document of record.

Vertical Datum: North American Vertical Datum of 1988 (NAVD88)

Legend

- Angular Riprap with Voids Filled by Smooth, Rounded Rock (e.g., Fish Mix)
- 50/50 Mixture of Sand and Organoclay
- NAPL Seep
- Ordinary High Water Mark (14 ft.)

20 0 20
Horizontal Scale in Feet
10 0 10
Vertical Scale in Feet
Vertical Exaggeration = 2X

Cross-Section E-E'
Cove Area - Alternative 4 - Riverbank Restoration, Armored Reactive Capping of Residuals

Former Pope & Talbot Wood Treating Site
St. Helens, Oregon

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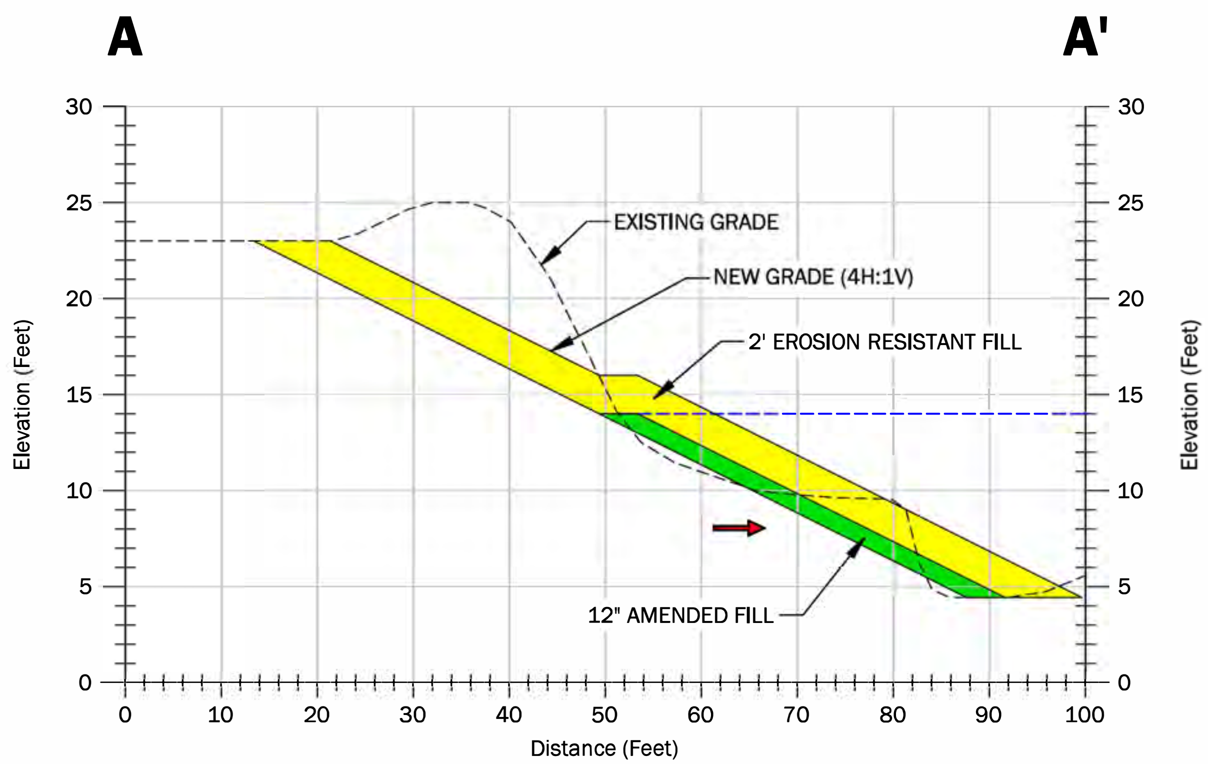
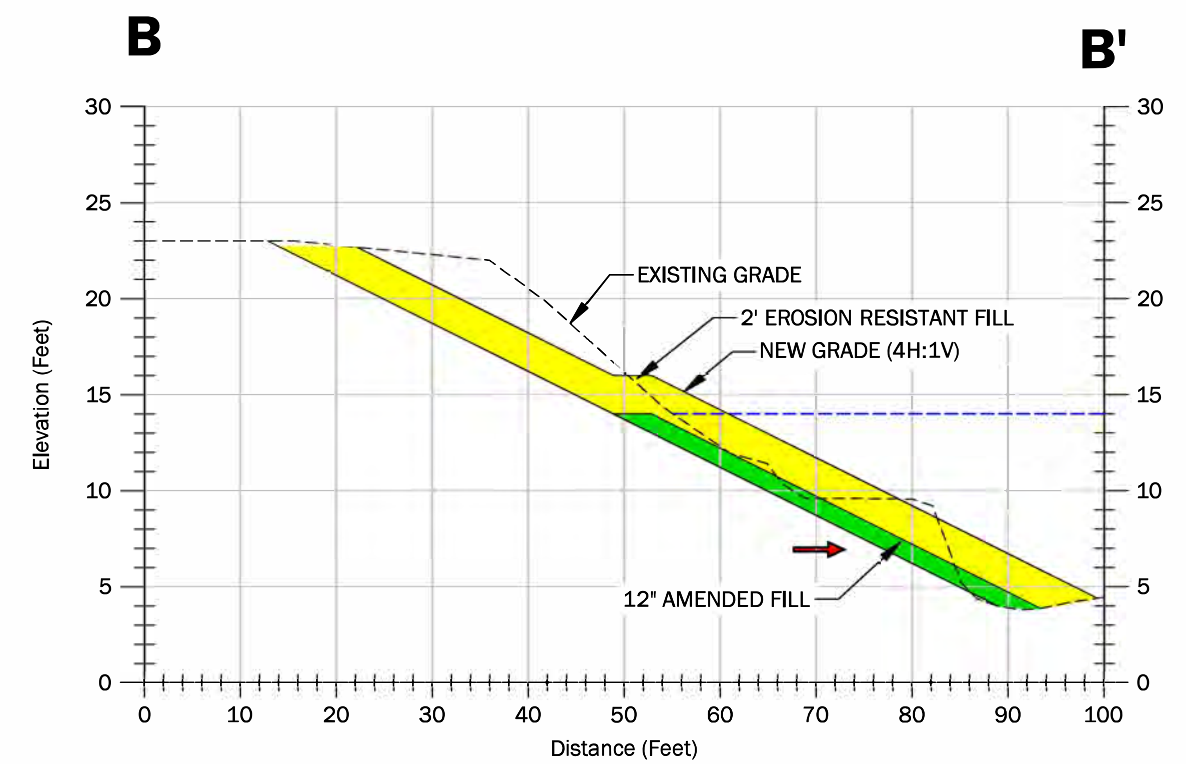
Figure 47C





Notes:

1. The subsurface conditions shown are based on interpolation between widely spaced explorations and should be considered approximate; actual subsurface conditions may vary from those shown.
2. This figure is for informational purposes only. It is intended to assist in the identification of features discussed in a related document. Data were compiled from sources as listed in this figure. The data sources do not guarantee these data are accurate or complete. There may have been updates to the data since the publication of this figure. This figure is a copy of a master document. The hard copy is stored by GeoEngineers, Inc. and will serve as the official document of record.

Vertical Datum: North American Vertical Datum of 1988 (NAVD88)

Legend

- Angular Riprap with Voids Filled by Smooth, Rounded Rock (e.g., Fish Mix)
- 50/50 Mixture of Sand and Organoclay
- NAPL Seep
- Ordinary High Water Mark (14 ft.)

20 0 20
Horizontal Scale in Feet

10 0 10
Vertical Scale in Feet
Vertical Exaggeration = 2X

Cross-Sections A-A' & B-B'
Upper Milton Creek - Alternative 4 Regrade Bank, Cap Residuals

Former Pope & Talbot Wood Treating Site
St. Helens, Oregon

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Figure 48

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