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Weldcraft Steel and Marine Site
Bellingham, Washington

Cleanup Action Plan

Issued by
Washington State Department of Ecology
Toxics Cleanup Program
Northwest Regional Office
3190 160th Avenue SE
Bellevue, Washington 98008-5452

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LIST OF ABBREVIATIONS AND ACRONYMS

AO .... Agreed Order
ARARs .... applicable or relevant and appropriate requirements
AS/SVE .... air sparge/soil vapor extraction
BTEX .... benzene, toluene, ethylbenzene, and total xylenes
CAP .... cleanup action plan
CD .... Consent Decree
COC .... constituent of concern
COPC .... constituent of potential concern
cPAH .... carcinogenic polycyclic aromatic hydrocarbon
CSL .... cleanup screening level
CSM .... Conceptual Site Model
CUL .... cleanup level
CY .... cubic yards
DCA .... disproportionate cost analysis
DMMP .... Dredge Material Management Program
DPE .... dual-phase extraction
Ecology .... Washington State Department of Ecology
HBU .... highest beneficial use
ft .... foot/feet
FS .... feasibility study
LNAPL .... light non-aqueous phase liquid
µg/kg .... micrograms per kilogram
mg/kg .... milligrams per kilogram
MTCA .... Model Toxics Control Act
PBT .... persistent, bioaccumulative toxin
Port .... Port of Bellingham
PQL .... practical quantitation limit
RAO .... remedial action objective
RCRA .... Resource Conservation and Recovery Act
RI .... remedial investigation
RCW .... Revised Code of Washington
RME .... reasonable maximum exposure
SCO .... sediment cleanup objective
SCUM .... Sediment Cleanup User’s Manual
Site .... Weldcraft Steel and Marine Site
SMS .... Sediment Management Standards
SQS .... sediment quality standard
TBT .... tributyltin

LIST OF ABBREVIATIONS AND ACRONYMS (CONTINUED)

TEQ .... toxicity equivalence
TPH-D .... total petroleum hydrocarbons as diesel
TPH-G .... total petroleum hydrocarbons as gasoline
UST .... underground storage tank
VOC .... volatile organic compound
WAC .... Washington Administrative Code

1.0 INTRODUCTION AND SITE BACKGROUND

This cleanup action plan (CAP) describes the cleanup action selected by the Washington State Department of Ecology (Ecology) for the Weldcraft Steel and Marine site (Site). This CAP is based on a remedial investigation/feasibility study (RI/FS; Landau 2015) prepared in accordance with an Agreed Order between Ecology and the Port of Bellingham (Port), as follows:

Site Name:	Weldcraft Steel and Marine
Site Location:	2652 North Harbor Loop Drive, Roeder Avenue, Bellingham, Washington
Facility Site Identification No.:	29583133
Cleanup Site ID:	1785
Agreed Order No.:	DE 03TCPBE-5623
Effective Date of Agreed Order	July 15, 2003
Parties to the Order:	Port of Bellingham
Current Property Owner:	Port of Bellingham

1.1 Site Location and Description

The Site is located in Bellingham, Washington in the northern corner of the Port's Squalicum Outer Harbor, as shown on Figure 1, and is defined by the limits of releases that occurred as a result of Weldcraft Steel and Marine's historical operations. This area is bounded approximately by the western limit of the former Dry Storage Yard to the east, Squalicum Way to the north, Squalicum Harbor to the west, and a parking lot to the south, as shown on Figure 2.

Weldcraft Steel and Marine's operations began at the Site in 1946 when it primarily operated as a boatyard. The Site currently consists of two large buildings (Buildings 1 and 2), several smaller buildings, open storage areas, parking lots, stormwater and washwater management systems, and until 2003, a marine railway. Current Site features are depicted on Figure 3. North of Building 1 is the location of a former gasoline underground storage tank (UST) and a former dispenser island pad that was used to dispense gasoline. The upland portion of the Site is approximately 2.5 acres in size and the in-water portion about 0.8 acres. Current and former Site features are described in greater detail in Section 1.3.

1.2 Regulatory Status

The Site is being cleaned up under the authority of the Model Toxics Control Act (MTCA), Chapter 70A.305 of the Revised Code of Washington (RCW), the MTCA Cleanup Regulation, Chapter 173-340 of the Washington Administrative Code (WAC), and under the requirements of the Washington State Sediment Management Standards (SMS). The Site cleanup action will be conducted under an Agreed Order (AO) between Ecology and the Port.

An AO was finalized between the Port and Ecology with an effective date of July 15, 2003. The scope of work under the AO was to complete a Site-wide final RI/FS and to complete an interim action for cleanup of Site sediment. An Interim Action Work Plan was included as an exhibit to the AO. The interim action construction work was completed in 2003 and 2004 and documented in an Ecology-approved Interim Action Completion Report (Landau 2006).

In February 2015, the Port completed the RI/FS for the Site (Landau 2015) in accordance with the above-referenced AO. The RI/FS report identified a preferred cleanup alternative, which is the basis for the final cleanup action presented in this CAP.

As specified in WAC 173-340-380, this CAP:

- Identifies Site cleanup standards
- Describes the selected cleanup action
- Summarizes the rationale for selecting the cleanup alternative for the Site
- Briefly summarizes other cleanup action alternatives evaluated in the RI/FS report (Landau 2015)
- Identifies institutional controls required as part of the cleanup action, if applicable
- Identifies applicable state and federal laws
- Provides the schedule for implementation of the cleanup action
- Specifies the types, levels, and amounts of hazardous substances remaining on Site, and the measures that will be used to prevent migration and contact with those substances.

The Site has been subdivided into three Site Units:

- The Former UST Site Unit
- The Work Yard Site Unit, and
- The Marine Site Unit.

The Site Units are discussed in Section 4.0 and shown on Figure 2. This CAP focuses on cleanup of the former UST Site Unit and the Work Yard Site Unit as the interim action conducted for the Marine Site Unit has addressed contaminated marine sediment. Compliance monitoring of post-interim action marine sediment quality indicates that the objectives of the interim action were met and further cleanup action is not required.

1.3 Site History and Background

Historical fire insurance maps from 1904 and 1913 show the Site area was originally undeveloped tidelands of Bellingham Bay. The Port has owned the property since 1927. In the 1920s, the Site uplands were filled with material dredged during construction of the Squalicum Waterway and from other upland sources of fill. By the 1940s and 1950s, various large businesses began operating in the fill areas along the waterway (Landau 2015).

Weldcraft Steel and Marine was established on the Site in 1946 and primarily operated as a boatyard that conducted various activities, including boat construction, repair, and maintenance; wood and metal fabrication; marine pipefitting; electrical work; sheet metal work; painting; machinery construction, installation, and repair; vessel haul-out and launching; lofting and pattern-making; canvas and plastic work; storage, brokerage, retail, and wholesale sales; and concrete work. The Port's lease with Weldcraft Steel and Marine was terminated in February 2000 and the Port obtained full operational control of the Site in July 2000. The Port entered into an AO with Ecology in 2003 to address cleanup of the Site.

The Site was identified as one of several cleanup sites in the Bellingham Bay Comprehensive Strategy final environmental impact statement (Anchor and PIE 2000) developed under the Bay-wide Demonstration Pilot. Ecology placed the Site on its Confirmed and Suspected Contaminated Sites List in 2001 and gave the Site the highest priority ranking of "1" under the Washington Ranking Method following completion of a Site Hazard Assessment in 2002.

Since April 2004, the Site has been leased to and occupied by Seaview Marine, operating as Seaview Boatyard North, a company that performs general boat repair activities. Seaview Boatyard North operates in compliance with its National Pollutant Discharge Elimination System boatyard permit and is not associated with the historical contamination being addressed under MTCA and SMS. A number of Site improvements have been completed since Seaview's tenancy, including installation of stormwater treatment systems and upgrades to existing infrastructure. Building 3 has been removed to its structural frame and slab. Seaview Boatyard North is planning to remove Buildings 1 and 2 to their slabs and use the slabs as a working surface for boat repairs. Seaview Boatyard North is also planning to construct a new building to support ongoing operations in the future, although the timing and location of these activities are uncertain.

1.4 Interim Action

An interim action was implemented in 2003 and 2004 to address marine sediment contamination identified during the 2000 and 2001 marine sediment remedial assessment. The interim action consisted of removing the marine railway, dredging about 6,800 cubic yards (CY) of contaminated marine sediment, and backfilling areas dredged to below the Port's authorized dredge depth with clean, imported gravelly sand. The interim action was documented in an Ecology-approved Interim Action Completion Report (Landau 2006).

Based on the results of 2004 and 2009 post-interim action marine sediment quality monitoring, it was concluded that sediment cleanup levels at that time were achieved by the interim action in conjunction with subsequent natural recovery. Sediment cleanup levels required re-evaluation to address human health and higher upper-trophic level species based on current information; Section 2.1.3 and Appendix A present the revised sediment cleanup level development.

1.5 Environmental Investigation and Conclusions

Environmental investigations at the Site began in the mid-1990s; a chronology of Site investigation activities is provided in Table 1. The Site RI/FS report was finalized in 2015 and identified the following constituents of potential concern (COPCs) and associated media:

- Gasoline- and diesel-range petroleum hydrocarbons; benzene, toluene, ethylbenzene, and total xylenes (BTEX); metals (i.e., copper, lead, mercury, nickel, and zinc); and volatile organic compounds (VOCs; i.e., trichloroethene) in soil
- Gasoline-range petroleum hydrocarbons, BTEX, and metals (i.e., copper, nickel, and zinc) in groundwater
- Tributyltin, metals (i.e., cadmium, copper, mercury, and zinc), and semivolatile organic compounds in pre-interim action marine sediment.

These COPCs were further evaluated during the Site RI/FS to eliminate those that did not exceed applicable cleanup levels or were not otherwise representative of Site conditions. The COPCs that remained from this evaluation process were identified as constituents of concern (COCs)[1] for the Site.

The identified Site COCs and their associated media are as follows:

- Benzene, ethylbenzene, o-xylene, metals (i.e., copper, lead, nickel, and zinc), and total petroleum hydrocarbons as gasoline (TPH-G) and as diesel (TPH-D) in soil
- Benzene, o-xylene, metals (i.e., copper, nickel, and zinc), and gasoline-range petroleum hydrocarbons in groundwater
- Mercury, zinc, acenaphthylene, fluorene, phenanthrene, fluoranthene, and dibenzofuran were carried forward in marine sediment, although the interim action achieved cleanup levels, as discussed below.

The RI/FS report also indicated that cleanup levels for persistent, bioaccumulative toxins (PBTs) protective of human health and higher trophic levels would be revisited in the CAP once regional background concentrations for PBTs in marine sediment had been evaluated for Bellingham Bay. Regional background concentrations for PBTs in Bellingham Bay were established in 2015 (Ecology 2015), which allowed for the development of marine sediment cleanup levels for PBTs and evaluation of Site marine sediment quality relative to new information for protection of human health and higher trophic levels. Cleanup standards for the identified COCs in soil, groundwater, and marine sediment are discussed further in Section 2.0.

Site surface water is not considered a medium of concern under current Site conditions provided that the cleanup action adequately addresses the affected groundwater to surface water pathway. Gasoline-affected soil and groundwater in the vicinity of the former UST represent the only Site release with the potential for affecting air quality. As a result, the potential for vapor intrusion through building floor slabs is addressed in the development of the cleanup action for Site soil and groundwater, and additional characterization of soil vapor will be conducted during remedial design for the final cleanup action.

[1] The term constituents of concern was used during completion of the RI/FS process for the Weldcraft Steel and Marine Site. In this context, constituents of concern equate to indicator hazardous substances as used in the current MTCA regulations.

2.0 CLEANUP STANDARDS

This section describes Site cleanup standards for COCs detected in affected Site media at concentrations above screening levels in the RI/FS. These affected media include soil and groundwater. As previously discussed, Site marine sediment was remediated through an interim action conducted during the RI/FS process, so additional remedial action is not required. However, based on new information, cleanup standards for marine sediment are developed in this section to document that Site sediment quality currently achieves marine sediment cleanup levels applicable to the Site.

Cleanup standards consist of: 1) cleanup levels (CULs) for hazardous substances at the Site (which are defined by regulatory criteria) that are adequately protective of human health and the environment and 2) the points of compliance at which the CULs must be met.

2.1 Cleanup Levels

The following subsections describe the methodology used to develop Site CULs for media of concern at the Site.

2.1.1 Groundwater

Based on the potential exposure pathways established and receptors discussed in the RI/FS report (Landau 2015), as illustrated by the Conceptual Site Model (CSM; Figure 4), the highest beneficial use (HBU) for groundwater is considered discharge to surface water (i.e., Bellingham Bay). Based on a groundwater HBU of discharge to Bellingham Bay, the reasonable maximum exposure (RME) for groundwater is the more conservative of 1) uptake by aquatic organisms based on aquatic water quality criteria, or 2) ingestion of affected aquatic organisms by humans. As a result, federal National Toxics Rule (40 CFR § 131.36) surface water criteria, based on human consumption of fish, and National Recommended Water Quality Criteria (EPA; accessed June 10, 2020) and state (MTCA Method B formula values and Chapter 173-201A WAC) surface water criteria, based both on human consumption of fish and protection of aquatic life, were evaluated as potential CULs for Site groundwater.

Surface water criteria for gasoline-range petroleum hydrocarbons were established in Ecology Implementation Memorandum No. 23 (Implementation Memo; Ecology 2021a). Protective values for gasoline-range petroleum hydrocarbons presented in the Implementation Memo (1,700 micrograms per liter [µg/L] for marine water and 1,000 µg/L for fresh water) are less conservative than the MTCA Method A groundwater CUL (800 µg/L) and existing data show that these constituents in groundwater do not extend to surface water, so MTCA Method A groundwater CULs were evaluated for this constituent. The groundwater to vapor pathway was also considered for VOCs due to the potential intrusion of soil vapor into Site buildings. Potential gasoline-range petroleum hydrocarbon vapor migration was evaluated using equations provided in MTCA and in Ecology’s draft guidance (Ecology 2018). The most stringent of the applicable criteria, adjusted to the practical quantitation limit (PQL) or background concentrations, if appropriate, is identified as the Site groundwater CUL. Groundwater CULs for the COCs identified for the Site are provided in Table 2.

2.1.2 Soil

Based on the potential exposure pathways established and receptors discussed in the RI/FS report (Landau 2015), as illustrated by the CSM (Figure 4), the HBU for soil is considered unrestricted site use. Although the Site may meet the criteria for industrial use, the Port does not want to restrict its future options for use of the Site. Based on a soil HBU of unrestricted site use, the RME for soil is the more conservative of 1) direct ingestion of soil or inhalation of soil vapors, or 2) impacts to surface water and the associated exposures described in the preceding section. The exception to this HBU determination is for soil CULs based on the vapor migration pathway, which is discussed in the following section.

Uptake of constituents in Site soil or groundwater by terrestrial plants and animals is not considered a potential exposure pathway for Site soil. The Site qualifies for an exclusion under WAC 173-340-7491(1)(c)(i) because there is less than 1.5 acres of contiguous undeveloped land within 500 feet (ft) of the Site, so a terrestrial ecological evaluation is not required.

Based on an HBU of unrestricted Site use, MTCA Method B standard formula values for direct contact and MTCA soil concentrations for surface water protection (calculated using the three-phase partitioning model [equation 747-1]), were evaluated as potential CULs for soil. In the event that a particular constituent did not have an associated MTCA Method B screening value, MTCA Method A CULs for unrestricted site use were identified as the soil CULs. MTCA soil criteria for protection of surface water were not applied if the COCs were not detected in groundwater at concentrations above the groundwater CUL. The most stringent of the applicable criteria, adjusted for soil background concentrations or the PQL, as appropriate, are identified as the Site soil CULs. CULs for the COCs identified in Site soil are provided in Table 2.

2.1.3 Sediment

The Washington State SMS (Chapter 173-204 WAC) provide a two-tiered approach for developing sediment CULs within an acceptable range of values. The lower limit of this range, the sediment cleanup objective (SCO)[2], is the contaminant concentration that represents the goal for protection of human health and the environment and the level below which no adverse effects to biological resources nor significant health threat to humans exists. The upper limit of the acceptable range is the cleanup screening level (CSL), which is the maximum allowable concentration to be achieved in any cleanup action under the SMS and is typically used to establish site boundaries. The CSL also represents the level for only minor adverse effects to biological resources, and a higher, but acceptable level of risk to humans and higher trophic levels. The CULs for marine sediment are typically set at the SCO, but could be increased to the CSL, at a maximum, if it is not technically possible to achieve and maintain the SCO and/or if meeting and maintaining the SCO would have a net adverse environmental impact on the aquatic environment.

The initially identified COCs for Site sediment include mercury, zinc, acenaphthene, fluorene, phenanthrene, fluoranthene, and dibenzofuran. The original CULs established for these sediment COCs

[2] Formerly the sediment quality standard (SQS).

were based on the benthic SCO (formerly the SQS). A two-phase sediment removal interim action was completed at the Site in 2004, followed by a planned period of natural recovery. In 2007, dredging at the Site was again conducted as part of the 2007 Squalicum Outer Harbor Gate 3 project. A-layer composite samples were collected adjacent to and within the vicinity of the Site to support the dredging program carried out under the US Army Corps of Engineers Dredge Material Management Program (DMMP). Additional compliance sampling was completed at the Site in 2009. The results of the two Site-specific compliance sampling events and the DMMP characterization activities demonstrated that sediment concentrations for Site COCs were below the CULs established for the Site at the time of monitoring.

Based on the potential exposure pathways identified in the final RI/FS report (Landau 2015), uptake by benthic organisms and ingestion of benthic organisms by humans and higher trophic levels were considered during re-evaluation of Site CULs for marine sediment. The current SMS require that marine sediment cleanup standards also consider the protection of human health and higher trophic levels for COCs that are considered PBTs. Based on the Sediment Cleanup User's Manual (SCUM; Ecology 2021b), cadmium, lead, mercury, carcinogenic polycyclic aromatic hydrocarbons (cPAHs), and tributyltin (TBT) are PBTs that were historically detected in Site marine sediment. As a result, the marine sediment cleanup standards for these PBTs were re-evaluated during preparation of this CAP to conform to current SMS regulations and SCUM guidance, and available Site marine sediment quality data were then compared to the revised PBT CULs to evaluate whether Site sediment conditions are adequately protective of human health and higher trophic levels as well as benthic organisms.

The basis for development of CULs for PBTs and the evaluation of Site marine sediment quality relative to these criteria are presented in a technical memorandum, which is included as Appendix A to this CAP. The Site CULs for PBTs, which are consistent with the values presented in Appendix A, are presented in Table 2. The following is a summary of the comparison of the CULs developed for PBTs detected in sediment to the most recent chemical-specific marine sediment data available for the Site:

- **Cadmium**: During the 2004 compliance monitoring event for the marine sediment interim action, all 12 samples had concentrations of cadmium below the CUL of 5.1 milligrams per kilogram (mg/kg), indicating that cadmium is not present in marine sediment at concentrations posing unacceptable risks to human health and the environment.
- **Mercury**: During the 2009 marine sediment sampling event conducted 5 years after the interim action, the nine samples (and one duplicate) analyzed for mercury had concentrations below the CUL of 0.41 mg/kg, indicating that mercury is not present in marine sediment at concentrations posing unacceptable risks to human health and the environment.
- **Lead:** Lead concentrations from samples collected during the 2004 Site compliance monitoring were under the CUL of 450 mg/kg established at the time of the monitoring event (i.e., the benthic SCO [formerly referred to as the SQS]). Since the samples collected during the 2004 compliance monitoring did not exceed the established CUL, lead was not analyzed for during subsequent compliance monitoring events conducted in 2009. However, lead concentrations from samples collected during the 2004 Site compliance sampling event compared to the calculated RBC for lead (discussed in the attached Appendix A, Section 5.1) were all below the current CUL of 89 mg/kg.

- **TBT (bulk)**: During the 2004 sampling event, the samples analyzed for TBT after the January and subsequent July removal events had concentrations below the CUL of 79 micrograms per kilogram (µg/kg), indicating that TBT is not present in sediment at concentrations posing unacceptable risks to human health and the environment.
- **cPAHs** toxicity equivalence (TEQ): During the 2009 sampling event, all nine samples (and one duplicate) analyzed for cPAHs had concentrations below the cPAH TEQ risk-based CUL of 496 µg/kg, indicating that cPAHs are not present in marine sediment at concentrations that pose unacceptable risks to human health and the environment.

Based on these results, Site CULs for marine sediment have been achieved throughout the Site for the PBTs detected in Site marine sediment, confirming that the marine sediment interim action achieved CULs for Site COCs in marine sediment, including PBTs. As a result, Site marine sediment does not require additional cleanup action.

2.1.4 Air

Gasoline-affected soil and groundwater in the vicinity of the former UST represent the only Site release with the potential for affecting air quality. As a result, vapor intrusion through building floor slabs is considered the only potential air exposure pathway for the Site. The vapor migration pathway is addressed in the development of Site soil and groundwater CULs above. As a result, air CULs were not developed for the Site.

2.2 Points of Compliance

Points of compliance at which the CULs must be met for the affected media at the Site are discussed in the following subsections.

2.2.1 Soil

The point of compliance for soil, as established in WAC 173-340-740(6), is throughout the Site. MTCA recognizes that for those cleanup actions that involve containment of hazardous substances, the soil CULs will typically not be met throughout the Site [WAC 173-340-740(6)(f)]. However, MTCA also recognizes that such cleanup actions may still comply with cleanup standards. The determination of the adequacy of soil cleanup is based on a remedial action alternative's ability to comply with groundwater cleanup standards for the Site, to meet performance standards designed to minimize human or environmental exposure to affected soil, and to provide practicable treatment of affected soil. Performance standards to minimize human and environmental exposure to affected soil may include institutional controls that limit activities that interfere with the protectiveness of the remedial action.

2.2.2 Groundwater

The points of compliance for groundwater are identified for the two areas of the Site exhibiting COC concentrations in groundwater above the CULs. As discussed in the following sections, a point of compliance is established for the former gasoline UST area and the area exhibiting metals contamination in groundwater in the vicinity of the shoreline.

2.2.2.1 Underground Storage Tank Site Unit

The point of compliance for groundwater is typically throughout the Site when the HBU is drinking water. However, Ecology can approve a point of compliance as close as practicable to the source, not to exceed the property boundary, if it is demonstrated that it is not practicable to meet the CULs throughout the Site within a reasonable restoration timeframe [WAC 173-340-720(8)(c)]. Based on the selected cleanup action, which includes containment/treatment of the source area (discussed in further detail in Section 4.0), a conditional point of compliance will be established for the UST Site Unit as close as practicable to the source area. The specific location of the point of compliance will be established during the design phase of the cleanup action.

2.2.2.2 Work Yard Site Unit

As discussed in the RI/FS report, the primary source of elevated zinc and nickel concentrations in groundwater near the shoreline appears to be dissolution (corrosion) of the galvanized coating on the bulkhead and associated tieback anchors that were installed during redevelopment of the Site in 2003/2004. Leaching of metals from soil contaminated by boat maintenance activities in the Site work yards is also a potential source. Elevated copper concentrations appear to be related to background surface water concentrations of copper in the marina. Copper is the only metal that has exceeded the groundwater CULs at the point of groundwater discharge to surface water (the bulkhead weep hole). Based on these considerations, the point of compliance for copper, nickel, and zinc for the Work Yard Site Unit is established at the shoreline. Because of the potential impact of surface water quality on groundwater near the shoreline, background surface water quality for metals will be taken into consideration when evaluating compliance with cleanup standards.

2.2.3 Sediment

In the Marine Site Unit, the point of compliance at which the CULs must be met is the predominant biologically active zone (upper 12 centimeters of sediment; current or future). For sediment CULs developed for the protection of benthic organisms, compliance is based on a point-by-point comparison between sediment quality data and the associated CULs. For the sediment CULs developed for PBTs, compliance is assessed based on area-wide mean concentrations, in accordance with SMS and the SCUM guidance (Ecology 2021b), since human health and higher trophic-level species have area-wide exposure scenarios.

3.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

In accordance with MTCA, cleanup actions conducted shall comply with applicable state and federal laws [WAC 173-340-710(1)]. MTCA defines applicable state and federal laws to include legally applicable requirements and those requirements that are relevant and appropriate. Collectively, these requirements are referred to as applicable or relevant and appropriate requirements (ARARs).

This section provides a brief overview of potential ARARs for the Site cleanup. The MTCA cleanup regulations (Chapter 173-340 WAC) and the SMS regulation (Chapter 173-204 WAC) are considered the governing regulations under which Site cleanup will be conducted, and as such are not considered ARARs. The primary ARARs that may be applicable to the cleanup action include the following:

- Washington Chemical Contaminants and Water Quality Act and Washington Water Pollution Control Act and the following implementing regulations: Water Quality for Surface Waters (Chapter 173-201A WAC) and SMS (Chapter 173-204 WAC)
- Resource Conservation and Recovery Act (RCRA) and Subtitle C regulations, to the extent that any hazardous wastes are discovered during the cleanup action
- Washington Hazardous Waste Management Act and Dangerous Waste Regulations, to the extent that any dangerous wastes are discovered during implementation of the cleanup action
- Clean Water Act, with respect to water quality criteria for surface water (Bellingham Bay)
- Shoreline Management Act, with respect to construction activities during the cleanup action
- Critical Areas Ordinance of the City of Bellingham (Bellingham Municipal Code Chapter 16.55 Critical Areas)
- Northwest Clean Air Agency Regulation 300 for point source emissions.

MTCA, Water Quality Standards for Surface Waters, SMS, and the Clean Water Act were considered in the development of cleanup standards (see Section 2.0). RCRA Subtitle C and Dangerous Waste Regulations are not expected to apply unless dangerous wastes are discovered or generated during implementation of the cleanup action; dangerous wastes are not known to be present at the Site. The Shoreline Management Act may apply during the implementation of the selected cleanup action but did not directly influence the evaluation of the cleanup alternatives conducted in the RI/FS.

In accordance with MTCA, the cleanup action will be exempt from the procedural requirements of Chapters 70A.15, 70A.205, 70A.300, 77.55, 90.48, and 90.58 RCW, and of any laws requiring or authorizing local government permits or approvals. However, the substantive requirements of such permits or approvals (WAC 173-340-520) must be met.

4.0 SELECTED CLEANUP ACTION

This section discusses the cleanup action alternatives evaluated and the preferred alternative identified in the FS and provides an overview of the selected cleanup action. The disproportionate cost analysis (DCA), completed as part of the FS, is included as Figure 5. The Site's cleanup action described below addresses the UST Site Unit and the Work Yard Site Unit. Because a permanent cleanup action has already been implemented at the Marine Site Unit, this area of the Site complies with cleanup requirements and no further remedial action is required.

4.1 Preferred Alternative Selection

Four cleanup action alternatives were evaluated in the Site FS. Cleanup alternatives were developed for each Site Unit using one or more of the technologies described in detail in the FS (Landau 2015). An overview of the four remedial alternatives evaluated includes the following:

- Remedial Alternative 1 – Containment with Source Recovery
  - Recovery of light non-aqueous phase liquid (LNAPL) with intermittent dual-phase extraction (DPE) methods, if LNAPL is present in recoverable quantities (UST Site Unit)
  - Containment of gasoline-range petroleum hydrocarbon and VOC-contaminated soil (i.e., BTEX), with soil vapor control if needed to manage affected soil vapor (UST Site Unit)
  - Containment of metals-contaminated soil (Work Yard Site Unit)
  - Groundwater and soil vapor compliance monitoring (Site Wide)
  - Institutional controls to maintain containment layer, restrict groundwater use, and manage potentially contaminated soil and groundwater disturbed during future intrusive activities (Site Wide).
- Remedial Alternative 2 – Containment with *In Situ* Treatment and Source Recovery
  - *In situ* treatment of gasoline-range petroleum hydrocarbon- and VOC-contaminated soil (i.e., BTEX) and groundwater using air sparge/soil vapor extraction (AS/SVE; UST Site Unit)
  - Recovery of LNAPL with intermittent DPE methods, if LNAPL is present in recoverable quantities (UST Site Unit)
  - Containment of metals-contaminated soil (Work Yard Site Unit)
  - Groundwater and soil vapor compliance monitoring (Site Wide)
  - Institutional controls to maintain containment layer and the AS/SVE treatment system, restrict groundwater use, and manage potentially contaminated soil and groundwater disturbed during future intrusive activities (Site Wide).
- Remedial Alternative 3 – Containment with Focused Source Removal
  - Excavation and offsite disposal of gasoline-range petroleum hydrocarbon and VOC- (i.e., BTEX) contaminated soil (UST Site Unit) within the area identified for the potential presence of LNAPL

- Placement of oxygen-release compound within excavation backfill to enhance treatment of any remaining contaminated soil or groundwater
- Backfill excavations with clean fill, grading, and paving consistent with Site use (UST Site Unit)
- Containment of residual gasoline-range petroleum hydrocarbon/VOC- (i.e., BTEX) contaminated soil, if needed (UST Site Unit)
- Monitored natural attenuation of residual gasoline-range petroleum hydrocarbon-contaminated groundwater, if needed (UST Site Unit)
- Containment of metals-contaminated soil (Work Yard Site Unit)
- Soil, groundwater, and soil vapor compliance monitoring (Site Wide)
- Institutional controls to maintain containment layer, restrict groundwater use, and manage potentially contaminated soil and groundwater during future intrusive activities (Site Wide).

- Remedial Alternative 4 – Site-Wide Source Removal
  - Excavation and offsite disposal of soil contaminated with metals, gasoline-range petroleum hydrocarbons, and VOCs (Site Wide)
  - Backfill excavations with clean fill, grading, and paving consistent with Site use (Site Wide)
  - Soil, groundwater, and soil vapor compliance monitoring (Site Wide)
  - Institutional controls to restrict groundwater use (Site Wide, or as needed).

Alternative 1 was identified as the preferred alternative in the FS and is the selected cleanup action for the Site. The rationale for the selection is presented in Section 5.0.

4.2 Areas Subject to Cleanup

The selected cleanup action consists primarily of containment of gasoline-range petroleum hydrocarbon- and VOC-contaminated soil with soil vapor control and source removal (intermittent DPE of LNAPL), if present for the UST Site Unit; containment of metals-contaminated soil in the Work Yard Site Unit), and compliance monitoring and institutional controls for the entire Site (i.e., the UST and Work Yard Site Units). Figure 6 shows where these cleanup action elements will be applied.

4.3 Description of the Selected Cleanup Action

The selected cleanup action (Alternative 1) consists of using and maintaining the existing asphalt layer and building slabs on Site, installing new asphalt pavement in the North Work Yard (see Figure 6), and installing and/or repairing/replacing additional asphalt, where needed, to prevent human contact with contaminated soil, and to reduce the potential for stormwater infiltration. If a practicably recoverable quantity of LNAPL is identified during additional investigation in support of the remedial design within the UST Site Unit, intermittent DPE will be implemented to recover free-phase product. In addition, pending the results of the soil vapor survey to be conducted during the remedial design phase, this alternative includes installation of a vapor capture/control trench to help manage potential vapor migration from the area of the UST Site Unit, as shown on Figure 6. The following subsections describe how the selected cleanup action would be implemented and how the remedial action objectives (RAOs) will be achieved, as applicable.

4.3.1 Underground Storage Tank Site Unit

The selected cleanup action consists of addressing the potential presence of recoverable LNAPL using intermittent DPE methods, and containing gasoline-range petroleum hydrocarbon and VOC-impacted soil in the UST Site Unit, with soil vapor control, compliance monitoring, and institutional controls. The primary elements of the cleanup action for affected media within the UST Site Unit are:

- Soil
  - Containment by repairing/replacing existing asphalt pavement (as needed) and maintaining existing pavement cover to prevent potential human exposure to contaminated soil and to reduce infiltration to minimize leaching of contaminants in the unsaturated zone.
  - LNAPL recovery using intermittent DPE, if LNAPL is established to be present in practicably recoverable quantities during additional investigation to support remedial design.
  - Institutional controls (restrictive covenants) on the property to 1) require maintenance of the Site's containment layer discussed above, and 2) properly manage excavated soil and appropriate worker safety associated with future intrusive activities through implementation of a soil and groundwater management plan.
  - Compliance monitoring to ensure that the Site's containment layer is adequately maintained and functioning properly.
- Groundwater
  - LNAPL recovery using intermittent DPE, if LNAPL is established to be present in practicably recoverable quantities during additional investigation to support remedial design.
  - Repairing/replacing existing asphalt pavement (as needed) and maintaining the existing pavement containment layer to reduce infiltration, minimize leaching of contaminants in the unsaturated zone to groundwater, and reduce the rate of groundwater flow.
  - Institutional controls (restrictive covenants) on the property to 1) prevent the use of Site groundwater for drinking water, and 2) properly manage groundwater extracted for other uses such as construction dewatering through implementation of a soil and groundwater management plan.
  - Groundwater compliance monitoring (protection, performance, and confirmational monitoring) to demonstrate that groundwater cleanup standards are achieved and maintained. A groundwater compliance monitoring plan will be developed as part of the Engineering Design Report, following collection of groundwater data during the pre-remedial design investigation activities. It is anticipated that groundwater monitoring in select Site groundwater monitoring wells will occur no less frequently than a semi-annual basis; specific sampling locations, duration, and frequency will be recommended in the groundwater compliance monitoring plan included in the Engineering Design Report, and may be able to be reduced after consultation with Ecology if data appear to indicate that a reduction in scope is warranted.

- Indoor/Outdoor Air
  - If determined to be necessary during remedial design, installation of a soil vapor control (active or passive) system to control potential impacts of vapor into buildings at the Site and offsite migration of soil vapor.
  - If a soil vapor control system is installed, institutional controls to properly manage extracted vapors and/or containment if applicable and to monitor effectiveness of the system.
  - Compliance monitoring to ensure that migration of soil vapors at concentrations that could impact indoor air quality at buildings located at the Site and/or neighboring property/offsite buildings does not occur.

For the selected cleanup action, the existing pavement surface and Site building slabs will be utilized as the soil containment layer, as shown on Figure 6. The purpose of the soil containment layer is to provide a physical barrier to human contact with contaminated soil and to minimize stormwater infiltration and leaching of petroleum hydrocarbon contamination and VOCs from unsaturated soil to Site groundwater. Reducing groundwater recharge, via the installation and maintenance/repair of a low-permeability pavement layer will also help maintain the stability or potentially reduce the size of the affected groundwater plume.

During the remedial design, an investigation will be conducted to determine if LNAPL is present within the UST Site Unit in practicably recoverable quantities. If the presence of recoverable LNAPL is confirmed, intermittent DPE will be included in the final cleanup action to remove recoverable free-phase product. The number and location of wells necessary, and the frequency between DPE sessions, will be determined during the remedial design phase. It was assumed for conceptual design purposes that recoverable LNAPL is present within the area defined by the 300 mg/kg gasoline contour and in areas that exhibited a gasoline-like odor during boring investigations as the potential LNAPL treatment zone, as shown on Figure 6. It was also assumed for conceptual design that LNAPL recovery would require eight wells.

If the remedial design investigation determines that LNAPL is not present in practicably recoverable quantities, the implementation of a focused bioremediation program will be evaluated. Recent improvements and success of bioremediation have been shown at other similar sites and may provide a more expedited cleanup timeframe for residual groundwater contamination. A focused bioremediation program would be implemented in place of LNAPL recovery and at a similar cost that would not affect the cost/benefit (DCA) conclusions.

If soil vapor characterization monitoring conducted during the remedial design phase indicates that vapor control is needed to prevent benzene and other VOCs from migrating to buildings at the Site or across Squalicum Way at concentrations that pose an unacceptable risk to human health, a vapor control and capture system would be installed along the north side of the UST Site Unit, as shown on Figure 6. The specific configuration of the vapor control system would be developed during remedial design. For the purposes of conceptual design, it was assumed that the vapor control system would consist of a 150-ft-long trench backfilled with pea gravel or similar material over a perforated pipe connected to a low-flow vacuum system to intercept soil vapor. The need for air emission treatment would be determined during remedial design.

Institutional controls will be required to ensure that the soil containment layer at the Site will be protected and maintained. The institutional controls will also prohibit the use of Site groundwater as a potable water supply and require, through the implementation of a soil and groundwater management plan, that proper safety measures and soil and groundwater management practices are implemented as part of any project involving intrusive activities within the UST Site Unit, in accordance with WAC 173-340-440. The institutional controls would be conveyed as a restrictive covenant on the property.

The point of compliance for gasoline-range petroleum hydrocarbons will be established at existing and new monitoring wells. The number and locations of compliance monitoring wells will be determined during remedial design.

4.3.2 Work Yard Site Unit

The selected cleanup action for the Work Yard Site Unit consists of containment of metals-impacted soil. Groundwater is assumed to be potentially contaminated with metals throughout the Work Yard Site Unit, although available data indicate that metals groundwater contamination is limited to the vicinity of the galvanized steel bulkhead at the shoreline. Containment will be achieved by installing new asphalt pavement in the North Work Yard, repairing/replacing existing asphalt pavement (as needed), and maintaining the existing pavement cover and building slabs to prevent direct contact with and to limit stormwater infiltration through soil contaminated, or potentially contaminated, with metals. Institutional controls will be implemented to ensure the containment layer is properly maintained and repaired, as needed, to prevent exposure to Site construction workers. The containment areas for the Work Yard Site Unit are shown on Figure 6.

In addition to the physical remediation elements, groundwater compliance monitoring will be conducted per Section 4.3.1 and the forthcoming groundwater compliance monitoring plan, and institutional controls in the form of a restrictive covenant will be established. Groundwater compliance monitoring will be conducted at a conditional point of compliance at the shoreline. The restrictive covenant will require that an asphalt containment layer be protected and maintained or replaced by an equivalent low-permeability surface and will prohibit extraction of groundwater for use as a potable water supply. The restrictive covenant will also require the implementation of a soil and groundwater management plan, as described in the previous section. The containment layer will be inspected on an annual basis to ensure its integrity, and will be repaired, as necessary.

4.4 Institutional Controls

Institutional controls will be applied to the UST and Work Yard Site Units. These controls will include an Institutional Controls Plan (including containment/asphalt pavement inspection and repair requirements and a soil and groundwater management plan) and a restrictive covenant. The restrictive covenant will be filed as a deed restriction(s) with Whatcom County, will be binding on the owner's successors and assignees, and will impose limits on property conveyance. The restrictive covenant(s) will be part of the Institutional Controls Plan [WAC 173-340-440(9) and Chapter 64.70 RCW].

Restrictive covenant provisions applicable to the UST and Work Yard Site Units will prevent activities that could compromise the integrity of the cleanup action (i.e., containment) or otherwise result in unacceptable risks to human health or the environment. The restrictive covenant will prevent the use of groundwater for potable purposes and will place restrictions and management requirements on intrusive activities that could result in releases of hazardous substances or exposure of construction workers to contaminated media.

The Institutional Controls Plan will outline long-term care and maintenance of the elements comprising the cleanup action such as the pavement cover, outline the requirements for soil and groundwater management at the Site, establish protocols for intrusive activities, provide for record keeping and reporting, and describe any other activities necessary to maintain protection of human health and the environment.

4.5 Types, Levels, and Amounts of Hazardous Substances to Remain in Place

The extent of gasoline-range petroleum hydrocarbon- and VOC-impacted soil associated with the UST Site Unit was evaluated during the investigations conducted to support the RI/FS. The extent of contaminated soil within the UST Site Unit was conservatively estimated based on interpretation of boring logs and Site analytical data. Based on the estimated areal extent and thickness of impacted soil within the UST Site Unit, the total volume of gasoline-range petroleum hydrocarbon- and VOC-impacted soil is 3,200 CY. Of this volume, up to 1,700 CY could contain some volume of LNAPL. However, the potential presence of LNAPL associated with gasoline-range petroleum hydrocarbons will be evaluated during the pre-design investigation conducted to support the remedial design. Because the cleanup action relies on containment, this volume of impacted soil will remain-in-place following implementation of the cleanup action. However, the selected cleanup action includes intermittent DPE, as needed, which, if implemented, will reduce the amount of gasoline-range petroleum hydrocarbons remaining within the UST Site Unit through source recovery.

The volume of metals-contaminated soil associated with the Work Yard Site Unit was estimated in the RI/FS report to be approximately 4,600 CY. This impacted soil volume was assumed to be the upper 2 ft of soil within the Work Yard Site Unit, which represents a conservatively high volume estimate. Based on the cleanup action relying on containment as the primary cleanup technology for the Work Yard Site Unit, this volume of impacted soil will remain-in-place following implementation of the cleanup action.

4.6 Restoration Time Frame

The restoration time frame for the cleanup action following finalization of the CAP is anticipated to require approximately 2 years until sufficient LNAPL removal is achieved (if minimal LNAPL is observed during the pre-remedial design investigation phase and is determined to be applicable to the remedy design). This time frame does not include the pre-design investigations that will be conducted, or design and construction of the remedial design. Groundwater compliance monitoring will be conducted to demonstrate compliance with groundwater cleanup standards for both the UST and Work Yard Site Units. The need for additional compliance monitoring will be evaluated after the first 2 years of post-construction groundwater compliance monitoring to determine the required continued frequency of monitoring, if appropriate.

5.0 RATIONALE FOR SELECTED CLEANUP ACTION

The four cleanup alternatives presented in the FS were evaluated with respect to their ability to adequately achieve compliance with MTCA threshold criteria [WAC 173-340-360(2)(a)], including each alternative's ability to protect human health and the environment, comply with cleanup standards, comply with state and federal laws, and provide for compliance monitoring. Compliance with these requirements under MTCA is presumed by definition to be protective of human health and the environment and in compliance with applicable state and federal laws once cleanup standards have been met. The alternatives were further evaluated for their ability to satisfy these threshold criteria within a reasonable time frame [WAC 173-340-360(2)(b)(ii) and WAC 173-340-360(4)] and achieve the RAOs identified for the Site. All four alternatives were determined to meet these requirements.

MTCA provides for the costs and benefits associated with alternatives to be evaluated through a DCA, which compares the relative environmental benefits of each alternative against the most permanent alternative. Costs are disproportionate to benefits if the incremental cost of the most permanent alternative exceeds the incremental degree of benefits achieved over the lower cost alternative [WAC 173-340-360(3)(e)(i)]. Alternatives that exhibit disproportionate costs are considered "impracticable," and those alternatives are eliminated from further consideration. The six evaluation criteria for the DCA are:

- Protectiveness
- Permanence
- Long-term effectiveness
- Short-term risk management
- Implementability
- Considerations of public concerns.

Based on the results of the DCA, Alternative 1 was determined to be permanent to the maximum extent practicable. More detailed information on the alternatives evaluation and the DCA process is included in the Site RI/FS report (Landau 2015) and the results are illustrated on Figure 5.

The selected cleanup action complies with the provisions of WAC 173-340-360. It will be protective of human health and the environment, comply with cleanup standards and applicable state and federal laws, provide for compliance monitoring, and establish restrictive covenants. Impacted soil with hazardous substance concentrations that exceed CULs will be contained. Institutional controls will provide notification regarding the presence of residual contaminated soil and groundwater, regulate the disturbance/management/use of that soil/groundwater and the cleanup action components, and provide for long-term monitoring and stewardship of the cleanup action. The selected cleanup action is also considered to use permanent solutions to the maximum extent practicable, and to provide for a reasonable restoration time frame.

6.0 COMPATIBILITY WITH SITE LAND USE

Implementation of the cleanup action will be coordinated with the longer-term redevelopment strategy for the Site. The current Site tenant, Seaview Boatyard North, has been implementing improvements to Site infrastructure since its tenancy at the Site. The tenant's redevelopment plan calls for the existing building structures to be demolished and leaving the building slabs intact as the working surface for boat maintenance activities. Because of the open height within the existing Site buildings, pre-design investigation and implementation of the selected cleanup action could be conducted within the buildings, if necessary. As a result, implementation of the cleanup action is not dependent on the prior removal of the buildings to their floor slabs.

If there is a change to the remedy proposed in this CAP, it may require a formal amendment to this CAP and associated future AO or Consent Decree (CD) depending on the scope and scale of any proposed change.

7.0 CLEANUP ACTION SCHEDULE

A new AO or CD will be developed to support design and construction of the Site remedy. Because many of the project deliverables and other project milestones are contingent on the completion, review, and approval of preceding project tasks, the project schedule will be a living document that will require periodic updating during implementation of the cleanup action.

Anticipated key milestones for the project include the following:

- New AO for pre-design investigation, Engineering Design Report, and 90 percent/100 percent plans and specifications.
- Following completion of a new AO, Ecology and the Port anticipate entering into a CD for cleanup construction.
- Construction anticipated between 2026 and 2028 in coordination with land use and operational planning.

8.0 REFERENCES

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Map from Maptech Terrain Navigator 2002

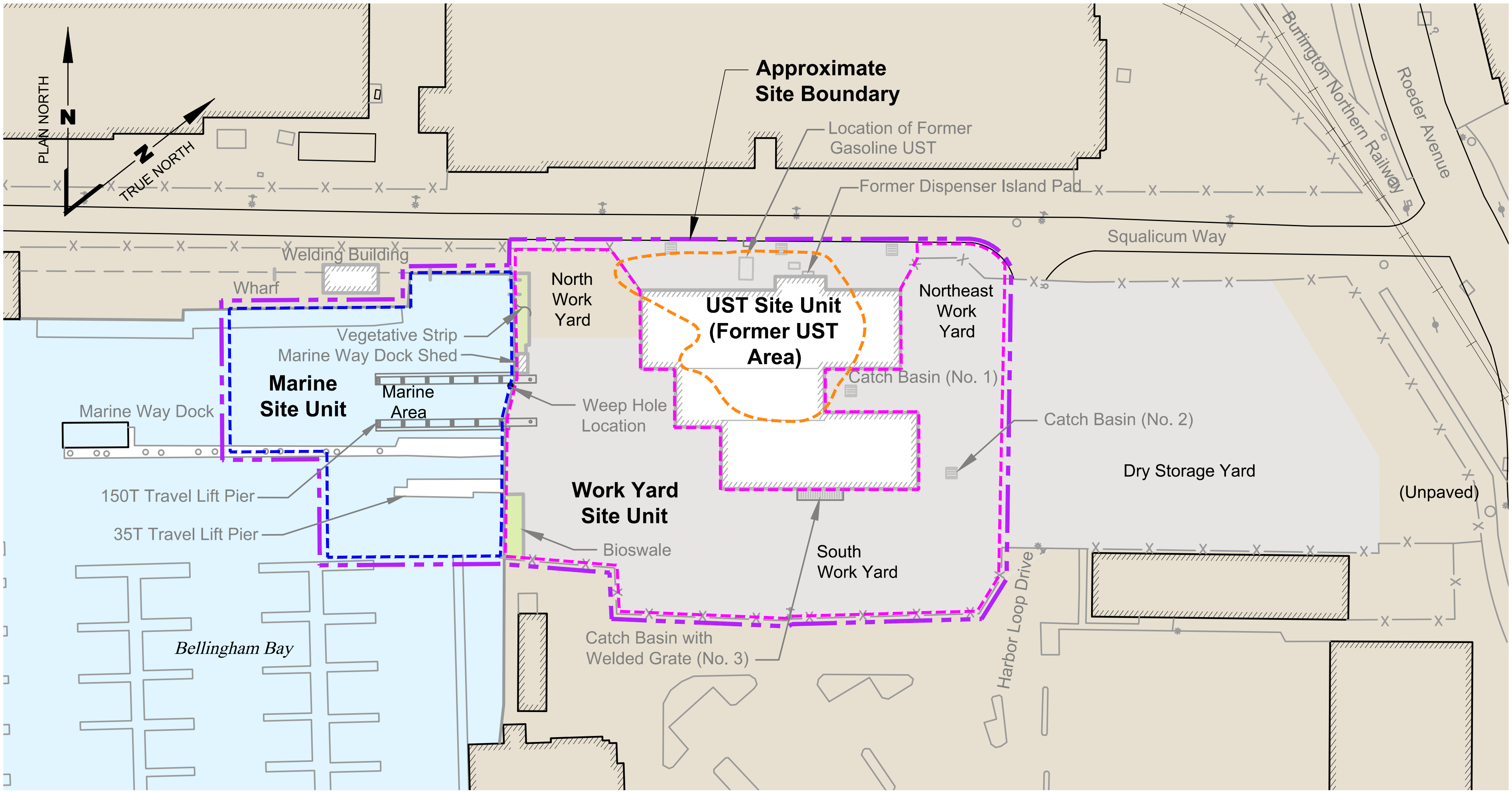
Landau Associates

Port of Bellingham
Weldcraft Steel and Marine
Bellingham, Washington

Vicinity Map

Figure 1

Landau Associates | G:\Projects\001\024\200\310\CAP\F02 SitePlan.dwg | 5/15/2020 12:50 PM | EZICK



Legend

- Catch Basin
- Pilings
- Upland Area
- Bellingham Bay
- On-site Paved Surfaces
- Fence
- Railroad
- Building Footprint
- Approximate Site Boundary
- Work Yard Site Unit Boundary
- UST Site Unit Boundary
- Marine Site Unit Boundary

0 120 240

Scale in Feet

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

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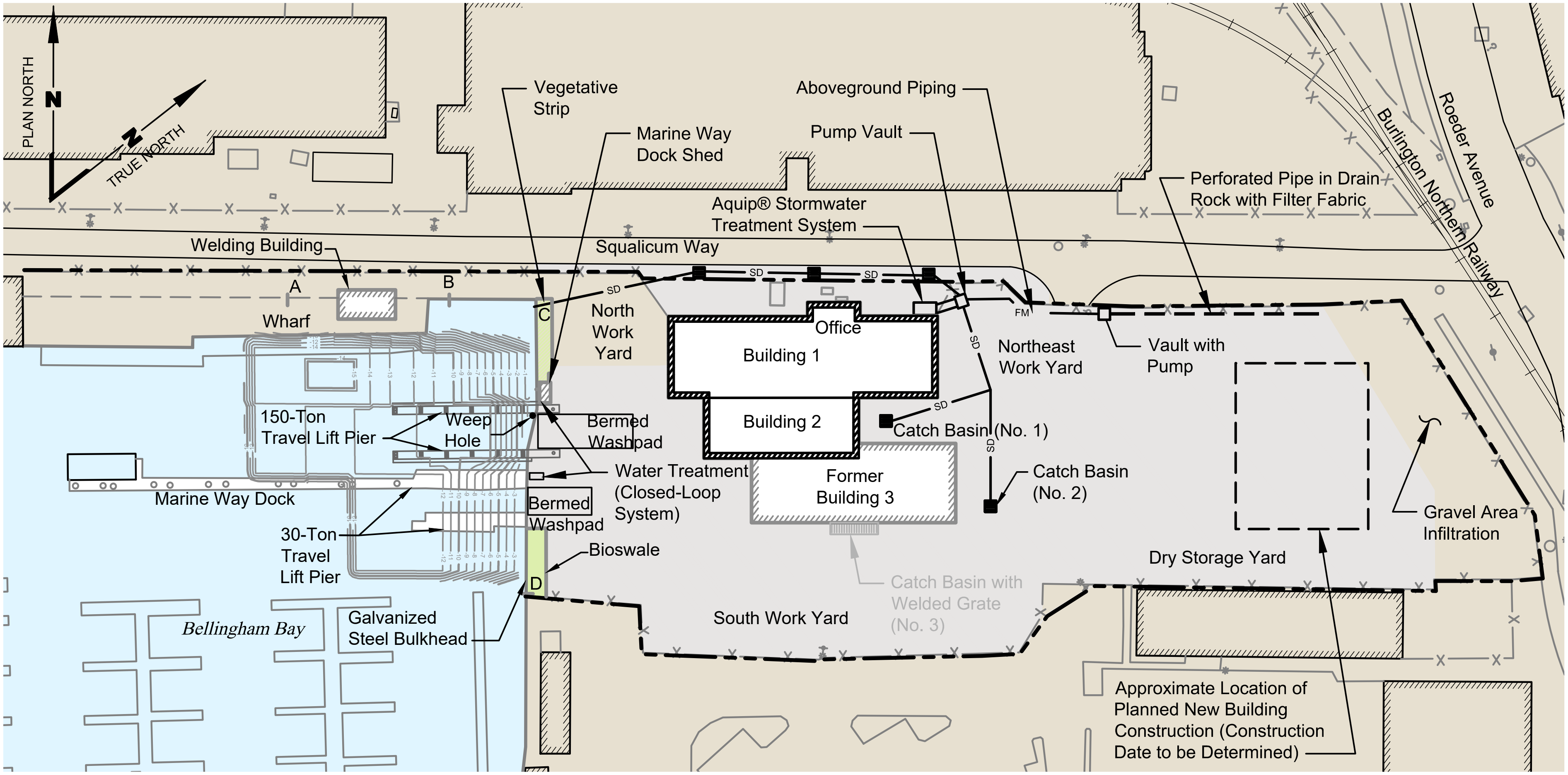
Port of Bellingham Weldcraft Steel and Marine Bellingham, Washington	**Site Plan**	Figure 2



Legend

- Catch Basin
- Pilings
- A — Approximate Location of Outfall and Identification
- Fence
- Railroad
- Former Weldcraft Steel and Marine Operations Area
- 4" Perforated Pipe in Drain Rock and Filter Fabric
- FM — 4" PVC
- SD — 12" PVC Stormdrain
- Structure
- Upland Area
- Bellingham Bay
- On-site Paved Surfaces

Ownership Information

The Site, adjacent properties to the north and south, and adjacent aquatic lands, are owned by the Port of Bellingham (Port). The Port also owns Squalicum Way and the historical Harbor Loop Drive. Roeder Avenue is a public right-of-way.

0 120 240

Scale in Feet

Note

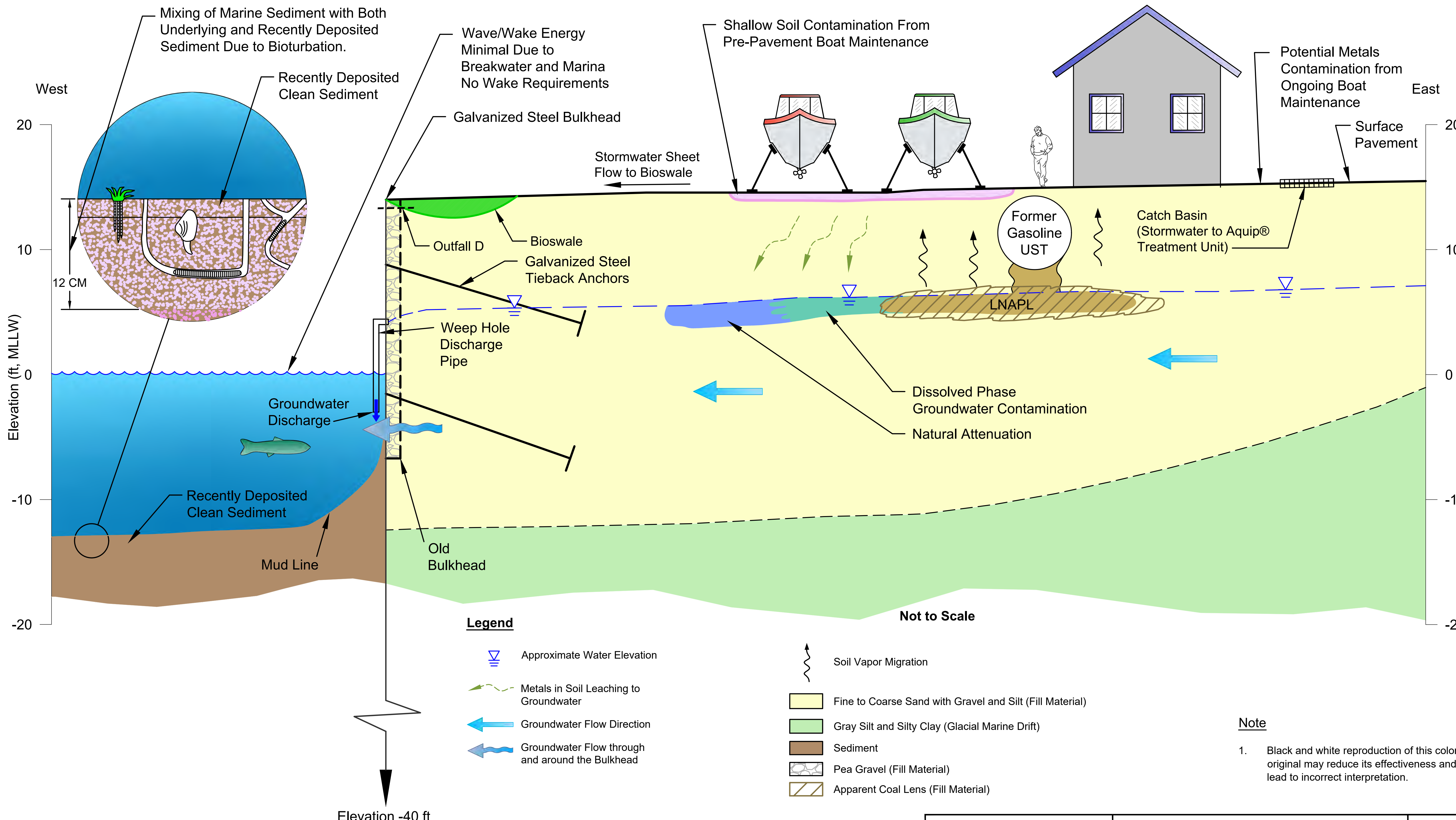
1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

LANDAU ASSOCIATES

Port of Bellingham
Weldcraft Steel and Marine
Bellingham, Washington

Current Site Features

Figure
3



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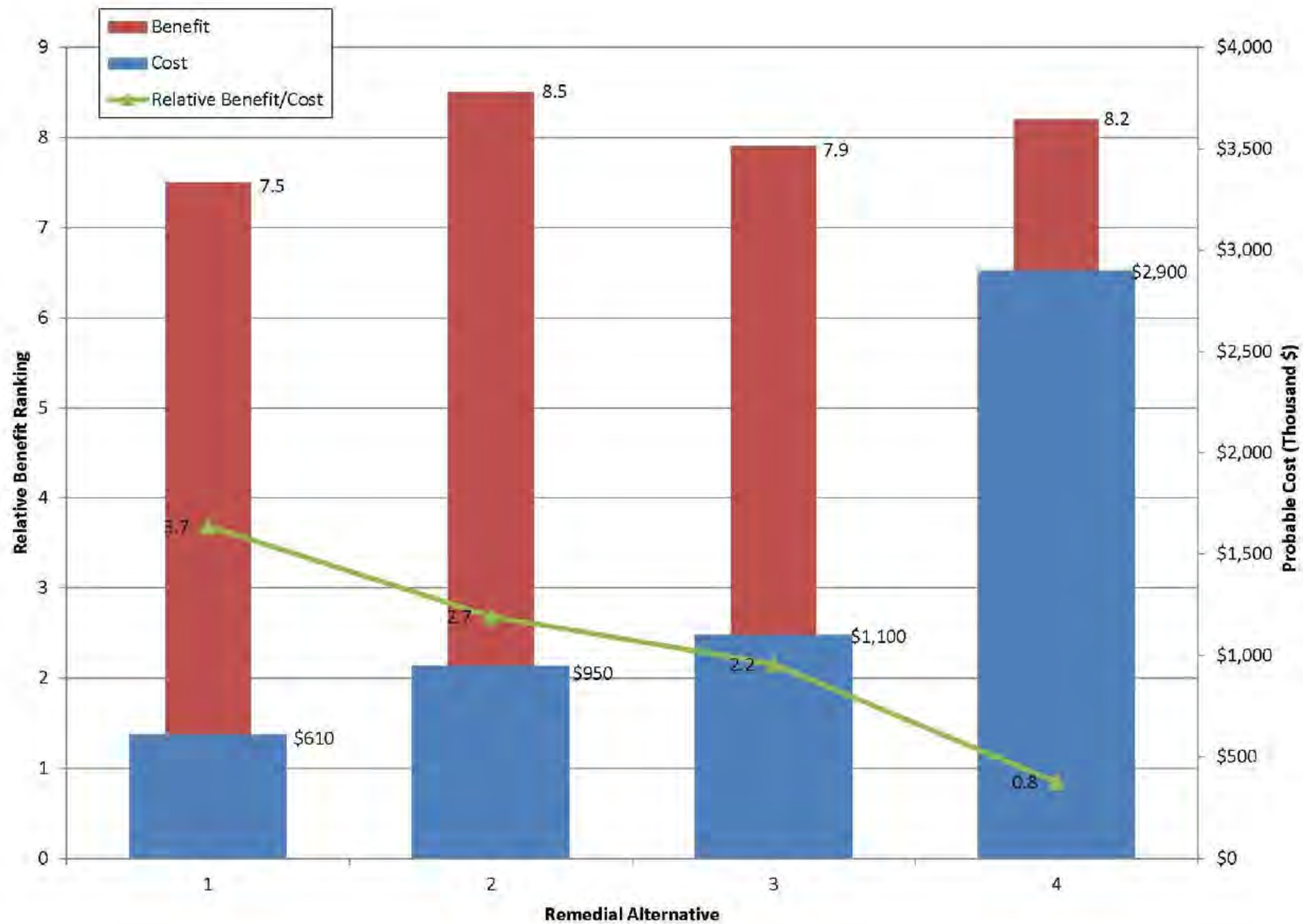
LANDAU ASSOCIATES

Port of Bellingham Weldcraft Steel and Marine Bellingham, Washington	**Conceptual Site Model**	Figure 4

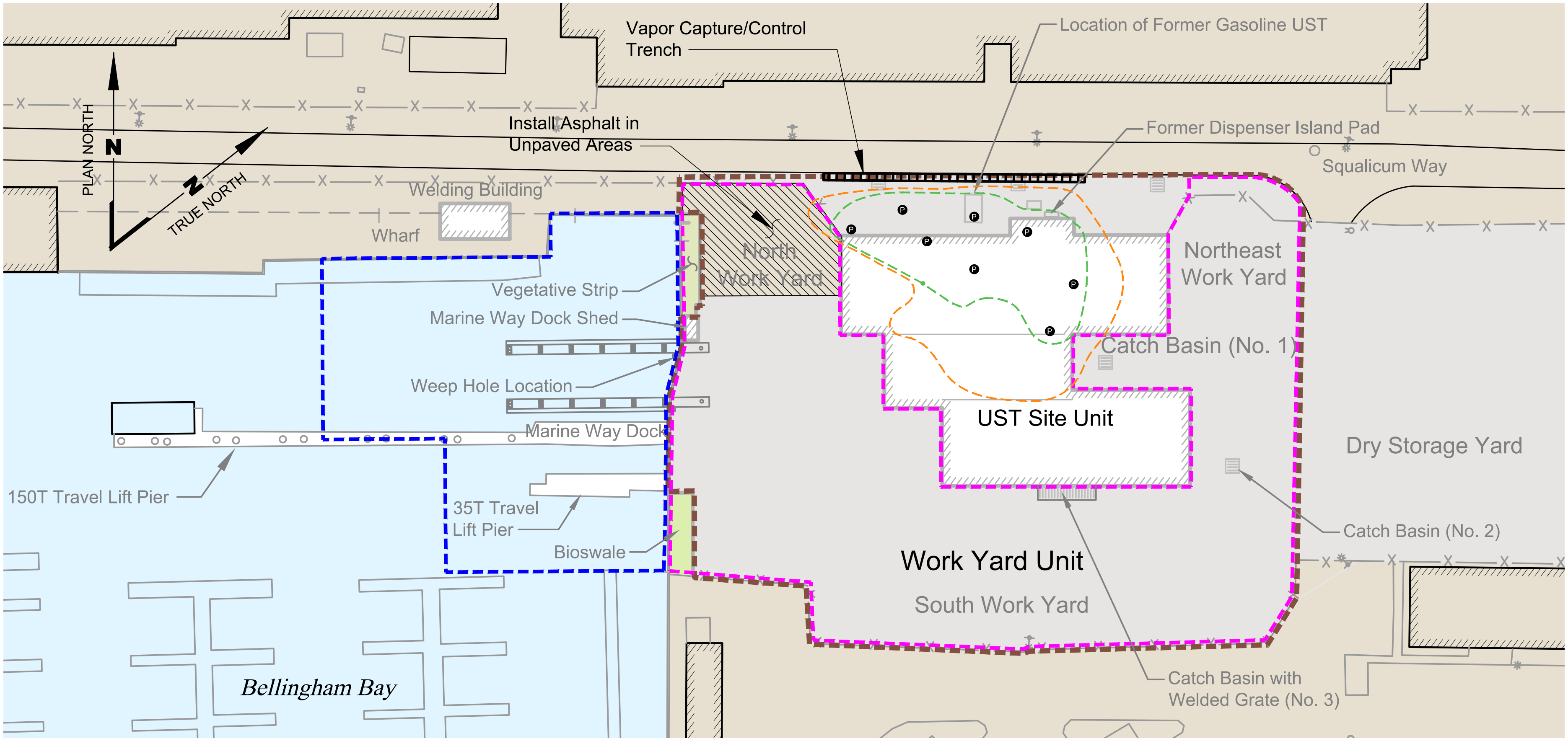


LANDAU ASSOCIATES

Port of Bellingham
Weldcraft Steel and Marine
Bellingham, Washington

Disproportionate Cost Analysis Rankings (Benefit/Cost Comparison)

Figure 5



Legend

- Catch Basin
- Pilings
- Product Recovery Well
- Work Yard Site Unit Boundary
- Marine Site Unit Boundary
- Area Designated for Containment, Including Existing Pavement and Foundation Slabs
- UST Site Unit Boundary
- Potential LNAPL Treatment Zone
- Fence
- Railroad
- Upland Area
- Bellingham Bay
- On-site Paved Surfaces
- Building Footprint
- Vapor Capture/Control Trench
- Area of New Containment

Work Yard Unit

- Containment (Installing, Repairing, and Maintaining Pavement/Slabs)
- Institutional Controls
- Compliance Monitoring

UST Site Unit

- Intermittent DPE LNAPL Recovery
- Containment (Repairing and Maintaining Pavement and Slabs)
- Soil Vapor Recovery
- Institutional Controls
- Compliance Monitoring

Note

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0 100 200
Scale in Feet

LANDAU ASSOCIATES

Port of Bellingham
Weldcraft Steel and Marine
Bellingham, Washington

Preferred Cleanup Remedy

Figure
6

Table 1
Chronology of Site Investigation Activities
Weldcraft Steel and Marine Site
Bellingham, Washington

Activity	Year	Scope of Site Explorations
Pre-Agreed Order		
Phase I Environmental Site Assessment	1993	None
Phase II Environmental Site Assessment	1998	33 borings 2 surface soil grabs 3 surface sediment samples
Phase III Environmental Site Assessment	2000	4 borings 1 hand auger 4 monitoring wells
Supplemental Sediment Investigation	2000	5 surface sediment samples
Sediment Remedial Assessment	2001	7 surface sediment samples 10 subsurface sediment samples
Waste Removal and Decommissioning - Independent Action	2001	5 soil samples
Upland Remedial Assessment	2002	5 monitoring wells
Agreed Order		
Interim Action Marine Sediment Cleanup	2004	17 performance monitoring samples
Remedial Investigation	2006 - 2007	31 borings 3 monitoring wells 2 surface water samples 2 weep samples
Interim Action Marine Sediment Confirmational Sampling	2009	9 surface sediment samples

Table 2
Cleanup Levels for Affected Media
Weldcraft Steel and Marine Site
Bellingham, Washington

COC	Soil Cleanup Level (mg/kg) (a)	Groundwater Cleanup Level (µg/L) (b)	Marine Sediment Cleanup Level (mg/kg) (c)
Acenaphthylene	--	--	66 (e)
Benzene	0.014 (d)	2.4	--
Cadmium	--	--	5.1 (h)
Copper	36 (k)	2.4	--
cPAHs, total (TEQ)	--	--	1.040 / 0.496 (e)(h)(i)
Dibenzofuran	--	--	15 (e)
Ethylbenzene	18 (d)	--	--
Fluorene	--	--	23 (e)
Fluoranthene	--	--	160 (e)
Lead	250	--	89 (h)
Mercury	--	--	0.41 (h)
Nickel	48 (k)	8.2	--
o-Xylenes	--	440	--
Petroleum hydrocarbons, gasoline-range	30 (g)	800	--
Petroleum hydrocarbons, diesel-range	2,000 (j)	--	--
Phenanthrene	--	--	100 (e)
Tributyltin	--	--	0.079 (h)
Zinc	100 (d)	81	410

Notes:

-- = Not applicable because constituent is not an Indicator Hazardous Substance for the medium.

(a) Cleanup level based on the Model Toxics Control Act (MTCA) Method A soil cleanup level for unrestricted land use, unless noted otherwise.

(b) Cleanup level based on lowest Water Quality Standard or PQL, unless noted otherwise.

(c) Cleanup level based on Sediment Management Standards (SMS; Chapter 173-204 WAC) and evaluation of risk-based criteria for chemicals considered persistent, bioaccumulative toxins.

(d) Calculated values from three-phase model, per MTCA Equation 747-1, with groundwater value (Cw) as most stringent value from groundwater screening (values from RI/FS, Landau 2015).

(e) Value normalized to total organic carbon.

(f) Cleanup level based on direct contact soil criteria.

(g) MTCA Method A cleanup level is 100 milligrams per kilogram (mg/kg) if benzene is not present and the total ethylbenzene, toluene, and xylenes is less than 1% of the gasoline mixture; otherwise, the cleanup level is 30

(h) Constituent of concern (COC) is considered a persistent, bioaccumulative toxin in marine sediment and marine sediment cleanup level addresses protection of human health and higher trophic-level species. See Appendix A for CUL basis.

(i) Lower cleanup level reflects early life stage risk-based calculation for cPAHs based on EPA 2005.

(j) MTCA Method A cleanup level is 2,000 mg/kg.

(k) Values are from Ecology’s Natural Background Soil Metals Concentrations in Washington State (Ecology 1994).

Abbreviations and Acronyms:

COC = constituent of concern
cPAH = carcinogenic polycyclic aromatic hydrocarbon
Ecology = Washington State Department of Ecology
EPA = US Environmental Protection Agency
µg/L = micrograms per liter
mg/kg = milligrams per kilogram
MTCA = Model Toxics Control Act
PQL = practical quantitation limit
RI/FS = remedial investigation/feasibility study
SMS = Sediment Management Standards
TEQ = toxicity equivalence
WAC = Washington Administrative Code

APPENDIX A

Development of Marine Sediment Cleanup Standards for Persistent, Bioaccumulative Toxins

TECHNICAL MEMORANDUM

TO: John Rapp, Washington State Department of Ecology

FROM: John McCorkle

DATE: September 8, 2025

RE: Development of Marine Sediment Cleanup Standards for Persistent, Bioaccumulative Toxins
Weldcraft Steel and Marine Site
Bellingham, Washington
Landau Project No. 0001045.010

1.0 INTRODUCTION

This technical memorandum, prepared by Landau Associates, Inc. (Landau) on behalf of the Port of Bellingham, presents the methodology used to develop marine sediment cleanup levels (CULs) for the Weldcraft Steel and Marine site (Site) in accordance with the Washington State Department of Ecology's (Ecology's) Sediment Management Standards (SMS; Chapter 173-204 of the Washington Administrative Code [WAC]). The developed CULs are protective of benthic organisms, human health, and higher trophic-level species for the persistent, bioaccumulative toxins (PBTs) detected in marine sediment at the Site. Additionally, the degree to which current contaminant concentrations in Site marine sediment achieve the PBT CULs is evaluated because cleanup of Site marine sediment was conducted in 2004 as part of an interim action prior to Ecology establishing cleanup standards intended to specifically address protection of human health for PBTs. The 2004 interim action was conducted to achieve SMS cleanup standards in place at that time, which were based on protection of benthic organisms. While the SMS benthic criteria are also intended to be protective of human health for most contaminants, they may not be adequately protective of human health and higher trophic-level species for PBTs.

PBTs detected in Site sediment consist of cadmium, lead, mercury, carcinogenic polycyclic aromatic hydrocarbons (cPAHs), and tributyltin (TBT). Polychlorinated biphenyls (PCBs), which are also considered PBTs, were detected at an estimated concentration of 48 micrograms per kilogram – dry weight (µg/kg – dw; Aroclor 1254) in a single sample collected during the 1998 Phase II environmental Site assessment (Landau 1998). However, PCBs were not detected at concentrations above the laboratory reporting limits in five samples collected from Site marine sediment during the subsequent 2000 supplemental sediment investigation (Landau 2001). As a result, PCBs are not considered a Site constituent of concern (COC) for marine sediment and PCB sediment cleanup objective (SCO) and cleanup screening level (CSL) CULs protective of marine sediment were not developed for the Site.

The SMS have a two-tiered approach to setting sediment CULs for PBTs. Site PBT CULs, as described within this appendix, were developed consistent with this two-tiered approach and in accordance with guidance provided by Ecology in the Sediment Cleanup User's Manual (SCUM; Ecology 2021). Using this approach, an SCO (the lower-tier criterion) and a CSL (the upper-tier criterion) were developed to be protective of the most sensitive receptor group (i.e., the benthic community, higher trophic-level species, or humans) for each PBT. The final SCO and CSL are the lowest value of the lower-tier and upper-tier criteria for each receptor group, respectively. The SMS provides SCO and CSL values for protection of benthic species for the PBTs under consideration, except TBT. The development of benthic criteria for TBT is discussed in Section 2.0.

For humans and higher trophic-level species, the SCO for PBTs is the highest of the following:

- Natural background concentration
- Practical quantitation limit (PQL)
- Risk-based concentration (limiting cancer risk to below $1x10^{-6}$).

For humans and higher trophic-level species, the CSL for PBTs is the highest of the following:

- Regional background concentration
- PQL
- Risk-based concentration (limiting risk to below $1x10^{-5}$).

The final CUL may be adjusted upward from the final SCO (lowest value of the SCOs for each receptor group) based on factors such as technical feasibility or net adverse impacts on the aquatic environment; however, it may not be adjusted above the final CSL (lowest value of the CSLs for each receptor group). The human and higher trophic-level species SCO and CSL values were calculated with a mix of standard and Site-specific input parameters, as described in the following sections. The ultimate goal of Site remedial management is to achieve the CULs that can be maintained over time upon completion of the remedy and not necessarily those concentrations in the range of regional background values.

2.0 BENTHIC CRITERIA

As noted in Section 1.0, the SMS provides SCO and CSL values for protection of benthic species for the PBTs under consideration, except TBT. Although no promulgated SMS values are available for TBT, the US Army Corps of Engineers (USACE) Dredged Material Management Program (DMMP) evaluation criteria for open water disposal identifies a "no effects" TBT marine sediment porewater criterion of 0.05 micrograms per liter (µg/L) and a "potential adverse effects" marine sediment porewater criterion of 0.15 µg/L for open water disposal of dredged material. These DMMP criteria provide a reasonable basis for assessing the potential effects of TBT on marine biota. For the purposes of the remedial investigation/feasibility study (RI/FS), a TBT porewater concentration of 0.05 µg/L is considered analogous to the benthic SCO and a TBT porewater concentration of 0.15 µg/L is considered analogous to the benthic CSL.

Because significantly more bulk sediment TBT data are available than porewater TBT data, a correlation between bulk sediment and porewater TBT concentrations was developed in the RI to allow for a more comprehensive evaluation of the extent of TBT contamination based on bulk sediment TBT data. A linear regression analysis was performed for co-located porewater and bulk sediment TBT data. A strong correlation with an R^2 of 0.96 was obtained for the six available data points. Based on this linear regression, the Site-specific bulk sediment TBT SCO and CSL criteria protective of benthic organisms are 79 micrograms per kilogram (µg/kg) and 156 µg/kg, respectively. These values were developed with the review and concurrence of Ecology during the RI (Landau 2015).

3.0 BACKGROUND AND PRACTICAL QUANTITATION LIMIT CONCENTRATIONS

The SCUM guidance presents calculated Puget Sound natural background concentrations using the BoldPlus dataset for cadmium, lead, mercury, and cPAHs (Ecology 2021). Regional background concentrations for Bellingham Bay for cPAHs and lead were established by Ecology using the Bellingham Bay Regional Background Study dataset (Ecology 2015). No natural or regional background concentrations are available for TBT, and no regional background concentrations are available for cadmium or mercury.

Natural background concentrations for cPAHs are presented as toxicity equivalence (TEQ) values. PQL values are provided in the SCUM guidance for cadmium, lead, mercury, and cPAHs. Ecology did not include PQLs for other constituents, such as TBT, in the SCUM guidance, but it was anticipated that the SCO and CSL criteria would be established above the PQL for TBT; therefore, establishing a TBT PQL was not considered necessary. PQLs and natural and regional background concentrations are provided in Table A-1.

4.0 RISK-BASED CONCENTRATIONS

For cadmium, lead, mercury, TBT, and cPAHs (as the TEQ), risk-based concentrations (RBCs) were developed to be protective of human health based on the following considerations:

- Site exposure pathways
- Site exposure scenarios
- Acceptable health risk.

Toxicity data and exposure assumptions were used as inputs to Ecology-provided equations to calculate the sediment RBCs for Site PBTs consistent with the exposure pathways and scenarios identified in the conceptual Site model. These parameters are described below and calculation parameter values used in the development of RBCs are provided in Table A-2.

4.1 Exposure Pathways

Human health exposure pathways may include absorption through the skin, incidental ingestion of sediment during beach activities, or exposure through bioaccumulation of contaminants through the food chain (i.e., seafood consumption). As identified in the RI/FS report, the potential Site-specific human health exposure pathways consist of uptake by finfish and benthic organisms and ingestion of these organisms by humans and higher trophic-level species. Contact by humans with contaminated marine sediment and consumption of sessile shellfish (e.g., clams, mussels) gathered at the Site were not considered potential pathways due to the inaccessibility of the marine sediment to humans at the Site. However, as discussed further in Section 4.2, the RBC calculations incorporated a seafood consumption rate for an exposure scenario based on shellfish consumption by adult members of the Tulalip Tribes, which included consumption of not only crabs, but also clams, mussels, and bivalves. Therefore, the resulting RBCs protective of human health and higher trophic-level species are considered conservative, especially in comparison to the RBCs established for other regional cleanup sites (e.g., I&J Waterway Cleanup Site), that used less conservative criteria.

No beach access is available at the Site and the shoreline is steeply sloped, greatly limiting the possibility of recreational clamming and beach play. The relative depth-to-mudline at the Site and in the surrounding marina does not provide productive habitat for bivalves. The Site and immediate area will be maintained to support the Port of Bellingham's commitment to the marine trades and productive commercial land use.

4.2 Exposure Scenarios

Exposure scenarios include identifying the most highly exposed population and the appropriate parameters that describe their exposure. For the Site, the tribal subsistence fishing population was used to develop the most conservative assumption scenarios, which are considered to occur through seafood consumption. Based on the exposure pathways described above, seafood consumption includes finfish (pelagic, benthic/demersal fish, and salmon) and crustaceans at 112 grams per day (g/day) and 81.9 g/day,[1] respectively. These consumption rates are based on seafood consumed by adult members of the Tulalip Tribes (95th percentile) as provided in the Fish Consumption Rates Technical Support Document (Ecology 2013). The average body weight of Tulalip tribal adults is 81.8 kg[2] (Toy et al. 1996). Ecology default values were used for the remaining exposure scenario parameters. These values are provided in Table A-2.

4.3 Acceptable Health Risk Factors

Acceptable health risk due to potential exposure to individual PBTs is based on a number of Site- or chemical-specific factors, described below. These factors include the following:

4.3.1 Cancer Risk and/or Hazard Quotient

The risk parameter for non-cancer health effects is the hazard quotient (HQ), which indicates whether the exposure estimated to occur at the Site exceeds the non-cancer toxicity parameter (i.e., the reference dose [RfD], discussed below). If the HQ exceeds 1, the Site exposure exceeds the RfD and the potential exists for non-cancer health effects. Non-cancer health effects include organ toxicity, developmental toxicity, reproductive toxicity, and damage to the immune system.

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[1] The seafood consumption rates include consumption scenarios for crabs, clams, mussels, and bivalves.

[2] Tulalip male average of 86 kg (n=42); Tulalip female average of 76 kg (n=31).

Cancer risk represents the likelihood that an individual will develop cancer as a result of the Site exposure. For individual carcinogenic substances, RBCs were developed for cancer risks of 1 in 1 million ($1x10^{-6}$) for the SCO and 1 in 100,000 ($1x10^{-5}$) for the CSL.

4.3.2 Cancer Potency Factor and/or Reference Dose

Cancer potency is quantified with the oral cancer potency factor (CPFo), representing an upper-confidence limit on the increased cancer risk over a lifetime of exposure to a chemical. CPFo values for each Site PBT were taken from Ecology's Cleanup Levels and Risk Calculations (CLARC) database (Ecology 2020), as provided in Table A-3.

Non-cancer hazard is quantified with the oral RfD (RfDo), which represents a conservative estimate of the threshold dose below which non-cancer health effects are not expected to occur. Carcinogenic substances may also cause non-cancer health effects, and non-carcinogenic hazards were also calculated for carcinogenic substances. RfDo values for each contaminant were taken from Ecology's CLARC database (Ecology 2020), as provided in Table A-3.

An RfDo value for mercury was not available through Ecology's CLARC database; therefore, the RfDo value of 0.0001 milligrams per kilogram per day (mg/kg-day) for methylmercury, which is a more toxic form of mercury based on effects via oral ingestion, was used as a conservative approach.

4.3.3 Site Use Factor

An organism may spend only part of its life in the vicinity of contaminated sediment at a site. The site use factor (SUF) is meant to quantify the amount of time that an organism is potentially exposed to contaminated sediment. The marine portion of the Site, for the purposes of developing PBT SCO and CSL values, is conservatively assumed to be the entirety of Squalicum Outer Harbor (about 0.2 square kilometers [km^2]) for calculation of the SUF. Based on an assumed home range of 10 km^2 for finfish, the SUF was set to 0.02 or 2 percent. A smaller home range for mobile crustaceans (i.e., 2 km^2) is assumed to reflect the population that would spend any quantity of time in the vicinity of the marine portion of the Site, given the Site's access limitations. Therefore the SUF for crustaceans is set at 0.1 or 10 percent.

The approach used to establish the SUF for the Site was the same approach used at the I&J Waterway Cleanup Site, using the organism's home range and the Site area. The SUFs discussed herein are more conservative than those values selected at the I&J Waterway Cleanup Site because the area of the entire Squalicum Outer Harbor (i.e., 0.2 km^2) is used, rather than the smaller site-specific area used for the evaluation conducted for the I&J Waterway Cleanup Site.

4.3.4 Biota-Sediment Accumulation Factor

The PBTs considered in this evaluation bioaccumulate at varying rates. The bioaccumulation of contaminants in organisms affected by marine sediment can be quantified as either a biota-sediment accumulation factor (BSAF) for non-polar organic contaminants or a bioaccumulation factor (BAF) for polar or metal contaminants. The BSAF is the lipid-normalized contaminant concentration in tissue divided by the organic carbon–normalized concentration in sediment. The BSAF is used for contaminants with generally high octanol/water partition coefficients (K_{ow}), which are hydrophobic and are preferentially distributed to lipids in organisms.

BSAF values for finfish were obtained from the US Environmental Protection Agency (EPA) Office of Research and Development BSAF database (EPA; accessed March 18, 2021) and the USACE Environmental Research Development Center BSAF database (USACE; accessed March 18, 2021). Mean BSAF values were calculated from listed BSAF values from whole body tissue samples, for the types of finfish species represented in each calculation. Finfish species used were the brown bullhead catfish (*Ictalurus nebulosus*), channel catfish (*Ictalurus punctatus*), common carp (*Cyprinus carpio*), and white sucker (*Catostomus commersoni*). BSAF values were screened for potential outliers with the ProUCL (EPA 2016) program and outliers were removed.

BSAF data for Pacific crab species native to the Squalicum Outer Harbor were not available from the EPA and USACE databases. BSAF values were available for other crustacean species, including crayfish and fiddler crabs; however, due to potential data quality issues and limited available data, these BSAF values were not applied to calculations for the Site. Crustacean species, similar to bottomfish, have enzymes that are capable of metabolizing polycyclic aromatic hydrocarbons; however, the metabolic rate of crustaceans is less efficient than bottomfish (Stegeman and Lech 1991). Therefore, a safety factor of 5 was applied to the bottomfish BSAF to account for uncertainty in generating corresponding crab BSAF values for the Site (Ecology 2019). The evaluation document herein used the same BSAF values as the evaluation that was conducted for the I&J Waterway Site, including the safety factor applied to account for crab BSAF values. BSAF values are provided in Table A-4.

4.3.5 Bioaccumulation Factor

The bioaccumulation factor (BAF) is the concentration of contaminants in an organism divided by the concentration of contaminants in sediment. The BAF is used for polar contaminants and for metals where the BSAF is not appropriate. Since tissue samples were not collected at the Site, BAF values were established based on information from other sites in Puget Sound. Average mercury and cadmium BAF values for finfish and crustaceans were used from the report Preliminary Sediment Cleanup Objectives for Port Angeles Harbor, an investigation conducted by Newfields on behalf of Ecology (NewFields 2013).

Appendix E of the Whatcom Waterway Supplemental RI/FS report (RETEC 2006) presents paired fish tissue and sediment data from Bellingham Bay and other Puget Sound bays with documented mercury contamination sources. Mercury BAF values computed for crustaceans and finfish using the Whatcom Waterway dataset were determined to be greater than 75 percent lower than the BAFs assumed for the Site, which were based on values presented in the aforementioned Newfields report. Therefore, the Weldcraft Site is using more conservative mercury BAF values than those associated with the Whatcom Waterway site.

BAF values are provided in Table A-4.

4.3.6 Fish/Shellfish Lipid Fraction

Lipid content in organisms is quantified with the fish/shellfish lipid fraction (SLf). For calculations herein, the SLf was assumed to be 0.03 based on the Ecology default value of 0.03 for both finfish and crustaceans (Ecology 2021).

4.3.7 Fraction of Organic Carbon in Sediment

The bioavailability of contaminants in sediment can also be affected by the fraction of organic carbon in sediment (Sfoc). For Site RBC calculations, the mean organic fraction (0.01619) for post-interim action surface sediment samples from 2009 collected from the Site was used.

4.4 Calculating Risk-Based Concentrations

The following subsections describe the development of RBCs for cadmium, mercury, TBT, and cPAHs. RBC development for lead is discussed separately in Section 4.6. Some PBTs, including mercury and TBT, pose a greater risk to higher trophic-level species than to humans. The second half of Ecology's default equation to identify a sediment RBC for higher trophic-level species is:

$$RBC = \left(\frac{1}{SUF \times BAF}\right)$$

For both mercury and TBT, the human health RBC was lower than the RBC for protection of higher trophic-level species, and the human health RBC was used as the more conservative value.

4.4.1 Metals

The RBCs for cadmium and mercury, which are non-carcinogens, were developed using the parameters discussed in Section 4.3, along with Ecology's default equation:

$$RBC_{Noncancer} = \left\{\left(\frac{(HQ \times BW \times AT_{nc} \times RfDo)}{(FCR \times FDF \times EF \times ED)}\right) \times \left(\frac{S_{foc}}{SUF \times BAF}\right)\right\}$$

4.4.2 Tributyltin

The RBC for bulk TBT, a non-carcinogen, was developed using the parameters discussed in Section 4.3, along with Ecology's default equation:

$$RBC_{Noncancer} = \left\{\left(\frac{(HQ \times BW \times AT_{nc} \times RfDo)}{(FCR \times FDF \times EF \times ED)}\right) \times \left(\frac{S_{foc}}{SUF \times SLf \times BSAF}\right)\right\}$$

Only one BSAF value for TBT was identified from a review of the EPA and USACE databases for finfish and crustaceans. Therefore, BSAF values for mollusks were used to calculate a very conservative mean BSAF. Mollusks do not metabolize TBT well, and coupled with their high intake of sediment-based contaminants, they are the most sensitive organism to TBT concentrations in sediment (Lee 1996). The mean BSAF value for TBT in mollusks [10.0 grams tissue (lipid-normalized)/grams sediment (organic carbon-normalized)] was calculated from 16 values. One outlier was identified with the ProUCL software and removed.

4.5 Carcinogenic Polycyclic Aromatic Hydrocarbon Toxicity Equivalence

Each individual cPAH present at the Site varies in extent, cancer potency, and rate of bioaccumulation in organisms. In order to derive a single carcinogenic-human health RBC for cPAHs, based on the individual potencies, uptake rates, and toxicity equivalency factors (TEFs), Ecology's default RBC equation (Ecology 2021) was rearranged following the method described below. From this arrangement, Site-specific total excess lifetime cancer risk (ELCR) through seafood consumption (both crustacean[3] and finfish) for cPAHs as a group ($ELCR_{cPAH\ TEQ}$) was calculated. These Site-specific ELCRs, along with the target ELCR ($1x10^{-6}$), were used to generate a standard Site-specific cPAH TEQ RBC, protective of human health.

In addition to generating the standard Site-specific cPAH TEQ RBC for the Site, preliminary early life stage (ELS)-based RBCs were also generated for comparison to the standard RBCs in order to factor in the mutagenic effects of cPAHs (EPA 2005). The EPA's guidance addresses cPAH mutagenicity by applying age-dependent adjustment factors (ADAFs) to modify the total dosage for each specific ELS age group. These ADAFs and corresponding exposure durations are provided in the table below.

Early Life Stage Age-Dependent Adjustment Factors and Exposure Durations

Age Group	Age-Dependent Adjustment Factor (ADAF; unitless)	Exposure Duration (years)
< 2 years	10	2
2 to <6 years	3	4
6 to <16 years	3	10
16 to 70 years	1	54

Source: EPA 2005.

To calculate the standard and ELS-based RBCs, first the expected tissue concentration ($C_{a,k}$) of a^{th} individual cPAH in k^{th} seafood type (finfish and crustaceans) was calculated using Equation 1, shown below.

Equation 1

$$C_{a,k} = SL_k \times BSAF_{a,k} \times CsedOC_a$$

By multiplying the fish/shellfish lipid fraction (Ecology default 0.03) by the uptake factor (BSAF for a^{th} individual constituent in each k^{th} seafood type), and by the arithmetic average Site concentration of each constituent (carbon-normalized; $CsedOC_a$), the expected tissue concentration for each constituent was calculated.

[3] The Tulalip Tribe shellfish consumption rates were inclusive of crab, clam, mussel, and bivalve consumption.

Using the expected finfish and crustacean tissue concentrations of cPAHs ($C_{a,k}$), the total chronic daily intake (CDI_a) of ath individual congener or cPAH in the summed kth seafood types was calculated using Equation 2, shown below.

Equation 2

$$CDI_a = \sum_{k=1}^{m} \left(\frac{\boldsymbol{C_{a,k}} \times FCR_k \times EF \times ED \times FDF_k \times SUF_k}{AT_{cr} \times BW \times UCF} \right)$$

The parameters used in Equation 2, unless noted otherwise in this section, were set to the Ecology default assumptions, as shown in Table A-2.

Using the potential total daily uptake of each cPAH through seafood consumption, the total excess lifetime cancer risk ($ELCR_a$) was calculated using Equation 3, shown below. Oral cancer potency factors ($CPFo_a$) for cPAHs were obtained from the CLARC database (Ecology 2020) and are based on the toxicity equivalency factor (TEF_a) that normalizes individual cPAH compound toxicity to benzo(a)pyrene, the most potent cPAH [$CPFo_{benzo(a)pyrene}$ = 1.0 (mg/kg-d^{-1})].

Equation 3

$$ELCR_a = CPFo_a \times \boldsymbol{CDI_a}$$

For the ELS-based RBC calculations, Equation 3 was adapted to reflect application of EPA's ADAF across the age ranges, including the additional recommended adjustments upward in risk to account for the potential greater susceptibility of children from 0 to 2 and from 2 to 6 years of age compared to older children/teens and adults. The ELS-based $ELCR_a$ was calculated using Equation 3.1, shown below.

Equation 3.1

$$\begin{aligned} ELCR_{a(0-70)} &= CPFo_a \\ &\times \left(\left[\boldsymbol{CDI_{a(0-2)}} \times \frac{2}{6} \times 10 \right] \right. \\ &\left. + \left[\boldsymbol{CDI_{a(2-6)}} \times \frac{4}{6} \times 3 \right] \times \left[\boldsymbol{CDI_{a(6-16)}} \times 3 \right] \times \left[\boldsymbol{CDI_{a(16-70)}} \times 1 \right] \right) \end{aligned}$$

The standard and ELS-based Site-specific total ELCR for cPAHs ($ELCR_{cPAH\ TEQ}$) were each calculated by summing together their corresponding ath individual cPAH $ELCR_a$, to the gth number of cPAHs, using Equation 4, shown below.

Equation 4

$$ELCR_{cPAH\ TEQ} = \sum_{a=1}^{g} \boldsymbol{ELCR_a}$$

The standard and ELS-based RBCs for cPAHs in sediment ($RBC_{cPAH\ TEQ}$) were based on the ratio of the SCO target excess lifetime cancer risk ($ELCR_{target}$ = 1x10^{-6}) to the Site-specific ELCR ($ELCR_{cPAH\ TEQ}$) to the sum of each constituent concentration multiplied by each individual cPAH TEF using Equation 5, shown below.

Equation 5

$$RBC_{cPAH\ TEQ} = \frac{ELCR_{Target}}{\boldsymbol{ELCR_{cPAH\ TEQ}}} \times \sum_{a=1}^{g} (Csed_a \times TEF_a)$$

4.6 Lead Risk-Based Concentration

The RBC for lead was calculated using the same methodology and Ecology default equation as the two other non-carcinogenic metals (i.e., cadmium and mercury), with the exception of the following input parameters:

Bioaccumulation Factor

As discussed above, the BAF is the concentration of contaminants in an organism divided by the concentration of contaminants in sediment. Tissue samples were not collected at the Site, and lead BAF values for finfish and crustaceans are not published relevant to other regional cleanup sites (e.g., I&J Waterway, Whatcom Waterway, Port Angeles Harbor, etc.). Therefore, lead BAF values were calculated using organism tissue data presented in the Lower Duwamish Waterway Remedial Investigation Baseline Human Health Risk Assessment report (Windward Environmental 2007), and Site-specific contaminant concentrations in sediment.

Tissue chemistry data from the Lower Duwamish Waterway were available for several different tissue types (e.g., whole body, skinless and skin-on fillet) from sampling events conducted between 1995 and 2004. Lead-specific tissue data were available for a variety of species that include species native to the Site’s vicinity and used in calculating cadmium and mercury concentrations. A total of 83 samples were included in the relevant dataset. Tissue concentration data are summarized in Table A-5. The maximum lead detection value in finfish and crustacean tissues (0.95 milligrams per kilogram [mg/kg] in a benthic fish whole body tissue sample) was conservatively selected for inclusion in the BAF calculation.

Site-specific sediment data were obtained from the Phase II environmental Site Assessment (Landau 1998), supplemental sediment investigation (Landau 2001), and post-dredging sediment investigation (Landau 2006) reports. Of the 34 samples analyzed for lead, 11 surface sediment data points appear to be representative of existing Site conditions (i.e., points that were not removed by interim action dredging and backfilled with clean, imported sand in 2004). The average lead concentration in sediment, shown in Table A-5, was conservatively selected for inclusion in the BAF calculation. It should be noted that use of the average lead concentration in sediment is more conservative than use of the maximum lead concentration in this calculation, which models biologic uptake of lead from sediment into tissue samples, so use of the lower average sample results in a higher BAF and consequently a lower (more conservative) CUL. The use of Site-specific sediment data is also more conservative than that of the Lower Duwamish Waterway, as the average sediment lead concentration at the Site was less than the average sediment lead concentration presented in the Lower Duwamish Waterway Remedial Investigation Baseline Human Health Risk Assessment report (Windward Environmental 2007).

Oral Reference Dose

Neither the EPA nor Ecology have published a RfDo for lead. Therefore, the RfDo for lead was assumed to be the lowest value (i.e., most conservative) of the pure metal values[4] available in Ecology's CLARC database (Ecology 2020) at 0.0001 mg/kg-day (methylmercury).

5.0 MARINE SEDIMENT PERSISTENT, BIOACCUMULATIVE TOXIN CLEANUP LEVELS

In accordance with SMS, the CUL is initially set at the SCO but may be adjusted upward as high as the CSL, based on Site-specific evaluation of technical feasibility and net adverse environmental impact. The SMS provides SCO and CSL values for protection of benthic species for the PBTs under consideration except TBT. The development of benthic criteria for TBT was discussed in Section 2.0.

For humans and other higher trophic-level species, the SCO for PBTs is the highest of the following:

- Natural background concentration
- PQL
- RBC (cancer risk at $1x10^{-6}$).

For humans and higher trophic-level species, the CSL for PBTs is the highest of the following:

- Regional background concentration
- PQL
- RBC (cancer risk at $1x10^{-5}$).

The Site marine sediment CULs were set at the lowest value of the SCOs compared across the relevant receptor groups (i.e., the benthic community, higher trophic-level species, or humans) for each Site-specific PBT, because the SCOs were determined to be technically feasible to achieve without a net negative impact to the environment. Table A-6 provides the CULs, as described below.

5.1 Metals

The RBC calculated for cadmium is 7 mg/kg, protective of human health through consumption of seafood (finfish and crustaceans) and based on an HQ of 1. This is a higher value than the natural background concentration (0.8 mg/kg) or the PQL (0.07 mg/kg); therefore, 7 mg/kg is established as the SCO for cadmium, protective of human health. Since no regional background concentration has been established for cadmium, the CSL protective of human health also corresponds to the RBC for cadmium, a non-carcinogen (7 mg/kg). However, these SCO and CSL values are higher than the SCO or CSL protective of the benthic community (5.1 and 6.7 mg/kg, respectively). Therefore, 5.1 mg/kg was

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[4] Metals with higher RfDo values than that assumed for lead include aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, manganese, molybdenum, silver, tin, vanadium, and zinc.

selected as the final SCO and the final CSL was set at 6.7 mg/kg. The CUL for cadmium is set at the final SCO (5.1 mg/kg).

The lowest RBC calculated for mercury is 0.5 mg/kg, protective of human health through consumption of seafood and based on an HQ of 1. This is a higher value than the natural background concentration or the PQL (0.2 and 0.02 mg/kg, respectively) and it is therefore established as the risk-based SCO for mercury protective of human health. Since no regional background concentration has been established for mercury, the CSL protective of human health also corresponds to the risk-based RBC for mercury, a non-carcinogen (0.5 mg/kg).The risk-based SCO value is higher than the SCO protective of the benthic community (0.41 mg/kg), and the risk-based CSL value is less than the CSL protective of the benthic community (0.59 mg/kg). Therefore, 0.41 mg/kg was selected as the final mercury SCO and the final mercury CSL was set at 0.50 mg/kg. The CUL for mercury is set at the final SCO (0.41 mg/kg).

The lowest RBC calculated for lead is 89 mg/kg, which is protective of human health through consumption of seafood and based on an HQ of 1. This is a higher value than the natural background concentration or the PQL (21 and 0.1 mg/kg, respectively) and it is therefore established as the risk-based SCO for lead protective of human health and higher trophic-level species. The CSL protective of human health also corresponds to the RBC (89 mg/kg) as it is higher than regional background concentration (16 mg/kg). Because the SCO and CSL values for protection of benthic organisms are significantly greater that the values for protection of human health, 89 mg/kg was conservatively established as the lead CUL for marine sediment.

5.2 Tributyltin

The lowest RBC calculated for bulk TBT is 173 µg/kg, which is protective of human health through consumption of seafood based on an HQ of 1. No background or PQL values have been established for TBT, so the SCO and CSL protective of human health were each set at 173 µg/kg. This SCO value is higher than the Site-specific SCO for protection of the benthic community (79 µg/kg). Therefore, 79 µg/kg was selected as the final bulk TBT SCO; similarly, the final CSL was set at the Site-specific CSL for protection of the benthic community (156 µg/kg). The CUL for bulk TBT is set at the final SCO (79 µg/kg).

5.3 Carcinogenic Polycyclic Aromatic Hydrocarbons

The lowest RBC calculated for cPAHs (based on the sum of the TEQs) is 1,040 µg/kg, which is protective of human health through consumption of seafood based on an excess cancer risk of $1x10^{-6}$. This RBC is higher than the natural background concentration (21 µg/kg) and PQL (9 µg/kg), and was therefore set as the SCO protective of human health through consumption of seafood. The CSL was set at an excess cancer risk of 10^{-5}, or 10,400 µg/kg. Since no SCO and CSL values are established that are protective of the benthic community, these SCO and CSL values protective of human health through consumption of seafood were selected as the final cPAH SCO and CSL values. Therefore, the CUL for cPAHs was initially set at the SCO, based on the RBC (1,040 µg/kg TEQ).

The ELS-based RBC, based on EPA guidance (EPA 2005), was also calculated for cPAHs to assist in further evaluation of potential CULs for PBTs at the Site. The calculated ELS-based RBC is 496 µg/kg TEQ.

Therefore, the ELS-based RBC value of 496 µg/kg TEQ, was established as the SCO value for the Site as it is protective of human health through consumption of seafood and reflects current evaluation requirements outlined in SCUM and ELS evaluation established by the EPA (Ecology 2021).

6.0 COMPARISON OF SITE DATA TO CLEANUP LEVELS

The 2004 interim action achieved the screening levels established in the RI/FS report at that time for Site marine sediment through contaminated sediment removal and subsequent natural recovery. However, the screening levels were established before Ecology established criteria for PBTs that specifically addressed protection of human health and higher trophic-level species. To determine if contaminant concentrations remaining in Site marine sediment are also adequately protective of human health and higher trophic-level species, available data were compared to the Site-specific CULs established for PBTs, which were developed as outlined in the preceding sections of this document.

In the instances where Site data from 2009 were not available for certain analytes, the 2004 interim action data were used. Because natural recovery is ongoing, the 2009 data represent conservatively high estimates of concentrations for Site COCs relative to current conditions and 2004 data represent even more conservative estimates of current concentrations because of the longer timeframe over which natural recovery has been occurring.

In cases where data were needed beyond the limits of the Site to estimate surface concentrations representative of the home ranges for target organisms relevant to the human health assessment (finfish and mobile crustaceans), data from A-layer samples (i.e., shallow sediment) collected in 2007 for the Port of Bellingham's suitability assessment for the Gate 3 project were used to provide additional context on area sediment quality. These Dredge Material Management Unit samples were collected outside of the Site boundary, but within Outer Squalicum Harbor.

Sediment compliance data are compared with CULs on a point-by-point basis to demonstrate protection of benthic criteria and to area-weighted averages to assess protection of human health, as appropriate. Up to nine Site samples (and one duplicate) were analyzed during the 2009 sampling event, and 12 Site samples were analyzed during the 2004 sampling event. In addition, four A-layer samples were analyzed for the Gate 3 2007 Dredged Material Management Program (DMMP) suitability assessment and are considered in the evaluation with respect to area sediment quality conditions. The following is a summary of the comparison of these data to the Site CULs provided in Table A-6 for marine sediment:

- **Cadmium**: During the 2004 compliance monitoring event for the marine sediment interim action, all 12 samples had concentrations of cadmium below the CUL of 5.1 mg/kg, indicating that cadmium is not present in marine sediment at concentrations posing unacceptable risks to human health and the environment.
- **Mercury**: During the 2009 marine sediment sampling event conducted 5 years after the interim action, the nine samples (and one duplicate) analyzed for mercury had concentrations below the CUL of 0.41 mg/kg, indicating that mercury is not present in marine sediment at concentrations posing unacceptable risks to human health and the environment.

- **Lead**: Lead concentrations from samples collected during the 2004 Site compliance monitoring were under the CUL of 450 mg/kg established at the time of the monitoring event (i.e., the benthic SCO [formerly referred to as the sediment quality standard]). Since the samples collected during the 2004 compliance monitoring did not exceed the established CUL, lead was not analyzed for during subsequent compliance monitoring events conducted in 2009. However, lead concentrations from samples collected during the 2004 Site compliance sampling event compared to the calculated RBC for lead (discussed in Section 5.1) were all below the current CUL of 89 mg/kg.
- **TBT (bulk)**: During the 2004 sampling event, the samples analyzed for TBT after the January and subsequent July removal events had concentrations below the CUL of 79 µg/kg, indicating that TBT is not present in sediment at concentrations posing unacceptable risks to human health and the environment.
- **cPAHs**: During the 2009 sampling event, all nine samples (and one duplicate) analyzed for cPAHs had concentrations below the cPAH risk-based CUL of 496 µg/kg TEQ, indicating that cPAHs are not present in marine sediment at concentrations that pose unacceptable risks to human health and the environment.

Based on these results, Site CULs for marine sediment have been achieved throughout the Site for Site-specific PBTs.

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This document has been prepared under the supervision and direction of the following key staff.

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Attachments

Table A-1
Background and Practical Quantitation Limit Concentrations
Weldcraft Steel and Marine Site – Bellingham, Washington

Parameter	Natural Background (a)	PQL (b)	Regional Background (c)	Units
Cadmium	0.8	0.07	-	mg/kg
Lead	21	0.1	16	mg/kg
Mercury	0.2	0.02	-	mg/kg
Bulk Tributyltin	-	-	-	-
cPAHs (sum TEQ)	21	9	86	µg/kg TEQ

Notes:

(a) From SCUM Table 10-1; calculated values (90/90 UTL) for marine sediment natural background from the data sets in Appendix I and Bold study (Ecology 2021).

(b) From SCUM Table 11-1; programmatic sediment and tissue PQLs used to establish the PQL-based SCO and CSL (Ecology 2021).

(c) From SCUM Table 10-2; calculated values (90/90 UTL) for marine and freshwater sediment regional background (Ecology 2021).

Abbreviations and Acronyms:

µg/kg = micrograms per kilogram
mg/kg = milligrams per kilogram
cPAHs = carcinogenic polycyclic aromatic hydrocarbons
CSL = cleanup screening level
PQL = practical quantitation limit
SCO = sediment cleanup objective
SCUM = Sediment Cleanup User's Manual
TEQ = toxicity equivalence
UTL = upper tolerance limit

Table A-2
Risk-Based Concentration – Calculation Parameters
Weldcraft Steel and Marine Site – Bellingham, Washington

Parameter	Symbol	Units	Value
Cancer Risk	CR	unitless	1.00E-06
Hazard Quotient	HQ	unitless	1
Body Weight	BW	kg	81.8 (a)
Averaging Time-Carcinogen	AT_{Cr}	days	27,375
Averaging Time-Non-Carcinogen	AT_{Nc}	days	27,375
Unit Conversion Factor	UCF	g/kg	1,000
Exposure Frequency	EF	days/yr	365
Exposure Duration	ED	years	70 (b)
Fish/Shellfish Consumption Rate (finfish)	FCR	g/day	112 (c)
Fish/Shellfish Consumption Rate (crustaceans)	FCR	g/day	81.9 (c)
Fish/Shellfish Diet Fraction	FDF	proportion	1
Fraction of Organic Carbon in Sediment	Sfoc	g/g	0.01619
Site Use Factor, Fish	SUF	proportion	0.02
Site Use Factor, Shellfish (crustaceans)	SUF	proportion	0.10
Fish/Shellfish Lipid Fraction	SLf	g/g	0.03

Notes:

(a) Average body weight of Tulalip tribal adults (Toy et al. 1996).
(b) Early-life stage exposure durations applied as promulgated in EPA 2005.
(c) Tulalip Tribes consumption for pelagic and benthic/demersal fish, salmon, and shellfish (Ecology 2013).

Abbreviations and Acronyms:

g/g = grams per gram
g/kg = grams per kilogram
kg = kilogram
yr = year

Table A-3
Cancer Potency Factors and Toxicity Equivalency Factors
Weldcraft Steel and Marine Site – Bellingham, Washington

Carcinogenic Polycyclic Aromatic Hydrocarbons			
Chemical	**CAS No.**	**CPFo**	**TEF**
Benz(a)anthracene	56-55-3	1.00E-01	1.00E-01
Benzo(a)pyrene	50-32-8	1.00E+00	1.00E+00
Benzo(b)fluoranthene	205-99-2	1.00E-01	1.00E-01
Benzo(k)fluoranthene	207-08-9	1.00E-01	1.00E-01
Chrysene	218-01-9	1.00E-02	1.00E-02
Dibenz(a,h)anthracene	53-70-3	1.00E-01	1.00E-01
Indeno(1,2,3-cd)pyrene	193-39-5	1.00E-01	1.00E-01

Cadmium, Mercury, Tributyltin, and Lead		
Chemical	**CAS No.**	**CPFo or RfDo**
Cadmium	7440-43-9	1.00E-03
Mercury (as methylmercury)	22967-92-6	1.00E-04
Tributyltin	688-73-3	3.00E-04
Lead	7439-92-1	1.00E-04

Abbreviations and Acronyms:
CAS = Chemical Abstracts Service
CPFo = oral cancer potency factor
RfDo = oral reference dose
TEF = toxicity equivalency factor

Table A-4
Biota-Sediment Accumulation Factor/Biota Accumulation Factor Values
Weldcraft Steel and Marine Site – Bellingham, Washington

Carcinogenic Polycyclic Aromatic Hydrocarbons			
		BSAF (a)	
Chemical	CAS No.	Finfish	Crustaceans
Benz(a)anthracene	56-55-3	1.22E-03	6.11E-03
Benzo(a)pyrene	50-32-8	9.52E-04	4.76E-03
Benzo(b)fluoranthene	205-99-2	1.22E-03	6.11E-03
Benzo(k)fluoranthene	207-08-9	1.11E-03	5.57E-03
Chrysene	218-01-9	1.49E-03	7.46E-03
Dibenz(a,h)anthracene	53-70-3	1.29E-03	6.46E-03
Indeno(1,2,3-cd)pyrene	193-39-5	8.14E-05	4.07E-04

Cadmium, Mercury, and Tributyltin			
		BAF (b)	
Chemical	CAS No.	Finfish	Crustaceans
Cadmium	7439-97-6	4.89E-02	1.57E+00
Mercury	7439-97-6	1.61E+00	2.24E+00
Tributyltin	688-73-3	1.00E+01	1.00E+01

Notes:

(a) Finfish BSAF data from USACE (accessed March 18, 2021) and EPA (accessed March 18, 2021) BSAF databases. Crustaceans BSAF is five times the finfish BSAF (Stegeman and Lech 1991).

(b) From NewFields 2013.

Abbreviations and Acronyms:

BAF = Bioaccumulation factor
BSAF = Biota-sediment accumulation factor
CAS = Chemical Abstracts Service
EPA = US Environmental Protection Agency
USACE = US Army Corps of Engineers

Table A-5
Lead Biota Accumulation Factor Values
Weldcraft Steel and Marine Site – Bellingham, Washington

Lead Concentrations in Tissue (a)			
Seafood Category	Detection Frequency	Mean Lead Concentration (mg/kg ww)	Maximum Lead Detection (mg/kg ww)
Benthic fish, fillet	8/17	0.04	0.14
Benthic fish, whole body	24/24	0.35	0.95
Crab, edible meat	21/21	0.05	0.24
Crab, whole body	21/21	0.07	0.22

Lead Concentrations in Sediment (b)			
Chemical	No. of Samples	Average (mg/kg)	Maximum (mg/kg)
Lead	11	21.60	48.00

Chemical	CAS No.	BAF (c)	
		Finfish	Crustaceans
Lead	7439-92-1	0.04	0.01

Notes:

(a) Tissue lead concentrations from the Lower Duwamish Waterway Remedial Investigation Baseline Human Health Risk Assessment report (Winward Environmental 2007).

(b) Site-specific sediment data were obtained from the Phase II environmental Site assessment (Landau 1998), supplemental sediment investigation (Landau 2001), and post-dredging sediment investigation (Landau 2006) reports. Surface sediment data points include those representative of existing Site conditions (i.e., points that were not removed by interim action dredging and backfilled with clean, imported sand in 2004).

(c) BAF = Concentration of contaminants in an organism / concentration of contaminants in sediment. The maximum tissue concentration and average sediment concentration were used to yield the most conservative BAF value.

Abbreviations and Acronyms:

BAF = Bioaccumulation factor
CAS = Chemical Abstracts Service
mg/kg = milligrams per kilogram

Table A-6
Cleanup Levels for Persistent, Bioaccumulative Toxins in Sediment
Weldcraft Steel and Marine Site – Bellingham, Washington

Parameter	Natural Background (a)	PQL (b)	Regional Background (c)	Risk-Based Concentration (HQ=1 or CR=10^{-6})	Risk-Based SCO	Risk-Based CSL	Benthic SCO	Benthic CSL	Proposed Cleanup Level	Units
Cadmium	0.8	0.07	-	7	7	7	5.1	6.7	**5.1**	mg/kg DW
Lead	21	0.1	16	89	89	89	450	530	**89**	mg/kg DW
Mercury	0.2	0.02	-	0.5	0.5	0.5	0.41	0.59	**0.41**	mg/kg DW
Bulk Tributyltin	-	-	-	173	173	173	79	156	**79**	µg/kg DW
cPAHs (sum TEQ)	21	9	86	1,040/496 (d)	1,040/496 (d)	10,400/4960 (d)	-	-	**496**	µg/kg TEQ

Notes:

(a) From SCUM Table 10-1; calculated values (90/90 UTL) for marine sediment natural background from the data sets in Appendix I and Bold study (Ecology 2021).
(b) From SCUM Table 11-1; programmatic sediment and tissue PQLs used to establish the PQL-based SCO and CSL (Ecology 2021).
(c) From SCUM Table 10-2; calculated values (90/90 UTL) for marine and freshwater sediment regional background (Ecology 2021).
(d) Represents risk-based concentration per EPA early-life stage calculation.

Abbreviations and Acronyms:

cPAHs = carcinogenic polycyclic aromatic hydrocarbons
CR = cancer risk
CSL = cleanup screening level
DW = dry weight
EPA = US Environmental Protection Agency
µg/kg = micrograms per kilogram
mg/kg = milligrams per kilogram
HQ = hazard quotient
PQL = practical quantitation limit
SCO = sediment cleanup objective
SCUM = Sediment Cleanup User's Manual
TEQ = toxicity equivalence
UTL - upper threshold limit